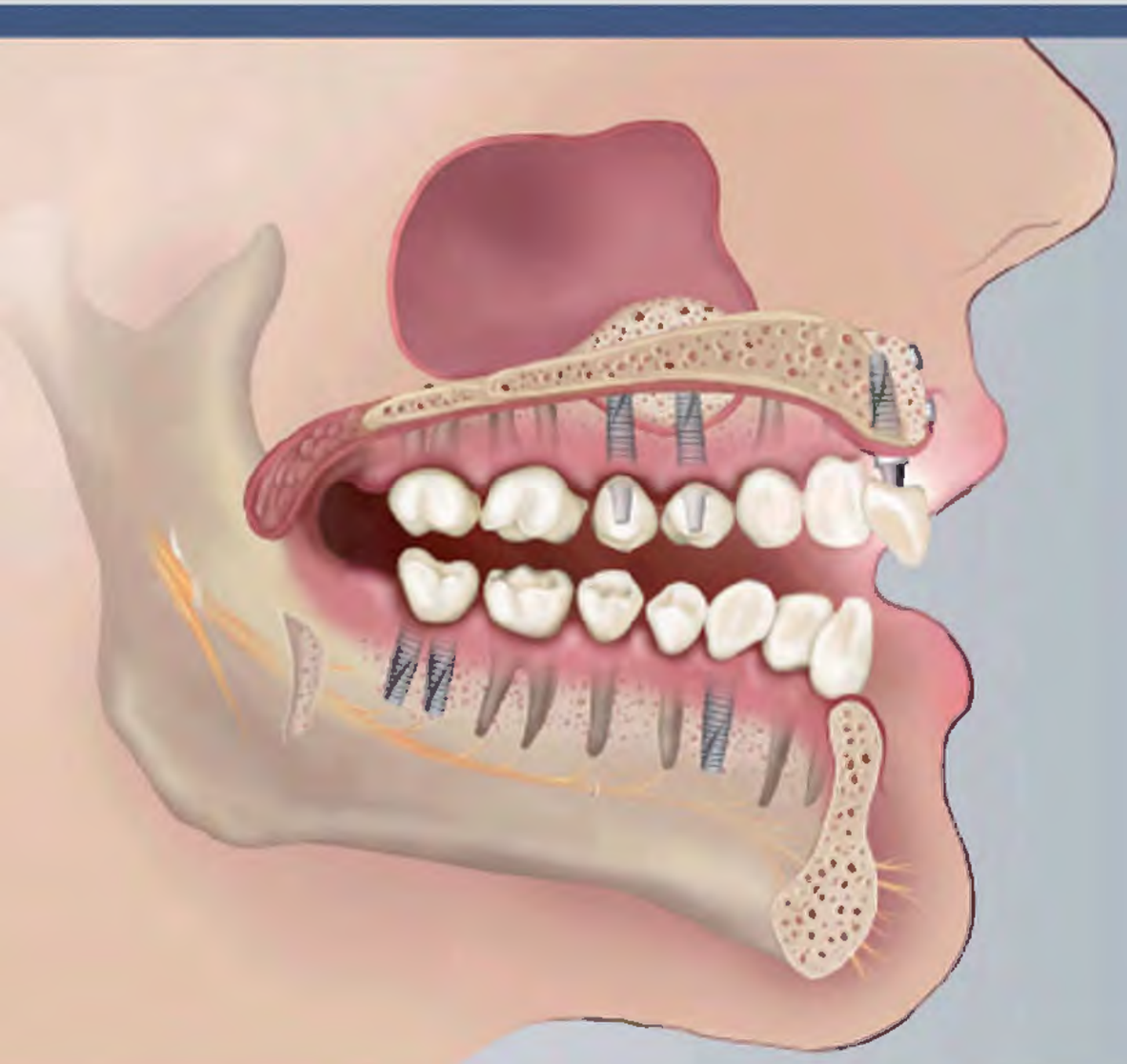
Pankaj P. Singh
A. Norman Cranin

Atlas of Oral Implantology



Third Edition

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Atlas of
Oral Implantology

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Oral Implantology

Third Edition

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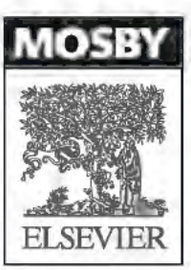

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Notice

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our knowledge, changes in practice, treatment and drug therapy may become necessary or appropriate. Readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of the practitioner, relying on their own experience and knowledge of the patient, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions. To the fullest extent of the law, neither the Publisher nor the Authors assume any liability for any injury and/or damage to persons or property arising out of or related to any use of the material contained in this book.

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This Atlas is dedicated to my family who mean the world to me.
They make everything possible.
My wife, Monica, and children, Meena and Shiv
and my dear friend and mentor, Dr. A. Norman Cranin
without whom this Atlas wouldn't have been a reality.

--Dr.Pankaj Singh

Foreword

In this new edition of *Atlas of Oral Implantology*, Pankaj Singh has skillfully updated and taken this Atlas into today's ever-evolving modern implantology practice. Detailed and comprehensive, this updated text uses a step-by-step approach to the latest advanced surgical techniques, implant management, imaging modalities, and even patient selection without losing sight of implant surgery fundamentals.

Countless illustrations guide the reader through diagnosis, planning, basic and advanced implant surgery, and post-treatment management.

Much has changed in the world of dental implantology since the first edition, from advancements in prosthetics to the ways in which specific diagnostic imaging techniques improve outcomes, and even advancements in modern antibiotic therapy. All these changes are discussed in exquisite detail to bring this version to the current standard of practice, a version desperately needed, but missing until now.

In this third edition of *Atlas of Oral Implantology*, Dr. Singh has produced a thoroughly unabridged guide to today's prosthodontics; it is an essential reference for all who practice in the field. This is a comprehensive textbook by a skilled and gracious young surgeon, co-authored with his mentor and trainer, Dr. A. Norman Cranin, who is a modern dental implantology pioneer in education, publishing, and clinical practice.

Arun K. Garg, DMD

Preface

When the editors at Mosby (now part of Elsevier) invited me to write a third edition to this Atlas, not only was I pleased and flattered, I also believed that I had been granted a sinecure.

The assignment would probably be completed in a short time, correcting a paragraph here, inserting a photograph there, and updating the chapter on abutments. (Oh, those abutments!)

I'd been teaching and operating regularly and did not realize the radical changes to which our specialty has been exposed.

I asked my associates to update the root form implant charts, to review the latest information on membranes (GTRMs), and to call for all the details on the newest abutments, and frankly, I thought that with a few hours at the computer, the revision would be completed.

As my more sophisticated readers know, this discipline of ours, from imaging to implant designs and textures, from abutments, to methods of overdenture fixation, has grown exponentially over the past decade.

As the realization of the great quantity of new material became clear, enthusiasm turned to panic. The book grew in size and content, and a review demonstrated that our references had quintupled in number and expanded enormously in content. Surgical and grafting techniques had been found to be limited only by the capabilities and imagination of the surgeons. Restorative dentists were producing lifelike results that defied nature.

With each new idea, each catalog, and each publication, my avarice became greater for leaving no stone unturned in making this an encyclopedic effort. As a personal learning experience for my colleagues and me, there could be no greater exercise than updating and supplementing 10-year-old information in an area of practice so vital and dynamic.

It is my consummate desire that the information found in the pages of this Atlas will contribute to the comprehension, capabilities, and skills of its readers and to the improvement of the health, well-being, and quality of life of their patients.

About the Author

Pankaj P. Singh DDS, ***Diplomate*** **ICOI and ABOI /ID,** ***Fellow*** **AAID**

Dr. Pankaj Singh is a graduate of New York University's College of Dentistry. He completed his residency in dental implants at Brookdale Hospital and New York University. He is a Diplomate of the International Congress of Oral Implantologists and the American Board of Oral Implantology/Implant Dentistry, a Fellow of the American Academy of Implant Dentistry, and the American Society of Osseointegration, and an active member of the Academy of Dental Sleep Medicine. He has advanced certification in IV sedation and anesthesia from the Albert Einstein/Montefiore Medical Center.

Dr. Singh is an attending faculty member in the Department of Dental/OS at LIJ-North Shore Hospital Medical Center in New York. He also teaches implant dentistry and is a clinical instructor (sabbatical) of Advanced Dentistry at New York University's School of Dentistry. He is a faculty member of the New York Maxi Course on Dental Implants with Dr. A. Norman Cranin.

Dr. Singh has published numerous articles in dental journals and has been profiled in several national magazines, television news programs, and radio. He lectures nationally and internationally and teaches hands-on live surgical courses on implants and restorative dentistry as well as on sleep dentistry. Dr. Singh was recognized as a pioneer in medicine in 2004 by *Biz India*, an international business publication, and was the only dentist to have ever been featured on the cover of their annual medical issue.

Dr. Singh is the founder and CEO of Arch Dental Associates and Le Visage Cosmetic & Implant Dentistry with New York offices in Manhattan, Huntington, and Garden City. He has been in private practice for more than 15 years, specializing in implant, sedation, and restorative dentistry as well as dental sleep medicine. He has extensive experience in implant surgery and hard and soft tissue grafting procedures. He emphasizes the use of computer-guided, navigated, and integrated three-dimensional technology for the evaluation and planning of the ultimate success of comprehensive rehabilitation of the implant and restorative patient.

Dr. Singh is a core member of the advisory committee "Alpha Team" of a major dental company specializing in endodontics and dental technology and also serves on advisory committees of several medical and dental companies.

Acknowledgments

Although producing this third edition was essentially a singular effort, I need to acknowledge the efforts of a great number of friends and colleagues. I want to tender gratitude to my senior associate, Jerome Kaufman, and junior associate, Mazen Natour, and my entire office team for their constant support and handling the day-to-day responsibilities of the offices while I concentrated on research and writing this Atlas.

Mazen Natour developed the tables in Chapter 4. Dr. Kaufman, a senior associate at Arch Dental Associates at Le Visage Cosmetic and Implant Dentistry, rendered advice in regard to the prosthetic chapters. Leslie Fang, MD, helped review Chapter 3. Jodie Bernard of Laser Words worked resiliently with my many corrections and produced some lovely new artwork.

The cooperation of the representatives of numerous implant companies made the cataloging of products simpler and allowed us to codify them into readily comprehensible charts and tables. Among them were Carl Misch of BioHorizons; Steri-Oss; Dental Research; Innova Implants; and the representatives of Zimmer, Straumann, Lifecore, NobelBiocare, Bicon, Pacific Bone Bank, and the Cal Ceram Dental Laboratory.

This third edition would not have come to fruition were it not for the confidence expressed in me by the senior editors of my publisher, Elsevier, Inc. of St. Louis. Particularly important are Brian Loehr, Developmental Editor, and John Dolan, the Acquisitions Editor, who listened to my every complaint.

Dr. A. Norman Cranin, my mentor for over a decade, believed in me and continues to support me while serving as my dear friend and counsel. His support, encouragement, and guidance inspired me to do what I do. Many of the techniques described in this book were generated by his innovative skills and fertile imagination.

Finally, an effort of this magnitude could not have been completed without the support and understanding of a wonderful and patient wife, Monica, and my children Meena and Shiv, who suffered through my not being with them almost every weekend while working on this Atlas. They offered support and understanding for which I am eternally grateful.

Pankaj P. Singh

New to this Edition

Updated coverage of current technology...

FIGURE 11-1 A, BioHorizons implants. These implants are made of a titanium alloy and have resorbable blast texturing (RBT) threads (reverse buttress threads) with the proprietary Laser-Lok microchannels. B-E, The osteotomy method follows classic techniques using drills of increasing diameter. (Courtesy BioHorizons Implant System, Birmingham, Ala.)

...and surgical techniques of today's implant designs

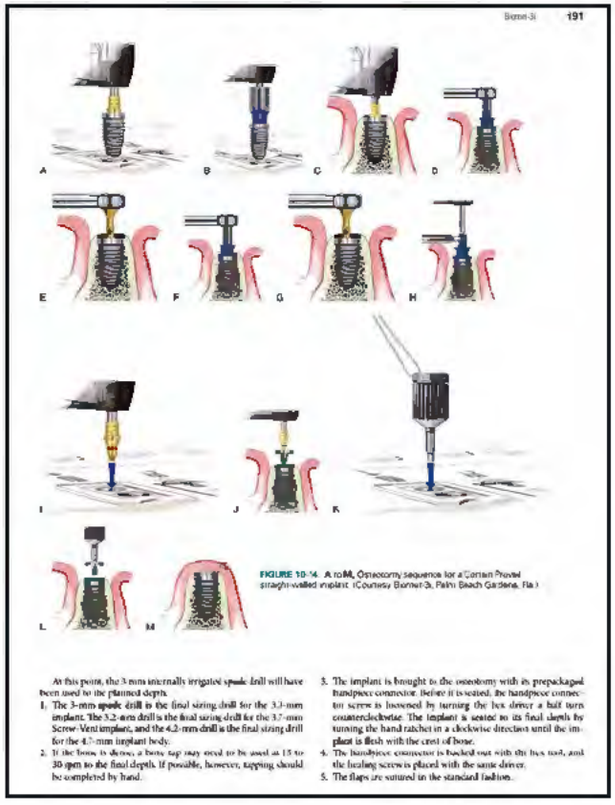
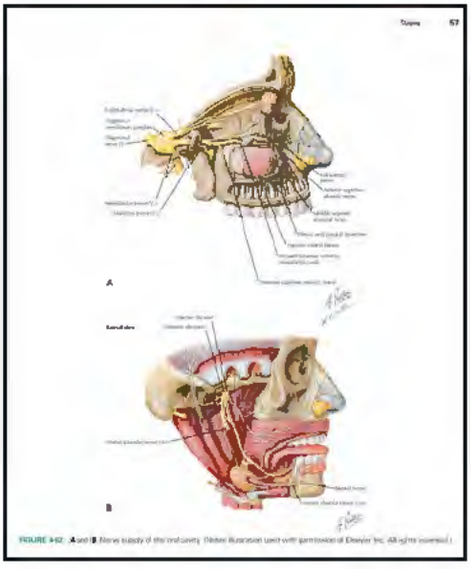


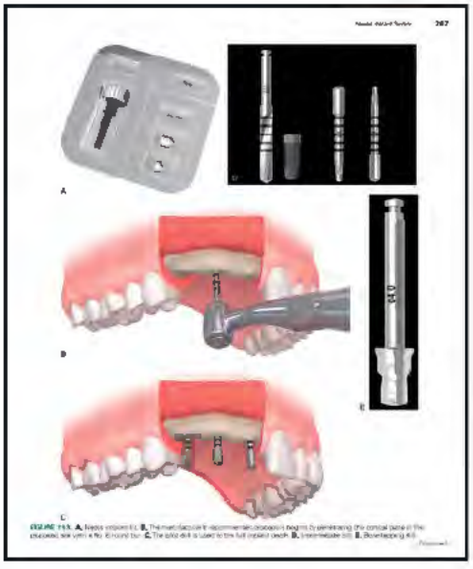
FIGURE 10-14 A to M, Osteotomy sequence for a Certain Prevail straight-walled implant. (Courtesy Biomet 3i, Palm Beach Gardens, Fla.)

At this point, the 3-mm internally irrigated spade drill will have been used to the planned depth.

1. The 3-mm **spade drill** is the final sizing drill for the 3.3-mm implant. The 3.2-mm drill is the final sizing drill for the 3.7-mm Screw-Vent implant, and the 4.2-mm drill is the final sizing drill for the 4.7-mm implant body.
2. If the bone is dense, a bone tap may need to be used at 15 to 30 rpm to the final depth. If possible, however, tapping should be completed by hand.
3. The implant is brought to the osteotomy with its prepackaged handpiece connector. Before it is seated, the handpiece connector screw is loosened by turning the hex driver a half turn counterclockwise. The implant is seated to its final depth by turning the hand ratchet in a clockwise direction until the implant is flush with the crest of bone.
4. The handpiece connector is backed out with the hex tool, and the healing screw is placed with the same driver.
5. The flaps are sutured in the standard fashion.

Colorized art throughout the book!

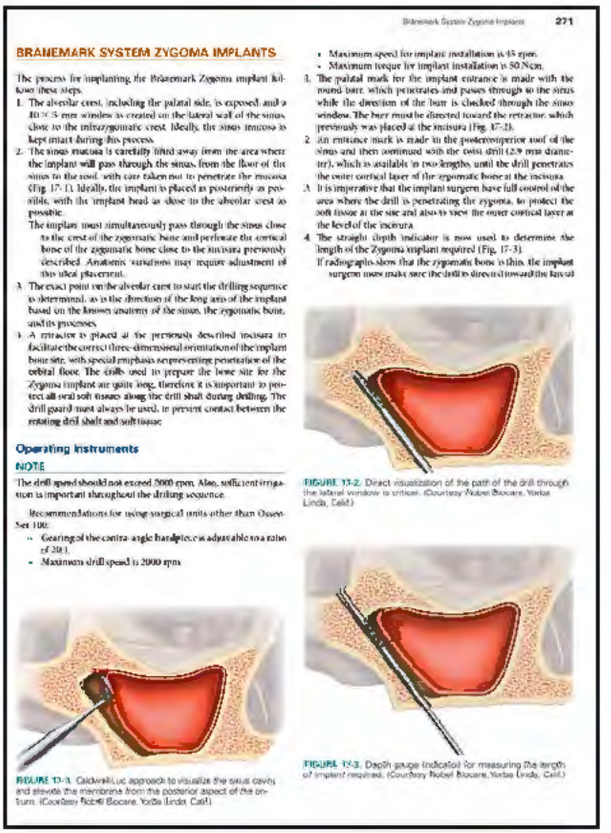




Keep up with the innovations of oral implantology with these new chapters!

Chapter 17: Zygomatic Implant Surgery and Prosthodontics
Offer your patients with adequate support for a fixed restoration with a zygoma implant.

Chapter 18: All-on-4
Whether using a conventional flap procedure or a flapless technique, this chapter will help you provide your patients with a secure and optimal prosthetic support for a prosthetic bridge.



Brånemark System Zygoma Implants 271

BRÅNEMARK SYSTEM ZYGOMA IMPLANTS

The process for implanting the Brånemark Zygoma implant follows these steps.

1. The alveolar crest, including the palatal side, is exposed, and a 10 × 5–mm window is created on the lateral wall of the sinus close to the infrazygomatic crest. Ideally, the sinus mucosa is kept intact during this process.
2. The sinus mucosa is carefully lifted away from the area where the implant will pass through the sinus, from the floor of the sinus to the roof, with care taken not to penetrate the mucosa (Fig. 17-1). Ideally, the implant is placed as posteriorly as possible, with the implant head as close to the alveolar crest as possible.
   The implant must simultaneously pass through the sinus close to the crest of the zygomatic bone and perforate the cortical bone of the zygomatic bone close to the incisura previously described. Anatomic variations may require adjustment of this ideal placement.
3. The exact point on the alveolar crest to start the drilling sequence is determined, as is the direction of the long axis of the implant based on the known anatomy of the sinus, the zygomatic bone, and its grooves.
4. A retractor is placed at the previously described incisura to facilitate the correct three-dimensional orientation of the implant bone site, with special emphasis representing penetration of the orbital floor. The drills used to prepare the bone site for the Zygoma implant are quite long, therefore it is important to protect all oral soft tissues along the drill shaft during drilling. The drill guard must always be used, to prevent contact between the rotating drill shaft and soft tissue.

Operating Instruments

NOTE

The drill speed should not exceed 2000 rpm. Also, sufficient irrigation is important throughout the drilling sequence.

Recommendations for using surgical units other than Osseo-Set 100:

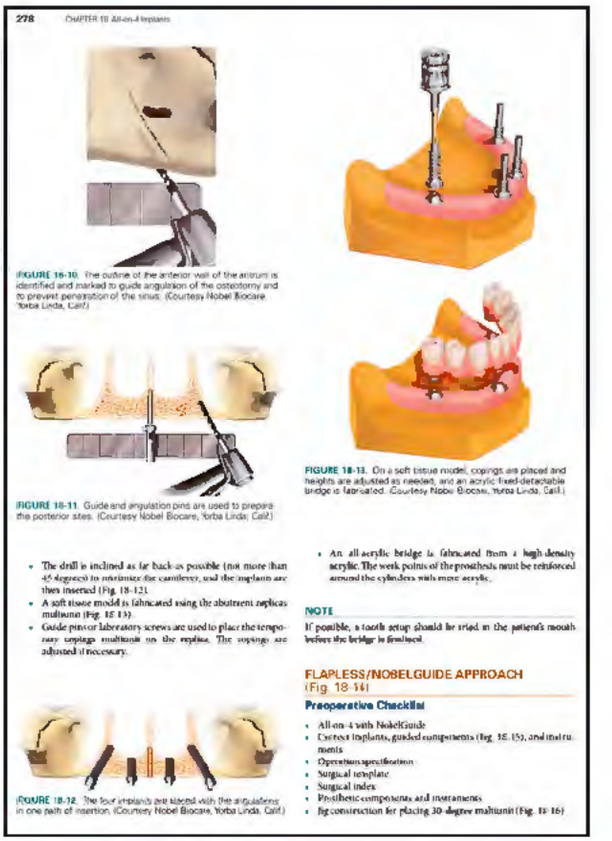
- Gearing of the contra-angle handpiece is adjustable to a ratio of 20:1.
- Maximum drill speed is 2000 rpm.
- Maximum speed for implant installation is 45 rpm.
- Maximum torque for implant installation is 50 Ncm.

1. The palatal mark for the implant entrance is made with the round bur, which penetrates and passes through to the sinus while the direction of the bur is checked through the sinus window. The bur must be directed toward the retractor, which previously was placed at the incisura (Fig. 17-2).
2. An entrance mark is made in the posteroinferior roof of the sinus and then continued with the twist drill (2.9 mm diameter), which is available in two lengths, until the drill penetrates the outer cortical layer of the zygomatic bone at the incisura.
   It is imperative that the implant surgeon have full control of the area where the drill is penetrating the zygoma, to protect the soft tissue at the site and always view the outer cortical layer at the level of the incisura.
4. The straight depth indicator is now used to determine the length of the Zygoma implant required (Fig. 17-3).
   If radiographs show that the zygomatic bone is thin, the implant surgeon must make sure the drill is directed toward the lateral

FIGURE 17-2. Direct visualization of the path of the drill through the lateral window is critical. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 17-1. Caldwell-Luc approach to visualize the sinus cavity and elevate the membrane from the posterior aspect of the antrum. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 17-3. Depth gauge (indicator) for measuring the length of implant required. (Courtesy Nobel Biocare, Yorba Linda, Calif.)



278 CHAPTER 18 All-on-4 Implants

FIGURE 18-10. The outline of the anterior wall of the antrum is identified and marked to guide angulation of the osteotomy and to prevent penetration of the sinus. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-13. On a soft tissue model, copings are placed and heights are adjusted as needed, and an acrylic fixed-detachable bridge is fabricated. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-11. Guide and angulation pins are used to prepare the posterior sites. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

- The drill is inclined as far back as possible (not more than 45 degrees) to minimize the cantilever, and the implants are then inserted (Fig. 18-12).
- A soft tissue model is fabricated using the abutment replicas multiunit (Fig. 18-13).
- Guide pins or laboratory screws are used to place the temporary copings multiunit on the replicas. The copings are adjusted if necessary.

- An all acrylic bridge is fabricated from a high density acrylic. The weak points of the prosthesis must be reinforced around the cylinders with more acrylic.

NOTE

If possible, a tooth setup should be tried in the patient's mouth before the bridge is finished.

FLAPLESS/NOBELGUIDE APPROACH (Fig. 18-14)

Preoperative Checklist

- All-on-4 with NobelGuide
- Correct implants, guided components (Fig. 18-15), and instruments
- Operation specification
- Surgical template
- Surgical index
- Prosthetic components and instruments
- Jig construction for placing 30-degree multiunit (Fig. 18-16)

FIGURE 18-12. The four implants are placed with the angulations in one path of insertion. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Detailed, step-by-step instructions from several of the leading implant manufacturers!

582 CHAPTER 19 Post-Form Implant Surgery: Preprosthetic I

Osteotomy Procedure

Mk III Ø 3.3-mm NP Implant

Fig. 19-4 presents the osteotomy sequence for a narrow platform implant.

Mk III Ø 4-mm RP Implant

A 4-mm diameter RP implant can be used in soft bone or when initial stability cannot be achieved with a 4.7-mm diameter RP implant. In very dense bone, a 3.8, 10 Screw Tap may also be required. Drills of different diameters can be used, depending on the bone quality and implant diameter.

Mk III Ø 3.75- and 4-mm RP Implants

The crestal preparation drill and final shaping drill for an RP implant are shown in Fig. 19-5.

FIGURE 19-3. Straight-walled external hex. Sequence of the osteotomy from initial pilot twist drill to the cover screw. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 19-4. Osteotomy sequence for the narrow platform (NP) implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Contents

Introduction to the Atlas of Oral Implantology

1
CHAPTER

We welcome the reader to the third edition of *Atlas of Oral Implantology*. This book is an instructional manual on how to evaluate patients for implant therapy, evaluate host sites, select implant types (although no preferences are stated for specific proprietary products), place implants step by step, observe patients, diagnose incipient problems, institute remedial techniques (troubleshooting), perform a wide variety of restorative modalities, and maintain and follow patients during the postoperative and postrestorative periods.

This atlas is arranged in a unique manner. It should be read in its entirety before any workups are performed or patient care is given. The reader may have no interest in some chapters or parts of chapters. Nevertheless, to harvest optimal benefits from the book, the reader must understand its design and all the material presented.

Chapters 2 through 5 and parts of the appendixes explain the value and application of implants in general, how to choose the appropriate design for each condition presented, which patients should be treated with implants and why, the tests that should be performed to assess a patient's eligibility for implants, the anatomic characteristics of potential host sites, and how the basic implant designs differ and, in these differences, how they may best serve practitioner and patient. These chapters should be read before any subsequent chapters on specific techniques.

Chapter 6 explains the armamentarium an implant surgeon needs before undertaking any procedure. In addition, at the beginning of each chapter on a particular implant technique, a list of special or additional instruments specific to that modality is presented. As a further aid, most chapters start with "caveats" for each technique described. To be forewarned is to be forearmed.

Chapter 6 also suggests a classic operatory design. A specific room need not be set aside for implant surgery; however, all necessary instruments and supplies must be available that will allow the implantologist to perform the surgery or change a treatment plan during the procedure. For example, a blade might be indicated instead of a planned root form because the ridge is too narrow, or a larger diameter implant may be required if the osteotomy becomes too wide.

Chapters 9, 10, and 11 cover root form surgery. This information is offered because not all companies have implants of larger diameters that can serve this purpose. In fact, the decision to perform a subperiosteal implant should be a viable one if endosteal implants are not suitable. The supplies and facilities for such a procedure must be immediately available. Optimally, the reader will become a complete implantologist; that is, one who develops the capability to manage any situation in which implants of any design may be used or substituted for the type selected during treatment planning.

It is important that practitioners refrain from attempting to insert implants if they do not yet have the necessary experience obtained from hands-on courses or the requisite surgical skills gained from previous training and clinical involvement. Furthermore, the information presented in these chapters is not etched in stone. Often specific problems, deviations from the expected, and unpredictable events occur, which must be anticipated as the practitioner proceeds with planning and operative efforts.

Chapter 5 is important because it offers advice on the prosthetic options available. The method of reconstruction should be selected before the implants are placed. A decision on an overdenture, a single-tooth replacement, a fixed-detachable prosthesis, or a cemented bridge should be made, through discussion with the patient. The patient's preferences, local conditions, cost, and the practitioner's skills and philosophy all play a role in the choice of these options.

Chapters 2, 5, 9, 10, and 11 present the specific types of implants that lend themselves to the prosthetic options best suited to the patient's needs.

Chapter 4 presents relatively noninvasive techniques that serve as guides to "sound" the bone (i.e., measure its height and width). These are provided to help the practitioner choose the kind of implant that is simplest to use and that offers the best chance for success.

The principles of surgery and anesthesia are of paramount importance in dental implantology. Chapters 6, 7, and 8 offer instruction in making incisions; techniques for dissection and reflection; methods of retraction; use of coolants; handling of drills, burs, and handpieces; management of osteotomies; soft and hard tissue manipulation; bone grafting; oral plastic surgery; and types of sutures and ways to use them. These fundamentals may seem rudimentary, but they are important, because they apply to all implant techniques. In addition, Chapter 6 and all other basic or introductory chapters (e.g., Chapter 9 on the generic root form implant) have been written and illustrated to make this atlas simple and efficient to use. They present basic principles that apply to all techniques and methods and allow the reader to proceed as though guided by a personal tutor on how to incise, reflect, cut bone, and suture, because these topics are logically arranged chapter after chapter.

Once the appropriate implant design has been chosen, the reader should proceed in the following manner.

If a root form implant has been chosen, Chapter 9 should be reviewed. This chapter presents instructions on the initial steps of placement (e.g., bur and drill sizes, number by number, up to the requisite diameter) for all types of root form designs (e.g., threaded, self-tapping, non-self-tapping, press-fit, one-piece, or two-stage submergible). By following these instructions, the practitioner can acquire a generic drill set (e.g., Salvin Dental) that not only is economical in cost and time, but also may be used for all steps of the procedure for every type of root form implant except the final one (i.e., seating of the implant). The names, addresses, e-mail addresses, and telephone numbers of the manufacturers whose products are described in this atlas are listed in the appendixes.

After completing Chapter 9, the practitioner may proceed to chapters 10 and 11 and choose a specific implant. These chapters present step-by-step reviews of the surgery for virtually every implant system, from the first to the final proprietary maneuver, by name or

number, including countersinks, bone taps, try-ins, and seating of the implant. Logically, the healing screws, caps, or inserts are described next. Closure is covered in Chapter 6, along with suture types, materials, and techniques.

The reader should pay special attention to the section on prosthodontics, covered by chapters 20 to 27; this is the next logical step in completing implant-borne reconstruction, and the chapters have been organized so that each of the numerous alternatives is available to the restorative dentist, from single-tooth implants to the complexities of abutment selection and fixed-detachable, full arch rehabilitation.

If a blade implant, a ramus frame, a subperiosteal, or even an intramucosal insert is selected, specific chapters guide the reader through each of the relevant procedures.

Not to be forgotten are endodontic implants, ridge maintenance, and augmentation procedures using autogenous bone and bone substitute grafting materials (hydroxyapatite, tricalcium phosphate [TCP], demineralized freeze-dried bone [DFDB], irradiated bone, and others); membranes, both absorbable and nonabsorbable; and, for the oral and maxillofacial surgeon, jaw augmentation, skeletal reconstruction with biomaterials, and transosteal implant procedures (described in detail in chapters 8 and 18).

If a problem develops during implant surgery or if difficulties or unexpected sequelae arise during the postoperative period, help is available in Chapter 28.

The appendixes offer product and manufacturers' information; methods of metal passivation, defatting, and sterilization; suggestions for postoperative management; and an example of an implant surgery consent form.

The atlas also includes a glossary of implant terminology and newly expanded Suggested Readings lists.

It is hoped that this book will meet many of the needs of the practitioner in clinical implant activities.

Implant Types and Their Uses

2
CHAPTER

IMPLANT TYPES

Endosteal Implants

We begin with a general introduction to the available implant types and the physical conditions required for their placement. Although their basic characteristics are presented in this chapter, the reader should refer to Chapter 5 for optimal prosthetic use; it would be best to read Chapter 5 after completing this chapter, because one of the key guides to implant selection is the patient's prosthetic requirements.

Root Form Implants

If the available bone has sufficient width and height, root forms (e.g., submergible, single stage, two stage, and one piece) are the first choice in selecting an implant. The types available are:

- Press-fit (unthreaded but covered with a roughened hydroxyapatite [HA] or titanium plasma spray [TPS] coating) (Fig. 2-1)
- Self-tapping (threaded) (Fig. 2-2)
- Pretapping (threaded) (Fig. 2-3)

Prosthetic options: Prostheses may be supported by fixed, fixed-detachable, overdenture, or single-tooth devices (antirotational design required).

Bone requirements:

Bone height (vertical)	>8 mm
Bone width (buccal to lingual)	>5.25 mm
Bone breadth (mesial to distal) per implant, including the interproximal spaces mesially and distally	>6.5 mm

Crête Mince (Thin Ridge) and Other Mini-Implants

Crête Mince implants are threaded, self-tapping, titanium spirals (Fig. 2-4, *A*).

Prosthetic options: Crête Mince thin-ridge implants add retention to a long-term, fixed bridge prosthesis by pinning it through the pontics to the underlying bone. They also may be used to support transitional prostheses (Fig. 2-4, *B* and *C*). When placed in confined areas between teeth or implants, these implants add long-term additional buttressing to superstructures.

Blade Implants

Blade implants are available as submergible, single-stage and two-stage, and one-piece devices (Fig. 2-5) in three forms:

- Prefabricated
- Custom cast
- Alterable (by cutting, bending, and shaping at chairside)

Prosthetic options: Single or multiple abutments. The suggested use for blade implants is for fixed bridge prostheses in combination with natural tooth abutments, although they may be used in multiples for full arch edentulous reconstructions. If the height of the available bone is adequate for root forms but the width is not, and osteoplasty is not an option, blade implants are the second choice in implant selection. The design of the blade chosen should follow that of the anchor philosophy, in which the shoulder does not meet the cervix at right angles, but rather dips in a semicircular configuration at the site of the neck.

Suitable arch: Maxillary or mandibular, completely or partially edentulous.

Bone requirements:

Bone height (vertical)	>8 mm
Bone width (buccal to lingual)	>3 mm
Bone breadth (mesial to distal except for single-tooth designs, which require less)	>10 mm

Ramus Blade and Ramus Frame

The ramus implant is a one-piece blade made for use in the posterior mandible when the body of the mandible has insufficient bone (Fig. 2-6). The ramus frame is a three-blade, one-piece device designed for relatively atrophied mandibles. It is used when a subperiosteal implant is not desirable because of cost or operator preference.

Prosthetic option: Overdentures.

Suitable arch: Mandibular, completely edentulous.

Bone requirements:

Bone height (vertical), symphysis, rami	>6 mm
Bone width (buccal to lingual)	>3 mm

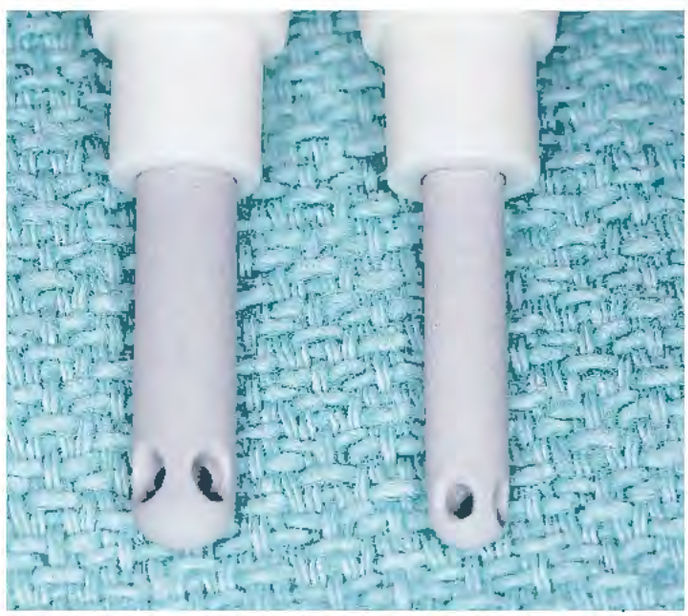


FIGURE 2-1. Endosteal root form implants. These implants are 3.25 to 4 mm in diameter, press-fit, and both are coated with hydroxyapatite.

FIGURE 2-2. Brånemark style self-tapping implants made of commercially pure (CP) titanium.

FIGURE 2-3. *Left,* The Zimmer threaded implant, coated with hydroxyapatite (HA), requires pretapping of the bone. *Right,* A coordinated, HA-coated, press-fit design of the same diameter.

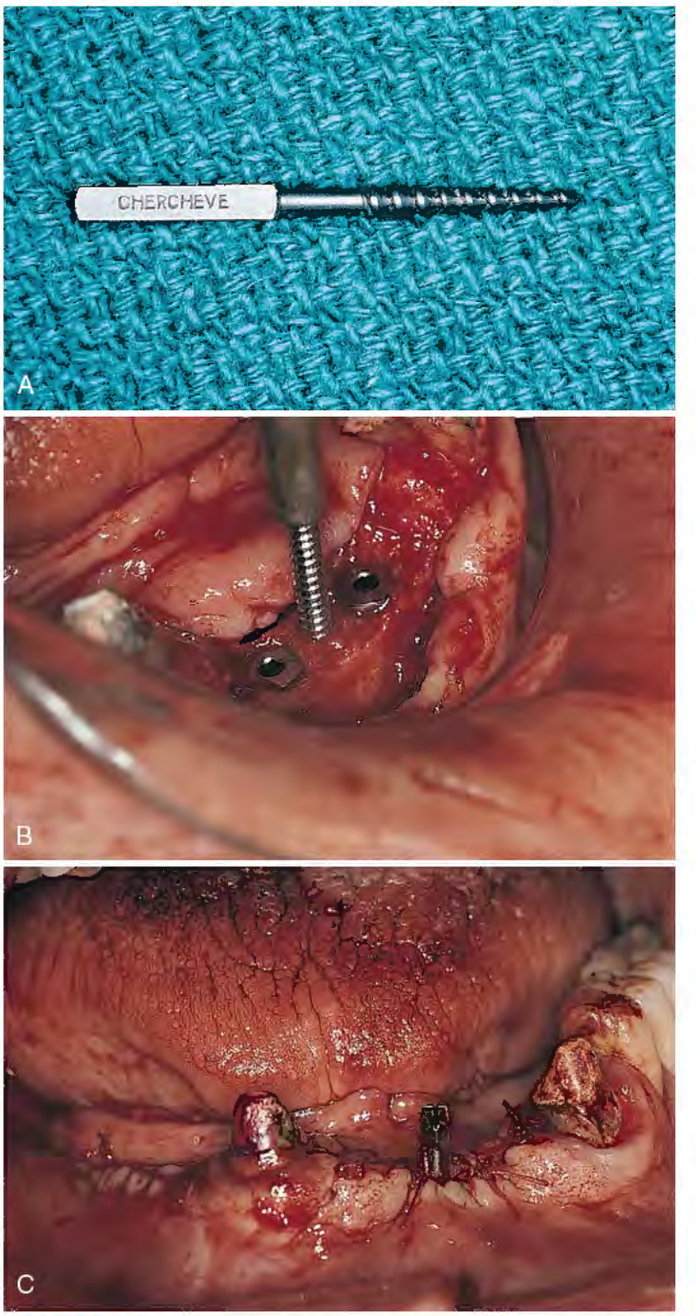


FIGURE 2-4. **A,** Crête Mince (M. Chérchève) titanium-threaded implant for thin ridges. **B** and **C,** Small Dentatus implants can be placed in strategic sites to support interim prostheses during osseointegration of the conventional implants at sites No. 24 and 25.

Transosteal Implants

Transosteal implants are one-piece, transmandibular, complex implants that also are available as individual abutments. For this type of implant, a submental skin incision must be made under surgical conditions. An advantage of the transosteal implant is its predictable longevity. Several designs are available, and because of the implants' long-term predictability, several patients still have prostheses supported by them. Designs include a single component device (Fig. 2-7) and several varieties of multiple component, staple devices (Fig. 2-8).

Prosthetic options: The usual application for these implants was to support an overdenture. Fixed bridges were rarely made as alternatives.

Suitable arch: Mandible, anterior region, completely or partially edentulous (single component may be used in the presence of adjacent teeth).

Bone requirements:

Bone height (vertical)	>6 mm
Bone width (labial to lingual)	>5 mm

Subperiosteal Implants

Complete, Universal, and Unilateral Implants

Subperiosteal implants, which generally are quite reliable, are used when insufficient bone is available to allow use of endosteal implants. If extreme mandibular atrophy is present, mandibular augmentation (see Chapter 8) further improves the prognosis (Fig. 2-9).

Subperiosteal implants are always custom-made. They may be fabricated either by making a direct bone impression (see Chapter 14) or by using stereolithographic technology. They can be used in any part of either jaw. They also can serve as abutments

FIGURE 2-5. Titanium, submergible blade implant with abutments attached (Park/Startanius). The anchor configuration is embodied in the shoulder design.

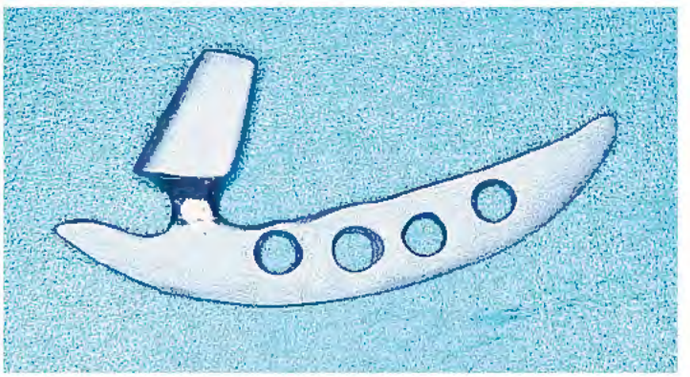


FIGURE 2-6. Ramus blade, a plate form implant designed for use in the mandibular ramus when insufficient bone is present in the body of the mandible.

FIGURE 2-7. Chrome alloy, threaded transosteal implants (Cranin/Vitallium).

for a variety of prosthetic configurations, although the overdenture is most widely used to complement the complete subperiosteal implant (Figs. 2-10 and 2-11).

Prosthetic options: Overdentures, fixed bridges.

Suitable arch: Maxillary or mandibular, completely or partially edentulous.

Bone requirement: >5 mm or mandibular augmentation. If the mandible or maxilla is extremely thin (pencil thin), the subperiosteal implant may settle through it. Therefore, a moderate amount of vertical bone height (at least 5 mm) must be present,

FIGURE 2-8. Titanium, two-component staple implant (I. Small/Zimmer).

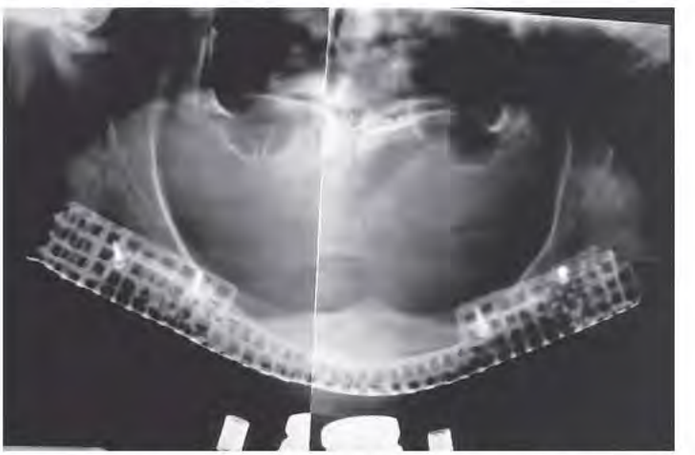


FIGURE 2-9. Titanium mortise mesh form, filled with autogenous bone harvested from the anterior iliac crest, materially alters the shape of the atrophied mandible.

or the inferior mandibular border or antral floor must be elevated to prevent this development.

Other Implants

Endodontic Stabilizers

Endodontic stabilizers are highly successful implants that lengthen the tooth root. One reason for their success is that they had no site of permucosal penetration, because they were placed in bone through the apices of natural teeth (Fig. 2-12).

This type of implant offers a one-stage treatment for stabilizing teeth with inadequate crown-to-root ratios. When periodontal problems are treated, the success rate of these implants approaches that of conventional endodontic therapy.

Prosthetic options: Crown and fixed bridge abutments.

Suitable arch: Maxillary or mandibular; any tooth may be treated.

Bone requirement: 8 mm of lesion-free bone in direct proximity to the apex, within the long axis of the recipient root canal.

Intramucosal Inserts

Intramucosal inserts are buttonlike, nonimplanted retention devices that can be used to stabilize full and partial maxillary and mandibular removable denture prostheses (Fig. 2-13). Because of the simple and

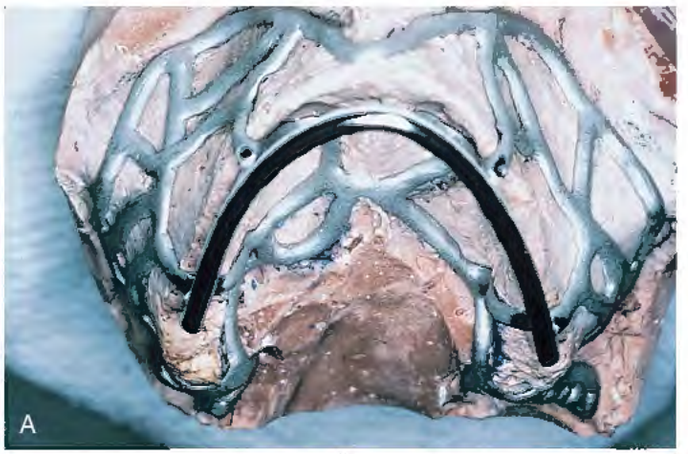


FIGURE 2-10. **A,** Additional cortical-bearing areas are used by the maxillary pterygohamular subperiosteal implant. **B,** The mandibular subperiosteal implant has undergone many design changes.

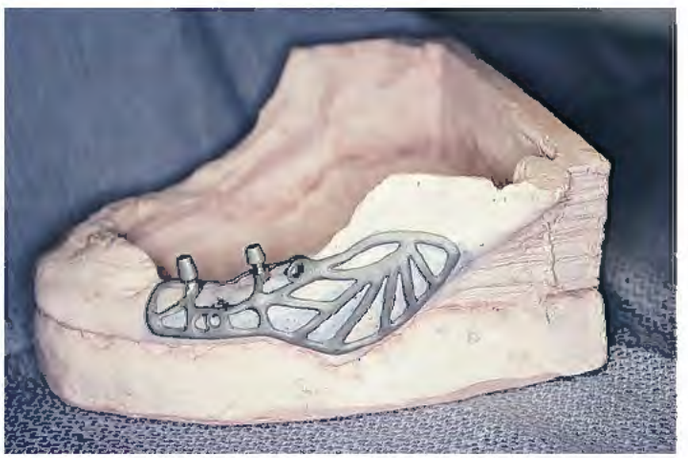


FIGURE 2-11. Unilateral mandibular subperiosteal implant uses the same design principles as the complete device.

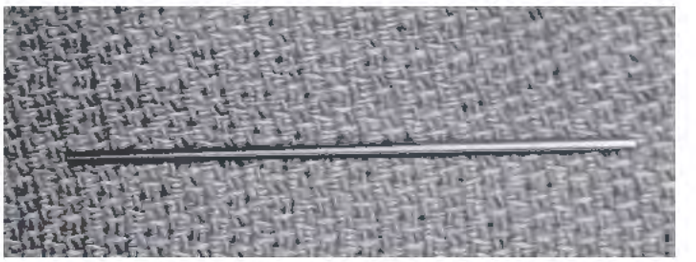


FIGURE 2-12. Smooth-surfaced, matte-finished endodontic implant made of cobalt, chromium, and molybdenum (Co-Cro-Mo) alloy (Howmedica/Vitallium).

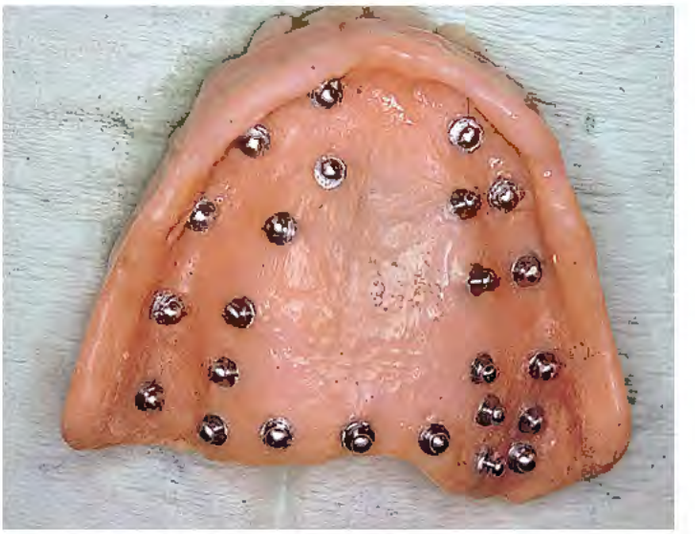


FIGURE 2-13. Intramucosal inserts (stainless steel) processed into a denture.

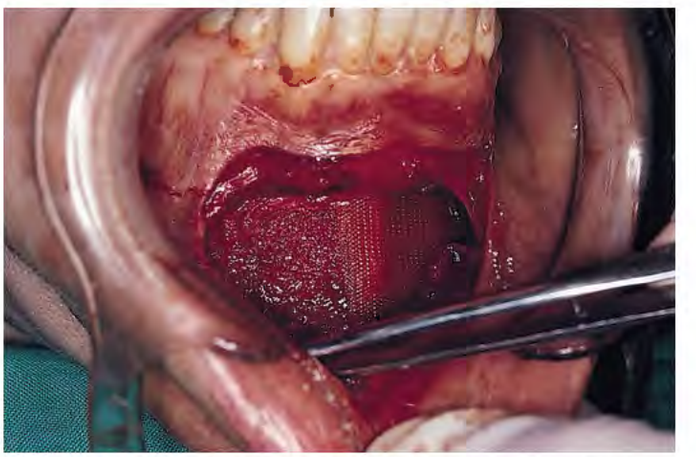


FIGURE 2-14. Classical donor site for autogenous bone is the parasymphyseal area. The area is repaired with demineralized freeze-dried bone (DFDB) mixed with hydroxyapatite and covered with a resorbable Vicryl mesh membrane.

relatively noninvasive nature of the placement procedure, they are particular useful for patients who are poor medical risks.

Prosthetic options: Removable dentures, full or partial.

Suitable arch: Maxillary, completely or partially edentulous; mandibular, partial only.

Bone requirement: None; required mucosa, 2.2 mm thick (bone beneath thinner mucosa may be deepened in nonantral areas).

Bone Augmentation Materials and Guided Tissue Regeneration Membranes

Bone augmentation materials are used for ridge maintenance after dental extractions, for ridge augmentation, for periodontal and periimplant repair and support, and for maxillofacial surgical onlay and inlay purposes when bone replacement is required (Fig. 2-14). Only autogenous bone, and possibly bone morphogenic protein (BMP), are osteogenic. Demineralized freeze-dried bone (DFDB) is said to be osteoinductive. Ceramic, polymeric, and biologic materials are also available.

Ceramic Materials

- Resorbable: Beta-phase tricalcium phosphate (B-TCP)
- Nonresorbable: Hydroxyapatite
- Porous particulate and block forms
- Nonporous particulate and block forms
- Blocks are available as particles held together in a resorbable collagen medium, strung like beads with polyglycolic acid suture or supported in a matrix of calcium sulfate (plaster of Paris-Hapset).

Polymeric Material

- Hard tissue replacement (HTR) particulate and porous block forms

Biologic Materials

- Autogenous bone
- Irradiated bone
- DFDB
- Bovine (e.g., Bio-Oss)
- Membranes, resorbable and nonresorbable
- Recombinant human bone morphogenic proteins (rhBMP) (e.g., GEM21-S, Infuse)

Evaluation and Selection of the Implant Patient

3
CHAPTER

PATIENT SCREENING AND MEDICAL EVALUATION FOR IMPLANT AND PREPROSTHETIC SURGERY

Implant and preprosthetic surgeries aim to restore normal anatomic contours, function, comfort, esthetics, and oral health. As such, they are not lifesaving procedures. The prime concern, therefore, must be not to undermine the patient's overall health and safety. The practitioner should meticulously follow every step in selecting the appropriate treatment plan and maximizing the longevity of the implanted system, including the overlying prostheses.

One particularly important factor influences the possibility of subsequent complications: inadequate systemic screening of patients before implants and biomaterial are implanted. The general contraindications to implant procedures no longer can be limited to the traditionally considered malfunctions of the pancreas, liver, and hematopoietic system; the devastating long-term effects of smoking or inadequate dietary habits cannot be ignored. In fact, a number of systemic problems can pose major risk factors.

On the other hand, modern standards of care should not systematically exclude implant surgery in patients with relative or marginal health conditions; the possibility of improving and stabilizing those conditions must be explored. Newer techniques of general anesthesia and intravenous sedation are being used more frequently on an ambulatory basis, allowing implant surgeons to take their patients into various degrees of conscious or deep sedation. Patient screening, therefore, also should take into consideration factors related to this form of management.

An arbitrary guideline for patient selection may be based on the classification system of the American Society of Anesthesiologists (ASA) (this system is discussed in more detail later in the chapter). With very few exceptions, the ASA system restricts intraosseous implants and implant-related graft surgeries to patients who fall into categories ASA1 and ASA2, and those judiciously selected in category ASA3.

Practitioners should consider assigning patients age 65 or older to an ASA category one level higher than the person's health factors would seem to indicate, depending on the individual's medical, social, and familial history. For example, a 65-year-old patient has a complete medical evaluation with blood workup, and no underlying systemic disease or disorders are found; therefore, no interventional therapy is indicated, either with medication or a procedure. This individual, if younger than age 65, would be assigned to category ASA1. However, because the patient is 65, he should be assigned to category ASA2, because his metabolic rate has declined, and he does not metabolize medications as rapidly as a younger person. With regard to sedation, it is important to note that older patients (i.e., over age 65) also are more sensitive to sedative drugs and are more likely to develop postoperative delirium.

The body seems to respond much less dramatically to subperiosteal implants inserted for the treatment of advanced mandibular atrophy than it does to endosseous devices. By far, the cortical histoarchitecture and metabolism are less affected by organ disorders than are the deeper endosseous structures. However, when endosteal (osseous) devices are used in purely cortical bone, the prognosis is very poor. To improve the chances of success, extensive bone grafting is required from sites in the patient's skeleton (i.e., the anterior iliac crest, calvarial spongiosa, and areas in the superior tibia). These procedures fall within the spectrum of significant, invasive surgery, therefore the surgeon must make it clear to the patient that the chances of success may be limited, and the complications are serious.

This chapter presents a number of *absolute contraindications* to implant procedures and analyzes a series of *relative contraindications* for which the dental surgeon's judgment remains the decisive factor. In the latter case, the chapter proposes treatment patterns that could optimize certain marginal heath conditions or stabilize unbalanced biologic functions before or at the time of surgery. As life expectancy in the industrialized countries continues to rise, more and more elderly patients will have implant-supported prosthetics. For these patients, efforts must focus on keeping a regular and watchful eye on their general health and screening for possible geriatric conditions responsible for long-term implant failure.

With advances in technology and improvements in complicated implant devices, optimal knowledge of internal medicine must become a prerequisite for future academic implant education.

INTRODUCTION TO PATIENT SCREENING AND MEDICAL EVALUATION

Technically speaking, contemporary implant surgery is a relatively innocuous procedure. A stable, well-integrated implant is as "clean" as a healthy tooth. However, although the management of complications in patients with minor systemic disorders usually is straightforward and successful, this may not be the case with systemically compromised patients. For example, the dental surgeon should not devise a treatment plan for a patient who recently has undergone heart valve surgery without fully considering the gravity of possible immediate or delayed complications if unexpected problems arise. The implant may not be the only thing that becomes compromised.

Some patients with marginal health conditions also are, in addition, "oral invalids" and urgently need comprehensive dental treatment. In such cases, many implantologists are naturally inclined to give functional oral rehabilitation the same priority as treatment of the critical health condition; they do not readily consider deferral of the implant treatments. However, until such patients' general health has stabilized, they should be provided with only provisional conventional prostheses that do not require surgery. After the patient has achieved a proper state of health, definitive implant surgery can be undertaken.

Implant dentistry has progressed amazingly during the past 20 years. Every aspect, whether scientific or clinical, is taught in academic institutions around the world with a discipline and

demands equal to those of other types of surgical instruction. However, one vital element that has been underemphasized is the meticulous physical evaluation of patients before, during, and after implant treatment. This element is becoming increasingly important because, as mentioned previously, life expectancy in the industrialized nations is increasing, and a growing number of elderly patients will have implant-supported prostheses.

Most patient follow-ups are restricted to local oral evaluation of the implant sites, and these evaluations seldom extend beyond 10 years. The long-term implant complications that arise from impaired health often are neglected. A total of 25 years of clinical experience in implant and preprosthetic surgery has brought us into contact with a significant number of long-term complications (15 to 20 years after implant treatment) that developed completely independently of the oral environment. For this reason, efforts must focus on carefully following patients' general health and screening for possible geriatric systemic conditions that might cause long-term implant failure.

As mentioned earlier, an arbitrary but practical method of patient selection may be based on the ASA's classification system. This system defines limiting risk factors in five categories. Because both implant and preprosthetic procedures are elective surgery aimed at restoring function and comfort, they should be restricted primarily to patients categorized as ASA1 (patients with no health problems) or ASA2 (patients with minor health problems who respond well to treatment). Patients whose health conditions put them in category ASA3 (major health problems with partial correction) or higher (ASA4 [major health problems with hospitalization or institutional intervention] and ASA5 [near terminal or death]) should be screened carefully for any absolute or relative contraindications.

Absolute Contraindications

Absolute contraindications arise from health conditions that may jeopardize the patient's overall health and seriously compromise the survival of implanted systems, resulting in residual chronic complications (Table 3-1).

The following lists presents discussions of the common systemic absolute contraindications. Dental surgeons must make it a top priority to understand these conditions thoroughly and to examine the patient methodically and carefully for them.

1. **Recent myocardial infarction.** Contemporary cardiology, including the use of nonsurgical interventions, has greatly improved the care and treatment of patients who have had a myocardial infarction (MI). Permanent use of potent anticoagulants is required much less frequently, whereas the cardiovascular protectors are used extensively; these include beta-adrenergic blocking agents, antihypertensive drugs, and antiplatelet agents (aspirin, clopidogrel bisulfate [Plavix]). Patients who have had an MI usually reach stable condition 6 to 12 months after initiation of primary care. However, it is important to avoid any surgical stress that could trigger uncontrolled vasoconstriction, with possible tachyarrhythmias, until the stable condition has remained unchanged for at least 3 to 6 months. In addition, if the patient has been prescribed anticoagulants or antiplatelet agents, interrupting administration of these drugs in the early stages of the disease may prove extremely dangerous.
2. **Valvular prosthesis.** The onset of bacteremia in patients fitted with valvular prostheses constitutes a major threat to the longevity of the cardiac valve. The oral cavity traditionally has been recognized as the principal gateway for such infections. Consequently, no implant surgery should be planned until the patient has reached stable condition, which usually occurs 15 to 18 months after cardiac surgery. Depending on the type of valve used (i.e., a mechanical valve), the patient may be required to take potent anticoagulants permanently. Any planned procedure must take into consideration surgical stress, anticoagulant imbalance, and the risk of an infection that in extreme cases may lead to endocarditis and loss of the artificial valve. All patients with prosthetic cardiac valves require prophylaxis with antibiotics before dental procedures that would result in manipulation of the gingival tissue or the periapical region of the teeth, or interruption of the mucosal surfaces.
3. **Coronary stents.** The incidence of cardiac disease seems to be on the rise, and more and more patients are undergoing percutaneous coronary angioplasty, with or without placement of coronary stents, instead of open heart surgery. Symptomatic cardiac conditions no longer are the primary indication for interventional therapy. In the absence of symptoms, if patients have a significant family history of cardiac or coronary artery disease or a lifestyle that puts them at risk for such disease, early intervention is recommended, through lifestyle changes with or without medications. Coronary artery disease may be detected in these asymptomatic patients through a positive stress test result. In other cases, coronary artery disease is diagnosed in patients who seek treatment for acute coronary syndrome (unstable angina), which may result in urgent angioplasty and the placement of stents. Coronary stents also are placed when arterial occlusions are identified during an angiogram after an MI. These patients undergo aggressive antiplatelet therapy for at least 6 months and sometimes for an indefinite period. Therefore, no

Table 3-1 Systemic Absolute Contraindications to Implant Surgery and Their Impact on Predictability

Health Condition	Risks for Patient's General Health	Severity of Immediate Implant Complications	Long-Term Predictability of Implant System
1. Recent myocardial infarction	++++	+	++
2. Valvular prosthesis	++++	+	++
3. Severe renal disorder	++++	++++	0
4. Treatment-resistant diabetes	+++	++++	0
5. Generalized osteoporosis	++	++++	+
6. Chronic or severe alcoholism	+++	++++	0
7. Treatment-resistant osteomalacia	+	+++	+
8. Current radiotherapy	+++	++++	0
9. Severe hormone deficiency	+++	++++	+
10. Drug addiction	++	++	+
11. Heavy smoking habits	++	++	+

The number of + relates to the degree of gravity of the complications associated with implant and graft surgery. One + is the least complicated (least predictable), and four ++++ is the most complicated (most predictable). Zero corresponds to total unpredictability.

implant surgery should be planned for at least 6 months after placement of the stents, because the stress of surgery on the healing but damaged myocardium may compromise it further, resulting in a dysrhythmia during implant surgery. In addition, achieving proper hemostasis during and after dental surgery could be challenging and could result in significant loss of blood volume or the development of a hematoma, which may compromise the viability of the surgical area.

4. **Severe renal disorder.** Severe renal disorder is probably the most important single contraindication to any form of implant or bone graft surgery. It has a number of possible causes; the most common are hypertensive vascular disease, diabetic nephropathy, polycystic kidney disease, glomerulonephritis, recurrent kidney infections (pyelonephritis), malignant or voluminous benign tumors, and complications arising from kidney stones. Most recently in Europe and other industrialized countries, the reappearance of tuberculosis of the kidneys has further expanded the list of potential complications. In all events, damage to the kidneys may cause bone destruction through reduced gastrointestinal (GI) absorption of calcium and excessive urinary calcium loss as a result of decreased kidney production of the active metabolite of vitamin D. In patients with renal insufficiency, retention of phosphate further triggers excessive production of parathormone (PTH), which aggravates bone demineralization. The combination of vitamin D deficiency and excessive production of PTH can rapidly result in metabolic osteopenia. The uremic environment further compromises the body's resistance, resulting in an increased risk of odontogenic infections.

Fig. 3-1 illustrates daily calcium metabolism. The kidneys initially filter about 10 g of calcium a day into the primary urine.

5. **Treatment-resistant diabetes.** Treatment-resistant diabetes is confirmed, severe diabetes that does not respond to treatment. The complications that arise with this disorder are related to the serum hyperosmolarity (e.g., sugar, urea), metabolic disorders (e.g., sodium [Na^+], calcium [Ca^{++}], phosphate [PO_4^-], and magnesium [Mg^{++}]), dehydration, and microdisease or macrodisease. These metabolic and vascular derangements predispose the patient to tissue degeneration, compromised healing, and a higher risk of infection.
6. **Generalized osteoporosis.** Generalized osteoporosis is an anatomic and a structural syndrome involving significant loss of bone mass and bone volume, which leads to rarefaction of cancellous bone and thinning of the cortical plates. Bone becomes devoid of osteoid and shows osteoclasia and medullary fibrosis. Consequently, nonintegration of endosseous implants results. A useful screening tool for evaluating the extent of osteoporosis is bone densitometry (dual photon absorptiometry). Bone densitometry studies can identify individuals with osteopenia (modest-risk patients) and those with osteoporosis (high-risk patients). It should be performed regularly on all patients with clinical signs of bone fragility like spontaneous fractures (hip, vertebrae, femur).
7. **Chronic or severe alcoholism.** Chronic or severe alcoholism is a major health disorder that frequently leads to liver disorder, cirrhosis, and medullary aplasia. These in turn give rise to a cascade of possible complications, such as platelet diseases, distress infarction, aneurysm, and the risk of insidious hemorrhage. In patients with severe alcoholism, healing often is retarded, which is aggravated by malnutrition, psychological disorders, inadequate hygiene, and the risk of a major infection.

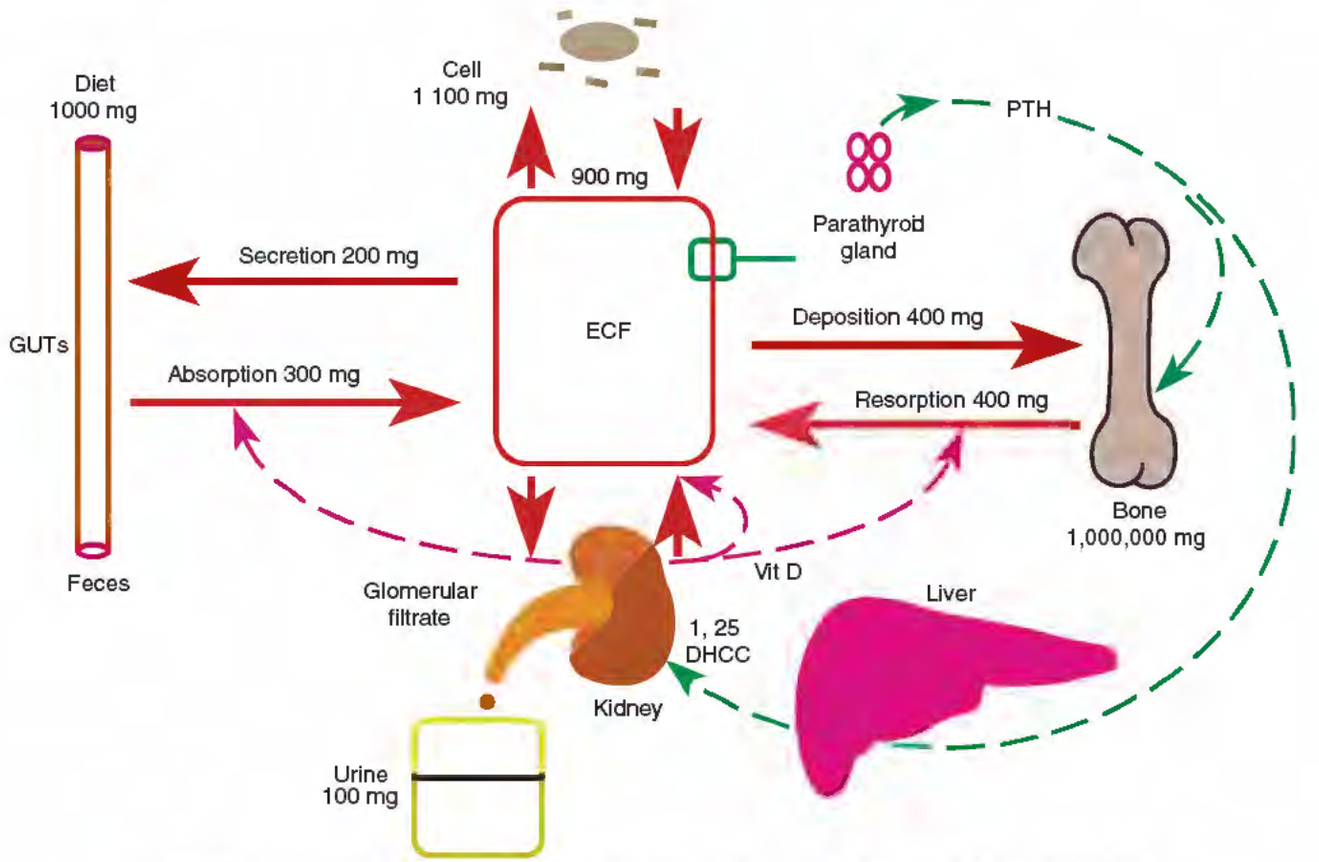


FIGURE 3-1. Complex mechanisms govern the daily calcium metabolism. *ECF,* Extracellular fluid.

For the purposes of implant surgeons, the most common tests for hepatic disorders measure the following:

- *γ-Glutamyl-transpeptidase (γ-GT):* (Normal: <25 mU/mL). Elevated values may be seen in alcoholic cirrhosis (to 50 mU/mL), hepatitis (to 100 mU/mL), jaundice (to 200 to 300 mU/mL), and pancreatic cancer (to 1000 mU/mL).
- *Serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT):* (Normal: SGOT, 5 to 35 IU; SGPT, 5 to 25 IU). SGOT and SGPT are elevated in hepatic cytolysis, infectious and toxic hepatitis, and prolonged salicylic treatment. With myocardial infarction, SGOT alone is elevated.
- *Bilirubin:* (Normal: Total <10 IU). Bilirubin is elevated in cases of hemolysis, cholestasis, and jaundice.
- *Alkaline phosphatases:* (Normal [pH of 9.2]: 13 to 39 IU, or 0.22 to 0.65 mmol/sec/L). The alkaline phosphatases are elevated with hyperparathyroidism, Paget's disease, hepatic disorders, and bone metastases.
- *Prothrombin time (international normalized ratio) (PT/INR):* (Normal: 11.5-13.5 seconds). The prothrombin time (PT) is a coagulation indicator (it also is reported as the international normalized ratio [INR]) . Vitamin K participates in coagulation with factors II, V, VII, IX, and X. The PT measures the activity of factor VII, the factor with the shortest serum half-life, and reflects the overall integrity of the coagulation cascade. This provides an accurate indication of the synthetic function of the liver.
- *Albumin:* (Normal: 3.5 to 5 mg/dL). A low serum albumin indicates compromised synthetic function of the liver and magnetron.

8. **Treatment-resistant osteomalacia.** Rickets resulting from vitamin D deficiency is a rare disease in the industrialized countries and is seldom seen in adults. In more than 95% of cases, this mineralization deficit (hypophosphocalcific bone with osteoidosis), which leads to demineralized osteopathy (soft bone), responds favorably to vitamin D therapy coupled with calcium supplementation. However, if the treatment fails, osteomalacia may lead to nonintegration of an implant and a higher risk of infection.
9. **Current radiotherapy.** Radiotherapy results in a number of insults to the body, primarily disruption of defense mechanisms, compromise of the endosseous vascular system, and inhibition of osteoinduction. The periosteum is the principal "organ" in which physiologic activities are almost completely disrupted. Depending on the proximity to the irradiated zone, this may lead to soft and hard tissue necrosis, risk of a major infection, and disruption of osteoconduction.
10. **Severe hormone deficiency.** Patients with a severe hormone deficiency have more than two different families of hormone disorders. The endocrine systems most affected that may be screened are the thyroid and parathyroid, pancreas, gonads, and adrenal and pituitary systems.
11. **Drug addiction.** Most drug addicts suffer from loss of a sense of priorities, low resistance to disease, predisposition to infection, malnutrition, psychological disorders, lack of hygiene, and difficulty with follow-up.
12. **Heavy smoking habits.** Heavy smoking (more than 10 cigarettes a day) was added to the list of absolute contraindications in 1996 because of the occurrence of a number of long-term implant complications in heavy smokers who had no other systemic disorders. In addition to poor healing in the early stage, problems arose as a result of relatively accelerated bone loss (possibly because of altered vascularity) and inflammatory diseases related to poor oral hygiene.
13. **Pregnancy.** Most medications used before, during, and after surgery are listed as category D for pregnant women: *There is positive evidence of possible fetal risk, but the benefits from use in pregnant women outweigh the risk.* According to current obstetric practice, no good reason can be advanced for performing implant or any elective surgery on pregnant patients.

Relative Contraindications

Systemic relative contraindications are related directly to the nature and severity of the systemic disorders and whether they can be corrected satisfactorily before surgery. The search for these contraindications requires meticulous screening of the patient's medical records.

Patient selection with regard to relative contraindications is much more subtle, and among all the criteria, the dental practitioner's judgment remains the critical factor. If the practitioner is not medically oriented, the patient may need to be referred to a specialist. If a disorder has been adequately corrected, the dental practitioner can carry out the treatment plan; otherwise, treatment should be postponed until optimal conditions prevail. Table 3-2 presents the possible effects of relative contraindications on the success of implant and bone graft surgery.

The following list presents common systemic relative contraindications to implant and preprosthetic procedures.

1. *Acquired immunodeficiency syndrome (AIDS) and other seropositive diseases.* A patient who is seropositive (i.e., tests positive for the human immunodeficiency virus [HIV]) may be considered normal, because the current statistical life expectancy after primary infection is 15 to 20 years. In a patient confirmed to have AIDS, the indications for an implant procedure are evaluated according to the classification system established by the federal Centers for Disease Control and Prevention. The stage of disease development and the patient's life expectancy and wishes are important considerations. Careful assessment for possible systemic complications from the disease may contraindicate any form of surgery or may dictate a pragmatic treatment plan with more realistic objectives based on function, comfort, and relief.
2. *Prolonged use of corticosteroids.* Prolonged use of corticosteroids often is associated with retarded healing, disorders of calcium and phosphate metabolism (osteopenia and osteoporosis), and medullary aplasia. A number of authors also have reported bone fragility, adrenal deficiency, metabolic disorders (including disorders of blood glucose metabolism), and fluid retention. Prolonged corticosteroid use also may inhibit bone formation. Therefore, it is important that the dental practitioner determine the reason for corticosteroid treatment and evaluate the patient's response to it. If corticosteroids are used exclusively for their antiinflammatory properties, resolution of this contraindication may be as simple as changing the medication to one of the many newer nonsteroidal antiinflammatory drugs.
3. *Calcium and phosphate metabolism disorders.* An imbalanced diet (e.g., excessive protein, inadequate calcium and/or vitamin D intake) may lead to such disorders. Also, minor hormone deficiencies (especially during menopause) in conjunction with systemic disorders and an unhealthy lifestyle may bring about a calcium and phosphate imbalance. A typical example is a patient with a disorder of the GI tract, such as inflammatory bowel disease or chronic diarrhea, which may be corrected or contained by carefully planned, long-term treatment. If such problems cannot

Table 3-2 Systemic Relative Contraindications to Implant Surgery and Their Impact on Predictability

Health Condition	Risks for Patient's General Health	Long-Term Implant Predictability in Absence of Proper Diagnosis or Treatment	Patient's Possible Response to Medical Treatment Before Implant Surgery	Long-Term Implant Predictability After Proper Diagnosis and Treatment
1. Acquired immunodeficiency syndrome (AIDS) (1) and other seropositive diseases (2)	(1) ++++ (2) ++	0 ++	++ ++	0 +++
2. Prolonged use of corticosteroids	+++	++	++	+++
3. Phosphate and calcium metabolism disorders	+++	+	++	+++
4. Hematopoietic disorder	+++	++	++	++++
5. Buccopharyngeal tumors	+++	0	++	+++
6. Current chemotherapy	+++	0	++	+++
7. Mild renal disorder	+	0	++	+++
8. Hepatopancreatic disorder	+++	0	++	+++
9. Multiple endocrine disorder	+++	0	++	+++
10. Psychological disorder or psychosis	+	+	++?	+++
11. Unhealthy lifestyle	++	+	+++	+++
12. Smoking habits	++	+	++?	+++
13. Lack of understanding and motivation	0	+	++	++
14. Unrealistic treatment plan	0	?	?	++
15. Osteoporosis and bisphosphonates	+++	+	++	+++

The number of + relates to the degree of gravity of the complications associated with implant and graft surgery. One + is the least complicated (least predictable), and four ++++ is the most complicated (most predictable). Zero corresponds to total unpredictability.

be managed effectively, daily calcium and phosphorus absorption may be disrupted completely, leading to metabolic bone disease and poor quality of mineralized bone.

4. *Hematopoietic disorder.* The possible complications from hematopoietic disorders in the short and medium terms are not as dramatic as those encountered in other forms of frank bone pathology and osteoporosis. However, satisfactory functioning of the hematopoietic system is an essential factor for long-term success of implant and reconstructive surgery. If a bone marrow disorder is suspected, the maturation cycle of the megakaryocytes (the precursors of platelets) must be explored. It also is important to screen the transformation of the premonocyte lineage to macrophages, osteoclasts, and circulating monocytes. The same attention must be paid to the lymphocyte cycle.
5. *Buccopharyngeal tumors.* Buccopharyngeal tumors must be analyzed with regard to their malignancy or nonmalignancy, their proximity to the proposed implant site, and the current oncologic treatment. If radiotherapy has been done very close to the planned surgical site, the contraindication becomes absolute. However, routine rejection grafts or implants should be discouraged after resective surgery. If no reason exists to suspect short- or medium-term metastases or extension of the tumor, and the patient otherwise has a satisfactory systemic screening result, the individual patient may be offered improved oral health rather than being required to endure an indefinite waiting period to exclude possible recurrence of a tumor.
6. *Current chemotherapy.* Few studies in the implantology and bone grafting fields have focused on the role of anticancer drugs in patient screening. Implant and bone graft surgeons frequently have followed a restrictive general guideline, with some ambiguity. In fact, many of the drugs used in contemporary anticancer regimens have a very limited or unknown direct destructive role with regard to implantology. For instance, methotrexate, a common chemotherapeutic agent, is used extensively (in smaller dosage) in contemporary rheumatology. However, when used in massive doses in oncology, it may cause severe thrombopenia and may disturb the osteogenic cycle. The chemotherapy contraindication essentially is related to the damage done to the vital organs, which may also be involved in calcium metabolism. Furthermore, when chemotherapy is administered for bone metastases, patient screening should take into account the extensiveness of the metastasis rather than the drugs used to contain it. An additional factor the dental practitioner should evaluate before performing implant surgery is the patient's degree of tolerance to the administered drugs. In any event, close collaboration between the implant surgeon and the oncologist is mandatory.
   Modern chemotherapy uses a wide range of drugs, which belong to 10 to 12 pharmacologic families. Treatment for each patient may include a complex combination of these drugs. Table 3-3 shows the principal cancer treatments that may present absolute contraindications to an implant procedure during the time they are administered or for up to 6 months thereafter. Table 3-2 also shows a proportionately limited number of drugs that are incompatible with the simultaneous insertion of implant devices. The interpolating agents on the whole, seem to be devoid of adverse effects on implantology. The interferons and interleukins prescribed in advanced stages of pathology, however, are particularly contraindicated.
7. *Mild renal disorder.* Mild renal disorders are common and frequently are revealed by an initial blood test after the first physical examination. However, such disorders may be predictors of the onset of major renal disorders or other systemic conditions, which then become absolute contraindications to implant and preprosthetic surgery. The wise course, therefore, is to investigate all renal problems and determine whether they are no more than mild disorders that respond to treatment and do not compromise calcium metabolism.
8. *Hepatopancreatic disorder.* Gallstones and infectious and viral hepatitis (except the severe hepatitis B, C, and E family) are among the liver disorders that have very little negative effect on the long-term success of implant surgery. Nevertheless, further hepatic tests, after a thorough physical examination, may reveal the onset of more serious liver or pancreatic conditions that would be detrimental to the outcome of implant treatment.
9. *Multiple endocrine disorder.* Multiple endocrine disorder is a complex syndrome. It can involve metabolic loss of calcium, secondary osteoporosis induced by hyperadrenocorticism, glucocorticosteroid disorders (Cushing's syndrome, Addison's disease),

Table 3-3 Effects of Chemotherapeutic Drugs on Critical Metabolic Functions

Type of Anticancer Drug or Agent	Drug Family	Commercial Brand	Principal Complications, Disorders, or Affected Organs
1. Antimetabolic	Antifolic	Methotrexate	Thrombopenia, osteogenesis
2. Alkylating	Nitrogen-mustards (III)	Ifosfamide	Blood, bone (osteogenesis)
	Nitrogen-urea (IV)	Streptozocin	Renal, hepatic, blood
	Mitomycin	Ametycin	Renal, hepatic, blood
3. Spindle poisons	Vinca alkaloids (III)	Vincristine	Renal, hepatic, blood
4. Interpolating	N/A	N/A	N/A
5. Splitting	Bleomycin	Bleomycin	Pulmonary fibrosis
6. Cytolytic	Plicamycin	Mithramycin	Renal, hepatic, blood (Ca)++
	Progestates	Medroxyprogesterone	Renal, hepatic
		Ethynodiol	Breast, uterine malignancies
7. Steroids		Norethisterone	
	Estrogens	DES	
		Fosfestrol	
8. Interferons (Int-Fs)	Int-F alfa-2a	Intron-A	Dehydration, thyroid, parathyroid
	Int-F alfa-2b	Roferon-A	
9. Interleukin-2	Aldesleukin-2	Proleukin	Toxic to cardiac, nephrologic, hepatic, and myelotic systems

mineralocorticosteroid syndrome (Conn's syndrome), and hyperandrogenism, any of which may lead to implant failure.

An arbitrary but practical method of screening for a suspected hormone deficiency may be preoperative evaluation of the hormones involved in bone remodeling. These hormones can be classified into two categories based on their dependence on calcium homeostasis (Ca-H): Ca-H dependent and non-Ca-H dependent.

The *Ca-H-dependent hormones* essentially are PTH, which is a stimulator of bone resorption (SBR); vitamin D (1-25-dihydroxycholecalciferol), which is an SBR; and calcitonin, which is an inhibitor of bone resorption (IBR).

PTH is a polypeptide hormone secreted by the parathyroid glands. It has four principal functions that are of interest to the implant and bone graft surgeon:

- It is hypercalcemic (or, less accurately, osteoporotic), because it removes calcium ions from bone and transfers them to the circulating blood.
- It increases urinary elimination of phosphates by reducing their tubular reabsorption.
- It helps maintain an optimal calcemia by intervening in tubular reabsorption of calcium in the kidneys.
- It plays an important role in intestinal absorption of calcium, working synergistically with vitamin D.

Vitamin D_3 (1-25-dihydroxycholecalciferol) is a hormone intimately linked to PTH activity. Its principal functions include active absorption of calcium in the proximal intestine and, in vitro, increasing the number and the activity of osteoclasts and the production of collagen, (gamma-carboxyglutamate) GLA bone proteins, and alkaline phosphatases.

Calcitonin is a 32–amino acid peptide synthesized by the C cells of the thyroid. Its principal functions are related to inhibition of bone resorption (i.e., it is antiosteoclastic and hypocalcemic).

The *non-Ca-H–dependent hormones* are the thyroid hormones (SBR), estrogens (IBR and SBR), glucagon (IBR), insulin (a stimulator of bone formation [SBF]), growth hormones (SBF), and corticosteroids (inhibitors of bone formation [IBF]).

The thyroid hormones are:

- Thyroglobulin (iodoprotein)
  - >Iodothyronines
  - >Iodotyrosines
- Triiodothyronine (T_3): (Normal: 70 to 190 ng/dL)
- Thyroxine, or tetraiodothyronine (T_4): (Normal: 4 to 12 μg/dL)
- Thyroid-stimulating hormone (TSH; adenohypophysis hormone): (Normal: 0.5 to 3.5 μU/mL)

Of the thyroid function tests, TSH probably is the most sensitive for indicating even early thyroid disease. Table 3-4 shows the two possible origins of thyroid disorders and the standard treatment regimens before implant surgery.

10. *Psychological disorder or psychosis.* This contraindication is one of the most difficult to evaluate. It depends essentially on the severity of the disorder and the patient's response to psychotherapeutic medication. A number of the psychoactive drugs severely alter the oral environment and cause dryness of the mouth, mucosal irritation, or polyaphthosis, all of which can damage peri-implant tissues. These conditions should be analyzed in collaboration with the treating psychiatrist, with consideration given to the patient's priorities, function, comfort, and esthetics. The patient should be made aware of the decisions involved. Implant surgery should not be performed in psychotic patients who are not under strict surveillance and receiving therapy.
11. *Unhealthy lifestyle.* Poor nutrition, chronic dieting, lack of exercise, inadequate hygiene, and excessive use of drugs, alcohol, and tobacco contribute to an unhealthy lifestyle. Common problems in modern society include irregular eating habits, menus that lack variety, excess consumption of fast foods (imbalanced diet), and not allowing enough time to eat each meal. Chronic or "yo-yo" dieting, especially in women and patients with anorexia or bulimia, may cause serious health and bone disorders. These contraindications can be aggravated by a lack of regular physical exercise. If the patient is amenable to correcting these habits, implant or preprosthetic surgery is a viable form of therapy; otherwise, a markedly unhealthy lifestyle becomes an absolute contraindication.

Table 3-4 Thyroid Pathology and Therapeutic Drugs

Thyroid Hormones/Drugs	Disorder	Antithyroid Drugs
Inferior Origin (Lower) Thyroid Gland Disorder		
Liothyronine (T_3)		T_3: Propylthiouracil Benzylthiouracil (Basdene)
L-thyroxine (T_4)	Hyperthyroidism	T_4: Carbimazole, imidazole
L-thyroxin Levothyrox	Hypothyroidism	(Neo-Mercazole)
Superior Origin (Upper) Adenohypophysis Disorder		
TSH: Thyroid extracts		

T_3, Triiodothyronine; *T_4*, thyroxine; *TSH*, thyroid-stimulating hormone.

12. *Smoking habits.* Tobacco use is one of the most stringent limitations, because it damages the angiogenic mechanisms for forming and maintaining bone and peri-implant and periodontal soft tissues. Depending on how many cigarettes the patient smokes daily and the individual's awareness of the dangers of smoking and willingness to reduce drastically or completely stop the practice, this particular contraindication may be reconsidered. If not, smoking remains an absolute contraindication to the long-term success of implant systems.
13. *Lack of understanding and motivation.* Patients who do not have a clear understanding of implant techniques despite repeated explanations or who remain entirely passive and lack any form of motivation may be patients in whom extensive implant treatment should not be performed. On the other hand, if such patients respond well to attempts at motivation, come to understand the proposed treatment and the need to work closely with the implantologist, and recognize the importance of regular follow-up sessions, they may become satisfactory candidates for implant surgery. Attempting to treat an ignorant, unmotivated patient spells disaster for all concerned.
14. *Unrealistic treatment plan.* The contraindication of an unrealistic treatment plan can be resolved if an in-depth analysis both from the clinical and economic standpoints is performed. This analysis should determine whether a gross disproportion exists between the proposed treatment plan and the patient's chief complaint, cultural predisposition, lifestyle, social environment, and finances. The patient's physical and psychological status must be assessed realistically with regard to the proposed treatment.
15. *Osteoporosis and bisphosphonate use.* Bisphosphonates are a class of agents with a well-established efficacy in the treatment and prevention of the skeletal complications associated with osteoporosis and malignant bone metastases. Nevertheless, bisphosphonate-related osteonecrosis of the jaw (BRONJ) is a significant complication in a subset of patients taking these drugs. Based on a growing number of case reports and institutional reviews, bisphosphonate therapy may cause bone to become exposed and necrotic. Currently, this phenomenon is isolated to the jaw. There are now reports of abnormal long bone fractures secondary to bisphosphonate-related osteonecrosis, including rare mid-femur fractures.

Bisphosphonate-Related Osteonecrosis of the Jaw

BRONJ usually manifests after simple dentoalveolar surgery. The pathogenesis of this complication appears to be related to profound inhibition of osteoclast function and bone remodeling. The use of bisphosphonates has increased dramatically over the past few years as new indications for their use have arisen.

Bisphosphonate therapy has had a significant impact in the palliation of cancer morbidity. Clinical trials have solidly established its role in reducing osteoclast-mediated lysis of bone in disease secondary to multiple myeloma, breast cancer, and other solid tumors. Thus bisphosphonates frequently are administered to patients with osteolytic metastases, especially if the risk of morbidity is significant.

According to clinical practice guidelines established by the American Society of Clinical Oncology (ASCO), bisphosphonates are considered the standard of care for the treatment of (1) moderate to severe hypercalcemia associated with malignancy and (2) metastatic osteolytic lesions associated with breast cancer and multiple myeloma, in conjunction with antineoplastic chemotherapeutic agents.

As potent suppressors of osteoclast activity, bisphosphonates slow the remodeling process and increase bone mineral density, thereby reducing the risk of fracture in women with osteopenia and osteoporosis. All bisphosphonates currently approved for the treatment of osteoporosis have been shown to reduce the risk of osteoporotic fractures significantly. Alendronate (Fosamax, Fosamax Plus D) is taken orally and has been shown to prevent bone loss at the spine and hip in menopausal women and to reduce fractures at these sites by approximately 50%. In a large prospective trial, risedronate (Actonel), which also is taken orally, reduced hip fractures by 30%. Ibandronate (Boniva), which is taken once a month orally or given intravenously (IV) every 3 months for the treatment of postmenopausal osteoporosis, claims to help reverse bone loss in 9 out of 10 women after 1 year. Zoledronate (Reclast, Zometa) are IV medications that are administered once a year.

Because of their proven clinical efficacy, bisphosphonates are considered first-line therapy in the treatment of osteoporosis and are the most widely prescribed antiresorptive agents. Several new drugs in this class soon will become available. However, in response to the growing number of case reports and institutional reviews revealing jaw necrosis, the U.S. Food and Drug Administration (FDA) in 2005 issued a broad drug class warning of this complication for bisphosphonates administered intravenously.

The exact mechanism of bisphosphonate-induced osteonecrosis has not yet been determined, but several hypotheses have been proposed. In most cases, the pathogenesis of this process is consistent with a defect in physiologic remodeling or wound healing in the jawbone. The profound inhibition of osteoclast function also can result in inhibition of normal bone turnover, to the extent that local microdamage from normal mechanical loading or injury (e.g., tooth extraction) cannot be repaired. Because only a minority of bisphosphonate users develop bone necrosis, individual genetic variations in drug metabolism or skeletal homeostasis may dictate a patient's susceptibility or resistance to the development of BRONJ.

The apparent selective involvement of the maxilla and mandible may be related to the unique environment of the oral cavity. Typically, in the presence of normal oral microflora, an open bony wound (e.g., an extraction socket) heals quickly and without complication. However, if the healing potential of the mandible or maxilla is compromised, either by tumoricidal doses of radiation or some other agent or pathologic process, minor injury or disease in these sites increases the risk of osteonecrosis and secondary osteomyelitis. Also, bisphosphonates are deposited preferentially in bones with a high turnover rate; because the maxilla and mandible are sites of significant bone remodeling, the bisphosphonate level in the jaw may be selectively elevated. Interestingly, to date this complication has not been reported in bones outside the craniofacial skeleton.

Risk Factors and Incidence

Several retrospective clinical studies have identified potential risk factors associated with the development of BRONJ. These risk factors include a history of dentoalveolar trauma, the duration of bisphosphonate exposure, and the type of bisphosphonate administered. In most cases of BRONJ thus far, recent dentoalveolar trauma was the most prevalent and consistent risk factor. Patients with a history of inflammatory dental disease, such as periodontal and dental abscesses, have a sevenfold greater risk of developing BRONJ. This underscores the importance of maintaining good oral health and avoiding extractions in these patients.

The longer the treatment with bisphosphonates, the greater the risk of developing necrosis. In addition, the more potent IV bisphosphonates (e.g., pamidronate and especially zolendronate)

appear to be significantly more problematic than the oral bisphosphonates. Initially, BRONJ was seen only with the IV forms of the drug; however, osteonecrosis has been reported in patients taking the less potent oral forms. The incidence of BRONJ for IV bisphosphonates has been variably reported as 2% to 12%, depending largely on the duration of therapy. The incidence is less well defined for the oral bisphosphonates but generally is believed to be about 0.7 per 100,000 patient-years.

These findings may have significant implications as the number of patients taking oral bisphosphonates increases. Although the condition is found in both men and women, the literature reports more cases of BRONJ in women than in men, which likely reflects the large number of cases reported in patients with breast cancer. Because postmenopausal osteoporosis is an indication for bisphosphonate therapy, a large percentage of women may be put at risk for developing BRONJ. Patients who were treated for osteoporosis with oral bisphosphonates and who developed BRONJ typically were exposed to the drug for a longer period (longer than 3 years), were older (older than age 65), or were undergoing concomitant long-term steroid therapy.

Clinical Presentation and Staging

The American Association of Oral and Maxillofacial Surgeons (AAOMS) has established a working definition of BRONJ that is fairly concise and specific. Three requirements must be met:

1. The patient must have a history of current or previous treatment with a bisphosphonate.
2. Exposed, necrotic bone must have been present in the maxillofacial region for longer than 8 weeks.
3. The patient must have no history of radiation therapy to the jaws.

The patient history and the clinical examination are the most sensitive diagnostic tools for this condition. Osteonecrosis lesions most often are symptomatic when surrounding tissues become inflamed or when clinical evidence indicates exposed bone. Signs and symptoms that may occur before the development of clinically detectable osteonecrosis include pain, tooth mobility, mucosal swelling, erythema, and ulceration. These symptoms may occur spontaneously, but they more commonly manifest at the site of previous dentoalveolar surgery. Most cases of osteonecrosis occur in regions of previous dental surgery (i.e., extraction sites); however, exposed bone also has been reported in patients with no history of trauma and in edentulous regions of the jaw. Radiographic changes typically are not evident until significant bone involvement or demineralization has occurred. Consequently, panoramic and periapical radiographs may not reveal significant changes in the early stages of osteonecrosis. With extensive bone involvement, regions of mottled bone or sequestrum similar to that seen in diffuse osteomyelitis have been noted.

A clinical staging system has been developed to categorize patients with BRONJ more accurately, to direct the use of appropriate treatment guidelines, and to collect data to assess the prognosis in patients treated with either IV or oral bisphosphonates. In stage 1 disease, exposed bone is present but the patient is asymptomatic. No significant adjacent or regional soft tissue inflammatory swelling or infection is apparent. In stage 2 disease, exposed bone is associated with infection, as evidenced by pain and adjacent or regional soft tissue inflammatory swelling or purulent exudate. Stage 3 disease is marked by exposed bone, pain, infection, and one or more of the following: pathologic fracture, extraoral fistula, or radiographic evidence of osteolysis extending to the inferior border.

Patients considered at risk for BRONJ are those who have no evidence of exposed or necrotic bone but who have been treated with IV or oral bisphosphonates. The potency of the bisphosphonate, the duration of treatment, and whether the patient has had dental surgery appear to be the main determinants for assessing risk. These patients do not need interventional therapy, but they must be informed about the potential risks of bisphosphonate use. If the patient is to undergo any dentoalveolar or alveolar surgery, the individual's treating physician should be consulted, and suspension of the bisphosphonate 3 months before the surgery should be considered.

Prevention and Management

It is important that patients and implantologists realize that a cure may not be a realistic expectation. The goal of treatment for patients at risk of developing BRONJ and those with active disease is to preserve the quality of life by controlling pain, managing infection, and preventing the development of new areas of necrosis. This must be balanced with oncologic management in a patient with osteolytic metastases.

The main emphasis at this time is to minimize the risk of BRONJ developing. A small percentage of patients taking bisphosphonates develop osteonecrosis of the jaws spontaneously; however, most experience this complication after simple dentoalveolar surgery (i.e., extraction, dental implant placement, or apical surgery). Therefore, prevention strategies that optimize dental health have been the main directive in managing patients who plan to take or are taking bisphosphonates. For patients about to start bisphosphonate therapy, the degree of risk likely depends on the type of bisphosphonate and how long the patient takes it. Management strategies similar to protocols for preventing osteoradionecrosis should be implemented for patients about to start IV bisphosphonate therapy for cancer metastasis. Specifically, teeth that cannot be restored and those with a poor prognosis should be extracted before therapy is started.

For patients with established BRONJ, treatment basically is directed by the symptoms. Because patients with stage 1 disease are asymptomatic, they require no intervention other than periodic oral rinses and close clinical follow-up. Patients with symptomatic disease (stages 2 and 3) require antibiotic therapy or surgical debridement, or both. All patients with established BRONJ likely are at high risk of developing BRONJ at any future sites of dentoalveolar surgery and therefore should be informed about the benefits of prophylactic dental care and should avoid dentoalveolar surgery.

Regardless of the clinical scenario or disease stage, dental prophylaxis, caries control, and restorative dentistry should be continued indefinitely for all patients taking bisphosphonates. Although patients do not appear to need to initiate prophylactic dental treatment before starting oral bisphosphonate therapy for osteoporosis, the prudent course is to encourage these patients to maintain an optimal level of dental health, because they are likely to be taking the bisphosphonate for a prolonged period.

Osteonecrosis of the jaws is a new and emerging complication of bisphosphonate therapy that is associated with significant morbidity and often requires symptomatic management for palliation in certain patients. Despite the strong clinical correlation between jaw necrosis and bisphosphonate therapy, a definitive causal relationship has yet to be established. Retrospective studies have established an association, but prospective clinical trials and basic scientific research are needed to elucidate the pathogenesis of this process and to define more accurately the clinical and perhaps genetic risk factors. The efficacy of bisphosphonates in treating and preventing the significant skeletal complications associated with osteoporosis and bone metastases has had a major positive effect on patients'

quality of life. A more complete understanding of BRONJ will allow implantologists to predict who will benefit most from bisphosphonate therapy and to judge more accurately the individual patient's risk, prognosis, appropriate treatment, and outcome.

INDICATIONS AND CONTRAINDICATIONS FOR TREATMENT

Thorough evaluation of an implant patient by the dental practitioner can minimize complications and the possibility of implant failure. It is important to determine whether the patient can successfully undergo implant procedures, or whether existing medical or psychological conditions contraindicate treatment. The guidelines already introduced in this chapter offer an excellent overview. Specifically, the patient's health history is the most important step in the evaluation (see Appendix A). This allows assessment of the patient's existing systemic conditions. Any positive responses should be followed with specific questions to elicit details of the past medical history.

The patient's vital signs should be taken as part of the routine screening process. These establish a baseline for each candidate. The pulse, blood pressure, respiration, and temperature should be recorded. Any significant variations from normal should be verified and resolved.

Along with the health history and vital signs, proper medical consultations, routine chemistries, blood counts, and urinalysis should be done before surgery. Tables of normal values can be found in Appendix B. Any discrepancies should be noted, and proper referrals should be made for evaluation and treatment. In-office tests to determine the patient's hematocrit, serum glucose level, and clotting and bleeding times provide valuable information.

Hematocrit

A fingertip on the patient's nondominant hand is prepared. The skin is pierced with a disposable stylet, and the first drop of blood is wiped away. The fingertip then is squeezed to produce a fresh drop of blood, and the open end of a capillary tube is laid alongside the drop. The blood is drawn into the tube by capillary attraction. When the tube is about 60% to 70% full, it is removed. The fingertip is cleansed with an alcohol wipe, and a dry sponge is used for tamponade. Both ends of the tube are plugged with clay, and the tube is placed in a slot in the microhematocrit centrifuge (a second, empty tube is placed across from it for balance). The centrifuge is closed, and the tubes are rotated for 3 minutes. This spins the cells to the bottom of the tube, and the percentage of serum to cells can be determined by inserting the tube into a reader.

Serum Glucose Level

To establish a reasonably accurate serum glucose level, the practitioner first should read the instructions on the label of the bottle of reagent strips. The practitioner then obtains another drop of blood from the finger stick used for the hematocrit and covers the chemically treated end of a reagent strip with the blood. After 60 seconds, the treated end of the strip is washed under cool running water for 60 seconds.

The color of the treated end of the strip is compared with a chart of standards printed on the bottle label. When recording these values, the practitioner should make sure to note whether (and if so, when) the patient had eaten, when insulin or any other hypoglycemic medication had been taken, and whether these are part of a regular regimen. This history plays an important role in the assessment of glucose levels. (Urine test strips can determine the acetone level, but no serum test strips do this).

Clotting Time

A clotting time test can be easily performed and requires only simple supplies (i.e., a finger-stick stylet and a 10-cm-long, fine glass capillary tube).

After fingertip sterilization, the skin is pierced and a glass tube is laid down with an open end obliquely against the bleeding site (Fig. 3-2). Capillary attraction draws the blood into the tube. At 30-second intervals, a small length of tube is broken off and laid aside. This process continues until the blood strings out in a fibrinous thread. At that point, the practitioner counts the glass segments and divides by 2; the result is the clotting time in minutes. A normal clotting time is 4 to 6 minutes (Fig. 3-3).

Bleeding Time

The bleeding time test is performed simultaneously with the clotting time test and requires a clean piece of white filter paper. The same fingertip puncture as for the clotting test is used for this

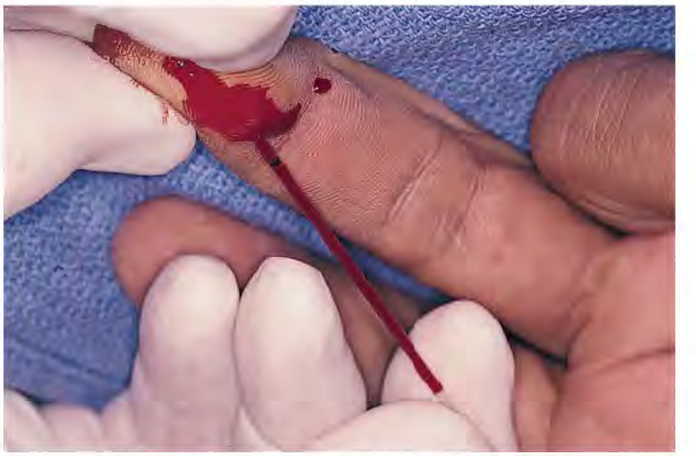


FIGURE 3-2. A glass tube, when placed obliquely against the blood drop from a finger stick, fills by capillary attraction.

FIGURE 3-3. Calculation of clotting time. Every 30 seconds, a segment of the capillary tube is broken until the blood threads out as a result of fibrin *(arrow)*. The glass segments are counted, and that number is divided by 2 to obtain the clotting time (in minutes).

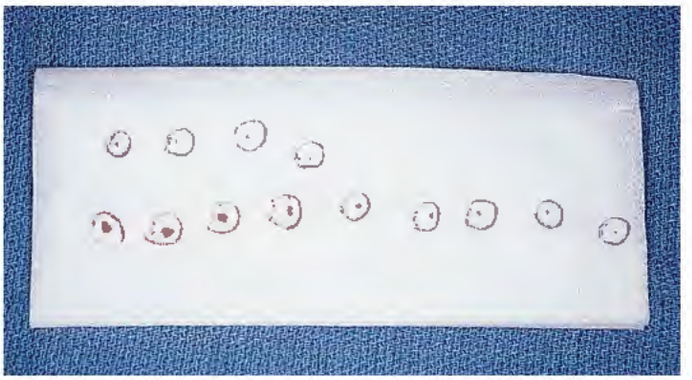


FIGURE 3-4. Calculation of the bleeding time. The same finger stick is used as for the clotting time. The bleeding spot is touched to a clean piece of blotting paper until no blood stain appears. The marks are counted, and that number is divided by 2 to obtain the bleeding time (in minutes).

simple evaluation. After each capillary tube segment is broken off (at 30-second intervals) during the clotting test, the untreated fingertip (i.e., no gauze, no pressure, no alcohol) is touched to the filter paper. When the blood transfer marks stop, the red dots are counted and divided by 2; the result is the bleeding time in minutes. A normal bleeding time is 5 to 8 minutes (Fig. 3-4).

Prothrombin Time/International Normalized Ratio

More than 7 million people worldwide take oral anticoagulants (e.g., warfarin, Coumadin) to help reduce the likelihood that harmful blood clots will form. In-office, handheld machines (e.g., the INRatio monitor) measure the PT and INR and provide those values in just 1 minute. This is the critical test performed to maintain the proper therapeutic range of oral anticoagulation therapy.

ABSOLUTE SYSTEMIC CONTRAINDICATIONS

Some conditions should be considered absolute contraindications to implant treatment. These include:

- Uncontrolled diabetes mellitus
- Long-term therapy with immunosuppressant drugs
- Connective tissue diseases (e.g., systemic lupus erythematosus)
- Blood dyscrasias and coagulopathies (e.g., leukemia, hemophilia)
- Regional malignancy (e.g., oral, perioral)
- Metastatic disease
- Previous irradiation of the jaws that might lead to postsurgical osteoradionecrosis
- Alcohol or drug addiction
- Severe psychological disorders

RELATIVE SYSTEMIC CONTRAINDICATIONS

In addition to the absolute contraindications, many relative contraindications to treatment exist. However, if these are managed properly, a patient may undergo implant surgery with a very good chance of success. Consultation with the patient's physician may be required so that the patient's acceptability is clarified and the requisite details of surveillance and support therapy are instituted throughout and after the procedure.

During the patient evaluation for implant surgery, certain symptoms, either subjective or objective, may become apparent. If a symptom is present, a more extensive investigation is warranted. The following box presents many of the common acronyms used to designate medical tests or diagnostic procedures. The practitioner would be well served by becoming familiar with them.

Common Acronyms Used in Medical Tests

ACE	angiotensin-covering enzyme	MCHC	luteinizing hormone
ACTH	adrenocorticotropic hormone	MCV	mean corpuscular hemoglobin concentration
ANA	antinuclear antibody	PCP	mean corpuscular volume
BP	blood pressure	PT	*Pneumocystis carinii* pneumonia
BUN	blood urea nitrogen	PTA	prothrombin time
CPK	creatine phosphokinase	PTC	plasma thromboplastin antecedent
CVA	costovertebral angle	PTH	plasma thromboplastin component
CXR	chest x-ray	PTT	parathormone
ECHO	echocardiogram	RBC	partial thromboplastin time
ECGK+	electrocardiogram	RF	red blood cell
ESR	erythrocyte sedimentation rate	SPEP	rheumatoid factor
FSH	follicle-stimulating hormone	T_3	serum protein electrophoresis
GH	growth hormone	T_4	triiodothyronine
Hgb	hemoglobin	TIBC	thyroxine
LDH	lactic dehydrogenase	TSH	total iron-binding capacity
LDL	low-density lipoprotein	WBC	thyroid-stimulating hormone
LFT	liver function test		white blood cell count
	LH		

Endocrinopathies

At the clinical level, endocrinopathy can result from hormone deficiency, hormone excess, or resistance to hormone action.

Hormone Deficiencies

Hormone deficiency diseases include diabetes mellitus, pituitary and adrenal insufficiency, and hypothyroidism.

Hormone Excess

Hormone excess can have a number of causes, including:

- Overproduction by the endocrine gland that usually makes the hormone (e.g., thyrotoxicosis, acromegaly, Cushing's disease).
- Production of a hormone by tissue (usually malignant) that ordinarily is not an endocrine organ (e.g., production of adrenocorticotropic hormone [ACTH] in oat cell carcinoma).
- Overproduction of a hormone in peripheral tissues caused by circulating prohormone.
- Iatrogenic causes (e.g., overadministration of glucocorticoids).

Hormone Resistance

The universal feature of hormone resistance is a normal or elevated blood level of the hormone even though the patient shows evidence of deficient hormone action. This frequently occurs secondary to hereditary causes (e.g., pseudohypoparathyroidism).

The symptoms that may become apparent during the patient evaluation are presented in the following boxes. Most of the conditions in this chapter do not constitute an absolute contraindication to implant surgery.

Patient Evaluation Factors

Diabetes Mellitus

Clinical Findings	Laboratory Findings/Studies
Type I (Insulin Dependent)	
Polyuria and thirst	Glucosuria
Weakness and fatigue	Ketonuria
Polyphagia and weight loss	High fasting glucose level (>140 mL/dL)
Recurrent blurred vision	High hemoglobin A1c (>6%)
Vulvovaginitis or pruritus	
Peripheral neuropathy	
Nocturnal enuresis	
Type II (Non-Insulin-Dependent [Adult Onset])	
Polyuria	Same as for type I diabetes mellitus
Weakness and fatigue	
Recurrent blurred vision	
Vulvovaginitis	
Peripheral neuropathy	
Often asymptomatic	

Pituitary Insufficiency

Clinical Findings	Laboratory Findings/Studies
Weakness and fatigability	Possible low fasting blood glucose
Lack of resistance to stress, cold, and fasting	Marked insulin sensitivity (as measured by the insulin tolerance test)
Loss of axillary and pubic hair	Mild anemia
Sexual dysfunction	Dilutional hyponatremia
	Decreased growth hormone
	Low T_4 (thyroid hormone)
	Low thyroid-stimulating hormone
	Decreased ACTH
	Low plasma cortisol
	Decreased testosterone
	Decreased estradiol

Acute Adrenal Insufficiency (Waterhouse Friderichsen Syndrome)

Clinical Findings	Laboratory Findings/Studies
Headache	Eosinophilia
Lassitude	Decreased blood glucose and sodium
Nausea and vomiting	Hypercalcemia
Abdominal pain	Decreased blood and urinary cortisol
Diarrhea	Elevated plasma ACTH if primary adrenal disease (>200 pg/mL)
Fever >40.6° C (105° F)	Some systemic infections (e.g., overwhelming meningococcemia) can result in adrenal infarction and adrenal insufficiency
Confusion or coma	
Dehydration	
Hypotension	
Cyanosis, petechiae	
Abnormal skin pigmentation with sparse axillary hair	

Chronic Adrenal Insufficiency (Addison's Disease)

Clinical Findings	Laboratory Findings/Studies
Weakness and fatigability	Moderate neutropenia (5000/mL)
Anorexia	Lymphocytosis
Nausea and vomiting	Eosinophilia
Diarrhea	Hemoconcentration
Nervous and mental irritability	Elevated BUN
Fainting, especially after missing meals	Elevated potassium level (K^+)
Diffuse bronzing of the skin	Decreased fasting blood glucose
Pigmentation of mucous membranes and gingivae	Hypercalcemia
Pigmentation around the lips	Low AM cortisol accompanied by simultaneous increase in ACTH
Vitiligo (7% to 15%)	
Hyperplasia of lymphoid tissue	
Absent or scant axillary and pubic hair	
Absence of sweating	
CVA tenderness	

Hypothyroidism

Clinical Findings	Laboratory Findings/Studies
Weakness and fatigue	T_4 <3.5 mg/dL
Cold intolerance	Free T_4 <0.8 ng/dL
Constipation	Decreased radioiodine uptake
Menorrhagia	Decreased T_3 resin uptake
Hoarseness	TSH increased in first-degree hypothyroidism and decreased in second-degree (pituitary) hypothyroidism
Thin, brittle nails	Anemia (macrocytic)
Dry, cold, yellow, puffy skin	Antithyroid antibodies (increased in Hashimoto's thyroiditis)
Scant eyebrows	
Enlargement of tongue (could lead to malocclusion)	
Bradycardia	
Delayed return of deep tendon reflexes	

Hyperthyroidism (Thyrotoxicosis)

Clinical Findings	Laboratory Findings/Studies
Restlessness, nervousness, easy fatigability	Increased T_4, radioiodine, and T_3 resin uptake
Unexplained weight loss despite increased appetite	Low TSH
Excessive sweating and heat intolerance	
Tremors	
Diarrhea	
Rapid, irregular heartbeat	
Wasting of muscle and bone	
Greatly accelerated alveolar atrophy and eruption of permanent teeth	

Acromegaly (Adult-Onset Hyperpituitarism)

Clinical Findings	Laboratory Findings/Studies
Extreme growth of hands, feet, and jaw	GH increased >7 ng/mL in active phase
Protrusion of mandible	Inorganic phosphate >4.5 mg/dL
Excessive sweating	Gonadotropins normal or low
Enlarged tongue, tipping of teeth to buccal or labial sides	Glucosuria and hyperglycemia
	Insulin resistance
	T_4 normal or low
Temporal headaches	
Photophobia and reduction in vision	

Cushing's Syndrome (Hyperadrenal Cortical Syndrome)

Clinical Findings	Laboratory Findings/ Studies
Moon face	Low glucose tolerance, often with glucosuria
Buffalo hump	Insulin resistance
Obesity with protuberant abdomen and thin extremities	Absence of diurnal variation of cortisol
Osteoporosis	Increased WBCs or low eosinophils
Oligomenorrhea or amenorrhea	Lymphocytes under 20%
Weakness	Increased RBCs
Headache	
Hypertension	
Mild acne	
Hirsutism	
Purple striae	
Bruises easily	

Hypoparathyroidism

Clinical Findings	Laboratory Findings/ Studies
Muscular fatigue and weakness	Hypocalcemia
Numbness and tingling in extremities	Hyperphosphatemia
Hypoplasia of teeth (when condition develops before tooth formation), chronic candidiasis	Decreased PTH

Hyperparathyroidism

Clinical Findings	Laboratory Findings/Studies
Bone pain	Hypercalcemia
Joint stiffness	Hypophosphatemia
Pathologic fractures	Hyperparathormone production
Urinary tract stones	Hypercalciuria
Giant cell tumor or cyst of the jaw	Radiography: General radiolucency of affected bone; oval, lobulated lesions in the jaws ("ground glass" appearance)
Generalized osteoporosis	
Malocclusion	

Granulomatous Diseases

Tuberculosis

Clinical Findings	Laboratory Findings/Studies
Fatigue	*Mycobacterium tuberculosis* in sputum culture
Weight loss	Positive tuberculin skin test
Fever	Classic CXR
Night sweats	
Cough	
Hemoptysis	

Sarcoidosis

Clinical Findings	Laboratory Findings/Studies
Fever	Increased ESR
Malaise	Leukopenia
Dyspnea	Eosinophilia
Skin rash	Elevated ACE
Parotid gland enlargement	Hypercalcemia (10%)
Hepatosplenomegaly	CXR

Cardiovascular Diseases

Atherosclerosis

Clinical Findings	Laboratory Findings/Studies
Intermittent claudication	Angiography
Leg weakness	Elevated cholesterol and LDL
Absence of distal pulses	
Atrophic skin changes	
Dependent rubor	

Arteriosclerosis (Arteriosclerotic Coronary Heart Disease)

Clinical Finding	Laboratory Findings/Studies
Chest pain	ECG

Hypertensive Vascular Disease

Clinical Findings	Laboratory Findings/Studies
Elevated BP (>140/90 mmHg)	Elevated BUN
Headaches	Elevated creatinine
Light-headedness	Proteinuria
Tinnitus	Granular casts in aldosteronism
Palpitations	Low serum K^+
Often asymptomatic presentation	Elevated sodium (Na^+) and bicarbonate (HCO_3)
	ECG: Stain pattern of ST segment
	CXR: Aortic dilation or calcification

Orthostatic Hypotension

Clinical Findings
Syncope
Dizziness
Light-headedness on standing
Increased heart rate
Decline in BP on standing
Disease of the aorta (see also Endocarditis)

Peripheral Vascular Diseases

Temporal Arteritis

Clinical Findings	Laboratory Findings/Studies
Headache	Increased ESR
Often associated with myalgia	
Malaise	
Anorexia	
Weight loss	
Loss of vision	
Scalp tenderness	

Thromboangiitis Obliterans (Buerger's Disease)

Clinical Findings	Laboratory Findings/ Studies
Intense rubor of feet	No pathognomonic diagnostic studies
Superficial migratory thrombophlebitis	
Absent foot pulses	
Decreased ulnar or radial pulse	

Arteriovenous Fistulae

Clinical Findings	Laboratory Findings/Studies
Headaches Hemorrhage Seizures Bruit on auscultation	CT scan, electroencephalogram, arteriography to localize site of lesion

Congestive Heart Failure

Clinical Findings	Laboratory Findings/Studies
Dyspnea Orthopnea Dry, hacking cough Paroxysmal nocturnal dyspnea Chest pain Nocturia Increased heart size Sinus tachycardia Ventricular gallop Rales Distended neck veins Peripheral pitting edema	Diagnostic tests CXR ECG ECHO Radionucleotide angiography "gated blood pool scan" Cardiac catheterization and myocardial biopsy Stress test Systolic versus diastolic dysfunction

Endocarditis/Valvular Disease

Please refer to Appendix M.

Mitral Stenosis

Clinical Findings	Laboratory Findings/Studies
Orthopnea Dyspnea Paroxysmal nocturnal dyspnea Pulmonary edema hemoptysis Middiastolic murmur	ECHO: Thickened valve that opens and closes slowly

Mitral Regurgitation (Insufficiency)

Clinical Findings	Laboratory Findings/ Studies
Pansystolic murmur Orthopnea Exertional dyspnea Paroxysmal nocturnal dyspnea Right-sided heart failure	CXR: Enlarged left atrium ECHO Cardiac catheterization to assess left ventricular function and pulmonary artery pressure

Mitral Valve Prolapse

Clinical Findings	Laboratory Findings/Studies
Mostly asymptomatic presentation Chest pain Fatigue Palpitations Late systolic murmur Midsystolic click	ECHO

Aortic Insufficiency

Clinical Findings	Laboratory Findings/Studies
Soft diastolic murmur Exertional dyspnea Chest pain Heart failure	ECHO: Diastolic flattening of anterior mitral valve leaflet or septum produced by regurgitant jet

Tricuspid Stenosis

Clinical Findings	Laboratory Findings/Studies
Right-sided heart failure Hepatomegaly Ascites Dependent edema Cyanosis Jaundice Diastolic rumble Liver pulsation	ECHO: Demonstrates lesion Right-sided heart catheterization is diagnostic

Tricuspid Insufficiency

Clinical Findings	Laboratory Findings/Studies
Harsh systolic murmur along left sternal border Regurgitant systolic V waves Presence of an inspiratory S_3	ECHO

Hypersensitivity Reactions

Atopic Diseases (Hay Fever, Atopic Dermatitis, Allergic Asthma, Allergic Eczema, Anaphylactic Reaction)

Clinical Findings	Laboratory Findings/Studies
Eczema Itchy rash on face, trunk, extremities History of asthma Atopic, spontaneous allergy	Delayed blanch reaction to methacholine Eosinophilia Positive skin test to multiple antigens, increased IgE binding to *Staphylococcus aureus*

Anaphylaxis

Clinical Findings
Apprehension Paresthesia Generalized urticaria Edema Choking Cyanosis Wheezing Incontinence Shock Fever Dilation of pupils Loss of consciousness Convulsions

Urticaria

Clinical Findings	Laboratory Findings/Studies
Wheals Hives Itching Swelling	Skin testing Eosinophilia

Angioneurotic Edema

Clinical Finding
Edema, commonly of the lips or another part of the face

Drug Hypersensitivity

Clinical Findings	Laboratory Findings/Studies
Rash	Eosinophilia
Fever	Increased ESR
Wheezing	
Cough	
Cyanosis	
Abdominal pain	
Loss of consciousness	
Convulsions	

Dermatomucositides

Pemphigus Vulgaris

Clinical Findings	Laboratory Findings/ Studies
Relapsing crops of bullae	Tzanck's test: Acantholysis on biopsy
Superficial detachment of skin after pressure (Nikolsky's sign)	Anemia
Tender oral lesions	Increased ESR
	Eosinophilia
	Leukocytosis

Bullous Erosive Lichen Planus

Clinical Findings	Laboratory Findings/Studies
Pruritic papules	Histopathology
Koebner's phenomenon	
Erosive papules	
Predilection for flexor surfaces, trunk, and oral cavity	

Metabolic and Other Diseases of Bone (Histiocytosis X [Langerhans' Cell Granulomatosis], Hand-Schüller-Christian Disease [Multifocal Eosinophilic Granuloma])

Clinical Findings	Laboratory Findings/ Studies
Single or multiple areas of "punched out" bone	Anemia
Bone destruction in the skull	Leukopenia
Unilateral or bilateral exophthalmos	Thrombocytopenia
Diabetes insipidus in young adults	Histologic confirmation
Tissue tenderness and swelling	
Facial asymmetry	
Otitis media	
Nodular lesions of the skin	
Sore mouth, gingivitis	
Loose teeth	
Failure to heal after extractions	
Loss of alveolar bone	

Eosinophilic Granuloma

Clinical Findings	Laboratory Findings/Studies
Local pain and swelling (commonly the skull and mandible)	Radiography: Irregular radiolucencies of the jaws and other bones
General malaise and fever	Pancytopenia
	Histologic confirmation

Organomegaly (Letterer-Siwe Disease [Children and Teenagers])

Clinical Findings	Laboratory Findings/ Studies
Skin rash (trunk, scalp, and extremities)	Progressive anemia
Low-grade, spiking fever with malaise and irritability (infants)	Leukopenia
Splenomegaly, hepatomegaly	Thrombocytopenia
Lymphadenopathy	
Oral ulcerative lesions	
Gingival hypertrophy	
Diffuse destruction of bone in jaw	
Premature eruption of teeth ectopically placed	

Paget's Disease (Osteitis Deformans)

Clinical Findings	Laboratory Findings/Studies
Bone pain	Radiography: Initially deossification, followed by osteoblastic phase ("cotton wool" appearance)
Headaches	Elevated serum alkaline phosphatase
Skeletal deformity	Elevated urinary hydroxyproline
Deformities of spine, femur, and tibia	Normal calcium and phosphorus
Progressive enlargement of skull, spacing of teeth	
Pathologic fractures	

Polyostotic Fibrous Dysplasia (Albright's Disease)

Clinical Findings	Laboratory Findings/ Studies
Painless swelling of bone	Normal calcium and phosphorus
Bones lesions and cysts	Elevated alkaline phosphatase and urinary hydroxyproline
Traumatic fractures	Radiography: Rarefaction and expansion of bones (multilocular cystic appearance)
Café-au-lait spots on skin (usually directly over bone lesions)	
Precocious puberty	
Hypogonadism	
Hyperthyroidism	
Enlarged jaw	

Blood Dyscrasias and Hematologic Disorders

Megaloblastic Anemia

Clinical Findings	Laboratory Findings/ Studies
Anorexia	Increased MCV (large red cells)
Fatigue	Megaloblasts
Diarrhea	
Glossitis	
Paresthesias in peripheral nerves	
Diminished vibration and position senses	
Folate and vitamin B_{12} deficiency	

Allergic Purpura (Henoch-Schönlein Disease)

Clinical Findings	Laboratory Findings/Studies
Purpuric rash on extensor surfaces of arms, legs, buttocks	Increased anemia
Colicky abdominal pain	Increased ESR
Polyarthralgia	Increased alpha-globulin and fibrinogen
Polyarthritis	Normal muscle enzyme levels
Hematuria	Osteophyte formation
	Bone cysts
	Increased density of subchondral bone
	Radiography: Narrowing of joint spaces

Hereditary Hemorrhagic Telangiectasia (Osler-Weber-Rendu Syndrome)

Clinical Findings	Laboratory Findings/Studies
Epistaxis	Anemia
Murmur of arteriovenous malformation over lung fields	
Multiple telangiectasia (readily seen on skin and in mouth; may also be internal)	

Idiopathic Thrombocytopenic Purpura

Clinical Findings	Laboratory Findings/Studies
Purpura	Decreased platelet count
Mucosal, gingival, and skin bleeding	Increased normal morphology bleeding time
Epistaxis	Some large platelets
Menorrhagia	Mild anemia
Petechiae	Positive tourniquet (Rumpel-Leede) test*: >3 petechiae

*For the Rumpel-Leede test, a blood pressure cuff is applied to the arm and inflated to a pressure half way between the diastolic and systolic pressures. The cuff is left in place for 1 minute. The examiner then counts the petechiae in a 2.5-cm circle below the inflated cuff.

Secondary to Hypersplenism

Clinical Findings	Laboratory Findings/Studies
Purpura	Decreased platelet count
Enlarged spleen	

Hereditary Coagulation Disorders

Hemophilias (Factor VIII deficiency)

Clinical Findings	Laboratory Findings/Studies
Bleeding into joints, muscles, and gastrointestinal (GI) tract	Anemia
	Normal PT
	Increased PTT
Fever	Low factor VIII
Anemia	Normal factor VIII antigenic activity
Massive gingival hemorrhage	Normal von Willebrand factor
Affects only males	

von Willebrand's Disease (Pseudohemophilia)

Clinical Findings	Laboratory Findings/Studies
Epistaxis	Prolonged bleeding time
Bruises easily	Low factor VIII coagulation activity
Menorrhagia	Defective in vitro platelet aggregation in response to ristocetin
Gingival bleeding	Normal platelet number and morphology
Troublesome bleeding after mild laceration or dental extraction	Low factor VIII antigenic activity
Affects both gender	

Factor Deficiencies

Factor IX: Christmas Factor (PTC Deficiency)

Clinical Finding	Laboratory Findings/Studies
Bleeding	Low factor IX
	Increased PTT

Factor X: Stuart Factor

Clinical Finding	Laboratory Findings/Studies
Bleeding	Abnormal PT and PTT
	Low factor X

Factor XII (PTA Deficiency)

Clinical Finding	Laboratory Findings/Studies
Bleeding	Increased PTT
	Low factor XII

Acquired Coagulation Disorders

Deficiency of the Vitamin K–Dependent Coagulation Factors

Clinical Finding	Laboratory Findings/Studies
Bleeding	Increased PT, corrected by giving vitamin K (Hykinone)
	Normal fibrinogen, prothrombin time, and platelet count

Disseminated Intravascular Coagulopathy (DIC)

Clinical Findings	Laboratory Findings/Studies
Bleeding (especially if from multiple sites; frequently posttraumatic)	Decreased plasma fibrinogen
	Increased fibrin degradation products
Purpura	Increased PT
Ecchymoses	Increased PTT
Digital ischemia and gangrene	Thrombocytopenia
	Decreased antithrombin III
	Decreased hematocrit

Granulocytopenia

Clinical Finding	Laboratory Findings/Studies
Opportunistic infections	Decreased WBCs

Cyclic Neutropenia

Clinical Findings	Laboratory Findings/Studies
Fever	Cyclic fluctuations in WBCs, platelets, RBCs (Have patient keep diary of oral lesions and attempt to match them with laboratory findings.)
Malaise	
Mouth ulcers	
Cervical adenopathy	

Lymphocytopenia

Clinical Finding	Laboratory Findings/Studies
Recurrent viral infections	Decreased lymphocytes

Leukemias

Acute Myeloid Leukemia

Clinical Findings	Laboratory Findings/Studies
High fever	Anemia
Bleeding	Thrombocytopenia
Severe prostration	Neutropenia
Infection	Elevated LDH
Gingival hypertrophy	Hyperuricemia
Bone and joint pain	Hypokalemia
Enlargement of liver, spleen, and lymph nodes	Auer red inclusions

Chronic Myeloid Leukemia

Clinical Findings	Laboratory Findings/Studies
Palpable splenomegaly	Presence of Philadelphia chromosome
Anemia	Normal or elevated platelets
Weight loss	Hypercellular bone marrow with left-shifted myelopoiesis
Night sweats	Decreased leukocyte alkaline phosphatase
Fever	
Severe bleeding	
Infection during blast crisis	

Acute Lymphocytic Leukemia

Clinical Findings	Laboratory Findings/Studies
Fatigue	Pancytopenia
Bleeding	Positive surface markers of primitive lymphoid cells
Infection	Positive terminal deoxynucleotide transferase in 95%, positive rosette formation with sheep erythrocytes
Enlargement of liver, spleen, and lymph nodes	Identification of cell markers by monoclonal antibodies in T-cell leukemias

Chronic Lymphocytic Leukemia

Clinical Findings	Laboratory Findings/Studies
Fatigue	Lymphocytosis
Lymphadenopathy	WBCs >20,000/ul
Enlargement of liver and spleen	Bone marrow infiltration with small lymphocytes
	Hypogammaglobulinemia

Lymphomas

Hodgkin's Disease

Clinical Findings	Laboratory Findings/Studies
Painless, enlarged mass in the neck, axilla, or groin	Increased ESR
Fever	Thrombocytosis
Night sweats	Leukocytosis
Fatigue	Decreased iron and iron-binding capacity
Weight loss	Elevated leukocyte alkaline phosphatase
Generalized pruritus	

Non-Hodgkin's Disease (Lymphosarcoma, Reticular Cell Sarcoma)

Clinical Findings	Laboratory Findings/Studies
Painless adenopathy in lymph nodes or extranodal sites	Peripheral blood usually normal
Night sweats	Bone marrow: Paratrabecular lymphoid aggregates
Weight loss	CXR: Mediastinal mass

Burkitt's Lymphoma

Clinical Findings	Laboratory Findings/Studies
Extralymphatic tumor in bones of jaws, abdominal viscera, ovaries, meninges, and breasts	Presence of Epstein-Barr virus

Plasma Cell Dyscrasia and Multiple Myeloma

Clinical Findings	Laboratory Findings/Studies
Frequent or recurrent infections, especially pneumonias	Increased ESR
Chronic renal dysfunction	Anemia
Painful fractures and bony lesions	Rouleau formation on blood smear
Back pain	Increased uric acid
	Hypercalcemia
	Bence-Jones protein in urine
	Paraprotein on SPEP (monoclonal spike in beta or gamma globulin region)
	Radiography: Lytic lesions or generalized osteoporosis

Collagen (Connective Tissue) Diseases

Rheumatoid Arthritis (Severe)

Clinical Findings	Laboratory Findings/Studies
Fatigue	Rheumatoid factor
Joint stiffness	Increased ESR
Myalgia	Anemia
Symmetric joint swelling (proximal interphalangeal and metacarpophalangeal joints of fingers, as well as wrists, knees, ankles, and toes)	Radiography: Soft tissue swelling, narrowing of joint space, osteoporosis, erosion of peripheral bare space of bone surface not covered by cartilage
Subcutaneous nodules over bony prominences	

Sjögren's Syndrome

Clinical Findings	Laboratory Findings/Studies
Keratoconjunctivitis	Mild anemia
Xerostomia	Hypergammaglobulinemia
Xerophthalmia	Special antibody from salivary duct
Chronic arthritis	Positive RF in 70% of patients
Parotid enlargement	Eosinophilia
Severe dental caries	Leukopenia
Dysphagia	Schirmer's test to measure volume of tears and saliva secreted
Pancreatitis	
Pleuritis	
Vasculitis	

Systemic Lupus Erythematosus

Clinical Findings	Laboratory Findings/Studies
Arthritis	Positive lupus erythematosus cells
Myalgia	ANA positive
Butterfly rash (nose)	Increased ESR
Nephritis	Anemia
Fever	Leukopenia
Weight loss	Thrombocytopenia
Raynaud's phenomenon	Decreased serum complement
Splinter hemorrhage	Mildly abnormal LFTs
Nail fold infarcts	

Scleroderma (Progressive Systemic Sclerosis)

Clinical Findings	Laboratory Findings/Studies
Diffuse skin thickening	Anemia
Subcutaneous edema	Increased ESR
Telangiectasia	ANA positive
Polyarthralgia	RF and lupus erythematosus cells
Raynaud's phenomenon	Anticentromere
Dysphagia	Scleroderma antibody (SCL-70) positive in 35% of patients
Hypomotility of GI tract	
Pigmentation, depigmentation	
Limited oral opening	

Polymyositis

Clinical Findings	Laboratory Findings/Studies
Bilateral proximal muscle weakness	Increased CPK
Papules over knuckles	Electromyography: Polyphasic potentials
Periorbital edema	Fibrillation and high-frequency action potentials
Raynaud's phenomenon	

Dermatomyositis

Clinical Finding	Laboratory Findings/Studies
Polymyositis symptoms (skin rash)	Increased CPK

Vasculitis, Polyarteritis Nodosum

Clinical Findings	Laboratory Findings/Studies
Fever	Leukocytosis
Chills	Anemia
Tachycardia	Proteinuria
Arthralgia and myositis with muscle reticularis	Cylindruria
	Hematuria
Hypertension	Increased ESR
Abdominal pain	RF positive
Mononeuritis multiplex	ANA positive
	Normal or increased serum complement

Immunodeficiency Diseases

Acquired Immunodeficiency Syndrome (AIDS)

Clinical Findings	Laboratory Findings/Studies
Fever	Decreased T4 cells
Weight loss	Increased T8 cells
Lymphadenopathy	Leukopenia
Diarrhea	
Frequent infections	
Oral candidiasis	

Severe Combined Immunodeficiency Disease

Clinical Findings	Laboratory Findings/ Studies
Increased susceptibility to infections at 3-6 months	Immunoglobulin (IgG) <1%
Diarrhea from *Salmonella* organisms or *Escherichia coli*	Lymphocytes <2000/mL
	Decreased delayed hypersensitivity reaction
PCP and *Pseudomonas* pneumonia	
Oral candidiasis	

Osteoporosis

Clinical Findings	Laboratory Findings/Studies
Spontaneous bone fractures	Computed tomography
Bisphosphate-related osteonecrosis of the jaw (BRONJ)	Serum test <150 pg/mL

Local and Regional Problems

Besides the systemic conditions, certain local problems must be evaluated before the dental surgeon undertakes implant treatment. These include the following:

- Root tips
- Cysts
- Infections
- Neoplasms
- Fibro-osseous disease

Once the patient evaluation has shown that the individual does not present a medical or psychological risk, or that such risks, if present, can be controlled adequately, determination of the specific approach for oral reconstruction can be initiated.

Selection of the Proper Implant

4
CHAPTER

DIAGNOSTIC METHODS

Examination

Once the patient has been found to be physically and medically acceptable for implant therapy and the decision has been made to proceed, a thorough diagnostic evaluation is performed and a treatment plan is chosen to provide the proper approach. A visual examination should be the first step. The implantologist should view the edentulous areas and conceptualize the height, width, and length of the proposed operative sites. The amount of gingiva that is attached or keratinized (or both) is noted. In addition, the level of the lip line and exposed gingivae are noted, along with any muscle attachments. If natural teeth remain, they should be free of decay, and the periodontal tissues should be healthy. Neither infections nor localized areas of pathologic change can be permitted.

The next step in the diagnostic sequence is manual palpation. Using the thumb and index finger, the examiner palpates the edentulous ridges (Fig. 4-1), assessing the firmness and thickness of the soft tissues.

A determination of the uniformity of thickness over the entire height and length of the underlying bone is important. Concavities and convexities may be present that might not be evident on visual or digital examination. To clarify and define the presence and extent of such irregularities, the practitioner should prepare to sound the bone (or delineate the shape by closed examination). A 30-gauge needle is used to deposit a small amount of local anesthetic along the labial and lingual aspects of the edentulous areas under consideration for implant sites. A sharpened periodontal probe then is used to measure the thickness of the soft tissue at several points. These and all other calibrations should be recorded on a diagnostic chart. Next, a sterilized Boley gauge with sharpened beaks is used to puncture the soft tissues by squeezing the calipers directly through tissue to bone (Figs. 4-2 and 4-3). The beaks should oppose one another so that an accurate reading results. This produces a measurement of bone width at varying ridge sites. By obtaining measurements from superior to inferior and from medial to distal at 5-mm intervals, the clinician develops a topographic map of the soft and hard tissue dimensions of the areas into which implant placement is intended. When these measurements are used, an accurate, three-dimensional representation of the operative site can be sketched (Fig. 4-4).

Study Casts

At this point, full arch alginate impressions of both arches are made so that the dimensions can be transferred to the casts made from them. The impressions are poured immediately with dental stone, and a second (surgical planning) cast of the arch is made that will be restored with implants. A centric recording in the material of choice is needed to allow the casts to be mounted on a semiadjustable articulator (Whip Mix, Hanau). Proper articulation of casts is an essential part of every restorative procedure. Correct reproduction of the patient's occlusal relationships on an articulator allows proper planning and saves a considerable amount of time that usually is wasted in adjusting prostheses. If the casts are not related to the patient's condylar axis before they are mounted on the articulator, the bite record may be inaccurate.

The facebow, a relatively simple device to use, relates the maxilla to the same location on the articulator that is found in the patient's skull. The facebow consists of three components: the bite fork, the bow, and the locator rods. To place the device properly, the practitioner must locate the patient's condyles; this can be done with accuracy by palpating for these important structures while the patient repeatedly opens and closes the mouth. These points are marked on the skin with an indelible pencil so that the axis locator rods of the facebow can be placed against them. In addition to the palpation method, the external auditory meatuses can be used to locate the condyles. These meatuses are related consistently to the condylar head axes. Several systems provide earpieces on the facebow for this purpose.

Next, a U-shaped, softened sheet of wax is fixed to the bite fork. The patient's mouth should be closed in centric relationship lightly into the wax so that indentations are made by the cusp tips of the teeth. For edentulous patients, stable base plates are used. The maxillary wax rim is attached to the fork, and the patient is guided into a centric closure of the proper vertical dimension. With the bite fork held in place by the patient's teeth, the facebow is assembled. The axis locators should be allowed to contact the marks on the skin, and the assistant should tighten the set screws, locking the bite fork, locator, and facebow in place. The axis locators are

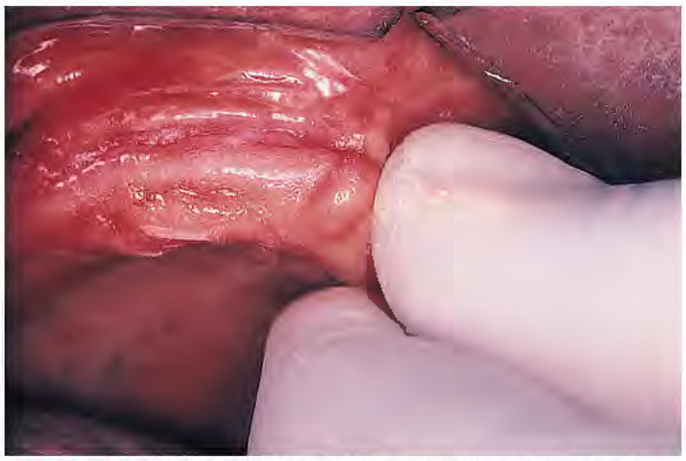


FIGURE 4-1. Digital palpation of the planned host site reveals undercuts, irregularities, and defects of the bone. Zones of attached gingivae also may be detected.

FIGURE 4-2. A standardized Boley gauge can be sharpened and sterilized for purposes of sounding. Such a device also is available commercially.

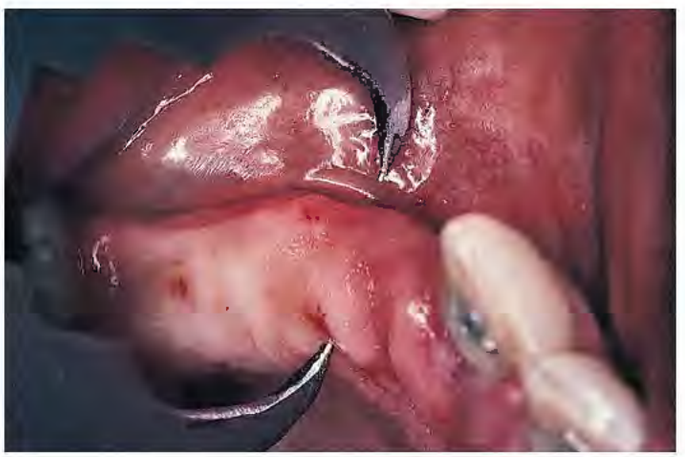


FIGURE 4-3. After anesthetization, the sharpened Boley gauge tips penetrate the soft tissues so that accurate direct bone dimensions may be recorded.

then loosened; if the system is stable, the locator's tips will not move. The patient may then open the mouth, and the entire assembly can be removed.

Although some articulators allow the transfer of intercondylar distance measurements, most have a preset distance. The locator rods are attached to the axes of the articulator, their set screws are fastened, and the maxillary cast is placed in the wax indentations on the bite fork. At this stage, the practitioner evaluates the position of the cast. The occlusal plane should be slightly higher in the posterior area. The cast should be supported with a block and attached to the upper member of the articulator with a mounting ring using model plaster. After the cast has set, the interocclusal bite record is used to relate the mandibular to the maxillary cast. It is affixed with plaster to the lower or fixed member of the articulator.

All of the occlusal relationship records should be derived from the articulator. Final prosthesis balancing also is accomplished by following these articulator-related techniques.

The implantologist should study the mounted casts with respect to interocclusal distances, existing occlusal relationships, and arch forms (Fig. 4-5). If a distance of 7 mm or less is found between the potential host site and the opposing natural or prosthetic occlusal surfaces (Fig. 4-6), an implant cannot be used unless additional space can be created by the following methods:

1. Grinding of the opposing occlusion
2. For edentulous patients: thinning of the overlying gingiva and/or bone of the opposing jaw (see chapters 6 through 8)
3. Reducing the alveolar height of the operative site by flattening the thin ridge (see chapters 6 and 8) while making sure that adequate bone height remains to provide sufficient dimension for seating of the planned implants

With edentulous posterior mandibular quadrants, extrusion of the maxillary molars or premolars directly opposing the area often is a factor. If significant periodontal disease is not present, the alveolar ridge actually is thrust downward, carrying the teeth with it. In such cases, an en bloc segmental osteotomy can be performed to intrude the problematic area, increasing the intermaxillary space (Fig. 4-7).

If the articulation indicates crossbite or ridge procumbency, the implantologist must determine that the angulation of the implants will permit the final prosthesis to be in functional position. Implants at greater than 35-degree angulations from the long axis of the ridge present significant aesthetic and functional problems. If an angle greater than 35 degrees is created, forces are exerted that may be detrimental to the longevity of implant host sites. For this reason, some excellent ridges may be considered questionable if the angulation places implants in compromised positions. Custom casting using wax patterns for cementable abutments can be done. In addition, some implant designs (i.e., Straumann, Nobel Biocare) have abutments with angles of 15 degrees or even 30 degrees. However, seating these to the proper alignment requires special skills (see chapters 21 and 27).

Radiology

The next step in the diagnostic sequence is a radiologic survey. The following radiographs and their purposes are listed so that the practitioner can select the fewest possible views required to attain the optimum data.

- *Panoramic radiograph (Fig. 4-8)*: A panoramic radiograph presents an overall view of both the mandible and maxilla. Normal anatomy and existing pathologic conditions of the dentoalveolar complex and adjacent structures can be noted. The remaining natural teeth are visualized. Unpredictable distortions of distances (25% or greater) are a constant characteristic of these films.
- *Periapical radiograph (Fig. 4-9)*: A periapical radiograph gives a view of higher resolution and greater accuracy than a panoramic study and indicates medullary and cortical bone density. Often measurements can be taken directly from these films, but distortions of up to 20%, depending on the angulation at which the PA was taken, can result in foreshortening or elongation.
- *Lateral cephalometric radiograph (Fig. 4-10)*: Lateral cephalometric radiographs are helpful if the patient has completely edentulous ridges. The cross-sectional morphology of the residual anterior ridge can be visualized, along with its angles

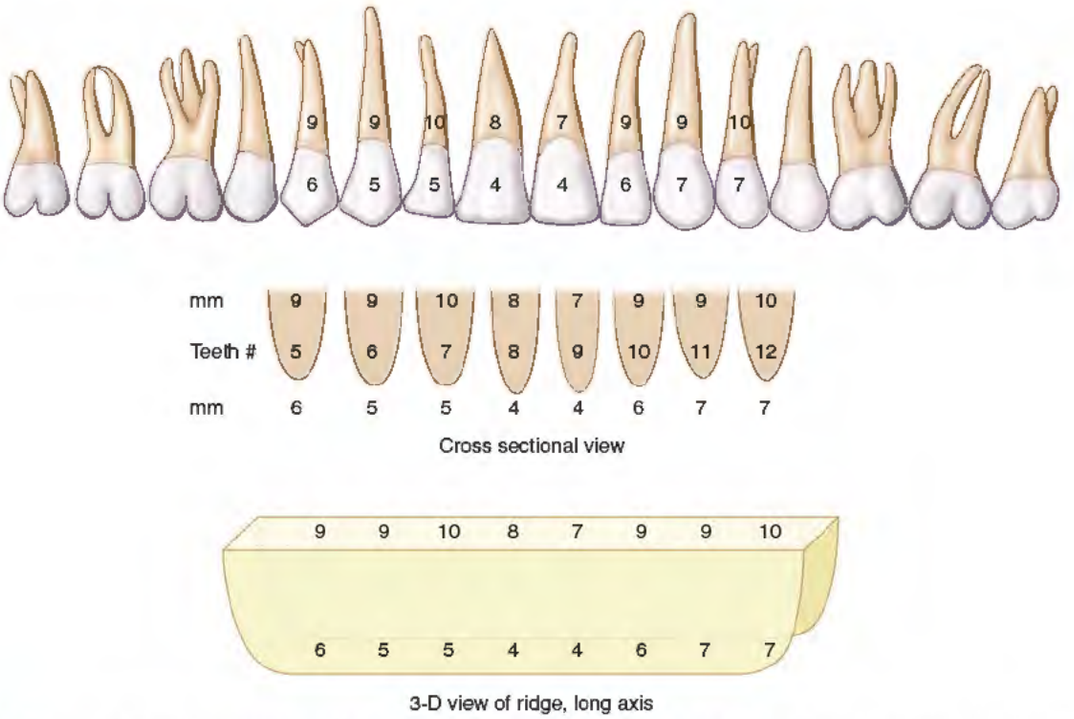


FIGURE 4-4. The Boley gauge measurements of bone are transferred to a dental chart. From these numbers, cross-sectional and three-dimensional views can be plotted to serve as dimensional guides in millimeters during surgery.

FIGURE 4-5. An integral step in the diagnostic process is the creation of mounted casts.

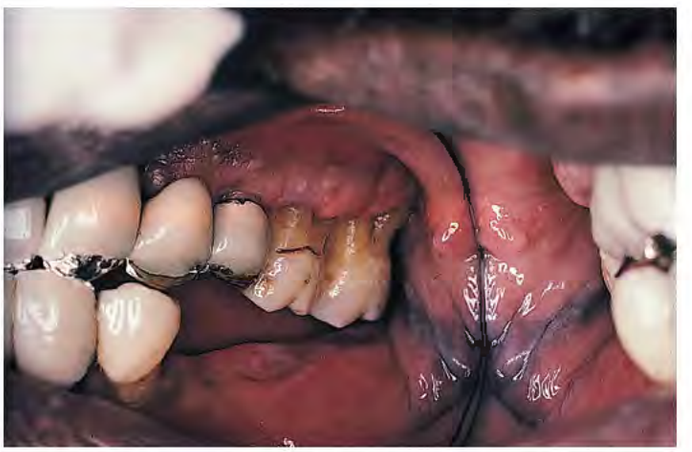


FIGURE 4-6. One cause of insufficient intermaxillary distance (7 mm or less) is supereruption of the opposing dentition. This problem may be solved by extraction, endodontic therapy, occlusal equilibration, an increase in the vertical dimension, or subapical en bloc resection (see Fig. 4-7).

of inclination. In addition, skeletal jaw relationships can be studied. This allows an estimate of labiolingual dimension. These views may be taken with occlusal films but are best produced with a cephalometric device using high-speed 8 × 10 cassettes.

- *Radiographic ball-bearing template:* Periapical ball-bearing evaluations can be valuable. A template is prepared using the second (surgical planning) cast. The 5-mm diameter, standardized metal marking spheres (Biomet-3I, Ace Surgical) should be countersunk into the cast at the crest of the ridge at each potential implant site to a depth of 1 mm using a No. 6 round bur. Each is secured in place with sticky wax. An Omnivac machine then is used to mold a piece of 0.02-inch gauge, clear plastic material to the cast; this material incorporates the spheres (Fig. 4-11). After proper trimming, the template produced can be seated intraorally before periapical radiography (Fig. 4-12). If the template is nonretentive, a small amount of denture adhesive is used to stabilize it. After obtaining long cone, periapical radiographs with the template in place, the implantologist records the diameter of the spheres on the films (Fig. 4-13). If the spheres are 5 mm in diameter, the height and length of available bone can be measured accurately directly on the radiographs. If the spheres

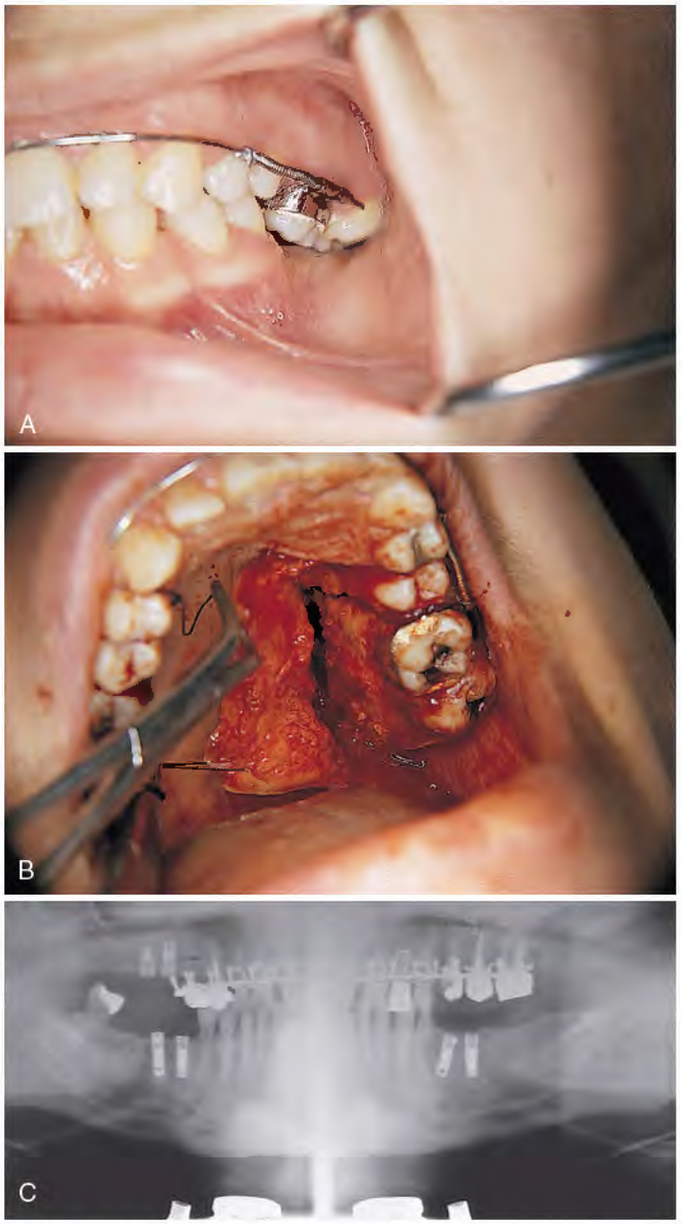


FIGURE 4-7. **A,** The extended posterior maxillary segment prevents placement of implants or prosthetics in the opposing mandible. **B,** A segmental osteotomy permits intrusion of the posterior segment, which includes alveolus and teeth. After healing, a mandibular prosthesis can be placed. **C,** A postoperative radiograph shows implants placed and the maxillary quadrant successfully intruded.

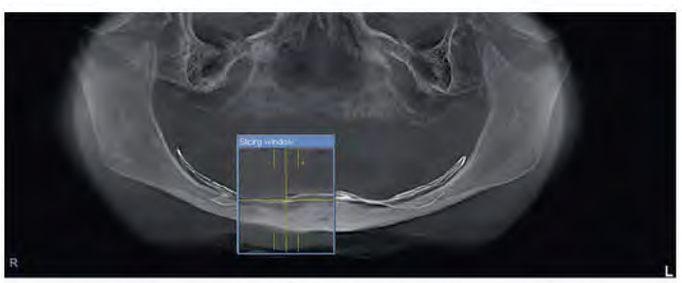


FIGURE 4-8. Panoramic radiographs present a scanning view, which is useful for surveying the jaws. Panoramic radiographs should not be used for definitive measurements.

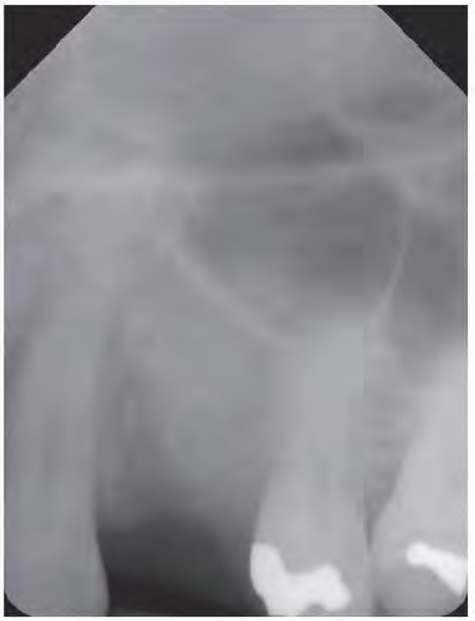


FIGURE 4-9. Periapical radiographs show detail of bony architecture and offer greater accuracy of measurement. Distortion, particularly in the maxillae, still exists but can be minimized by long cone techniques.

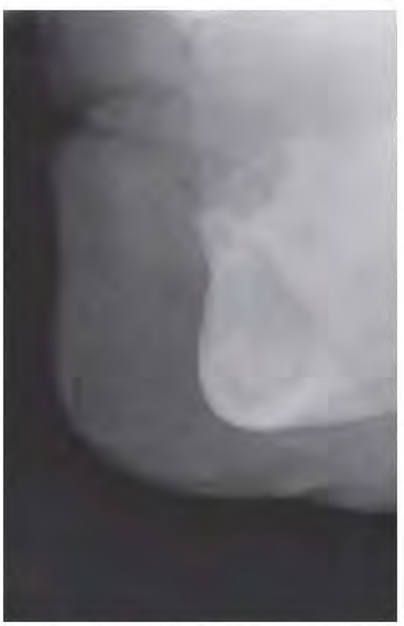


FIGURE 4-10. A lateral view of the mandibular symphysis, one of the most common sites of implantation, may be taken effectively with an occlusal film. It offers some information about cortical plate angulation, but the information is limited because only the greatest dimensions are outlined.

are not 5 mm in diameter on the film, a simple equation can be used to determine the actual bone dimensions:

$$\frac{rs}{5} = \frac{rm}{rx}$$

where *rs* is the radiographic sphere measurement, *rm* is the radiographic bone measurement, *rx* is the actual bone measurement sought, and 5 is the actual sphere measurement.

FIGURE 4-11. A clear Omnivac template is processed to the preoperative study cast after stainless steel spheres (5 mm in diameter) have been placed in slightly countersunk holes.

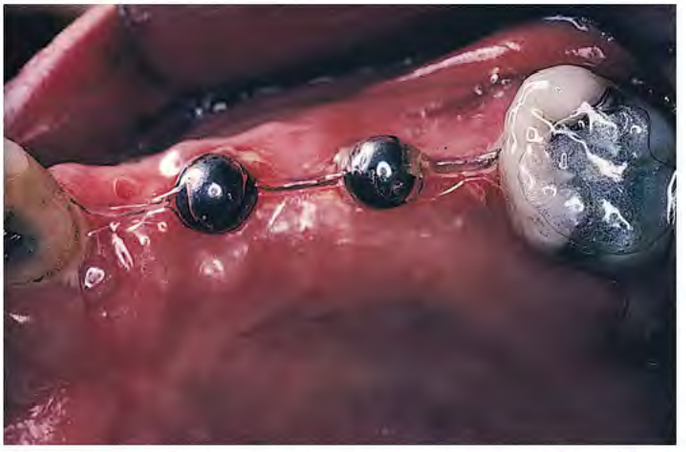


FIGURE 4-12. The trimmed Omnivac template is put in position in the patient's mouth, and long cone radiographs are taken (see Fig. 4-13).

The Omnivac guide is retained, because at the time of surgery, the spheres can be removed; the template then can be sterilized, and after the soft tissues have been reflected, it can be used as an implant site locator (this technique is explained in more detail in Chapter 9).

An alternative method that can be used to measure available bone is simpler but slightly less accurate. First, the surgical planning cast is marked at the potential implant host sites. An Omnivac template then is made on the cast. Next, a No. 557 bur is used to drill through the plastic template at each of the implant sites. Cold-cure acrylic then is used to process a 0.045-inch orthodontic wire into each hole. The length of each wire is measured carefully at 5 mm (errors in measurement will be directly proportional to bone length distortion). The template is placed in the patient's mouth, and the periapical radiographic survey is performed as in the previously described use of spheres. Because three factors are known, the unknown (the actual bone height) may be calculated using the formula given for the spheres.

Instead of these methods, a single, accurate technique of bone measurement and morphology may be achieved using computed tomography (CT) scanning.

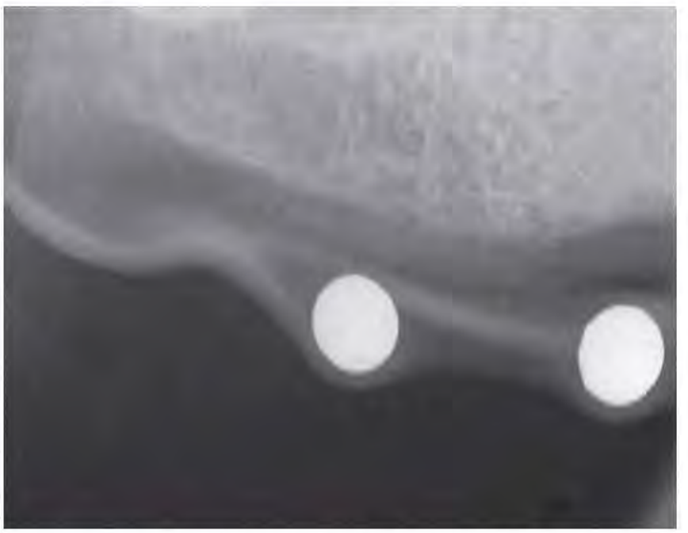


FIGURE 4-13. To verify accuracy, the diameter of the spheres on the radiograph must be compared with their actual size (5 mm).

Cone Beam Volumetric Tomography

Cone beam volumetric tomography (CBVT) involves a higher radiation dose for the patient compared to that from a periapical or panoramic radiograph. However, it also provides greater clarity and accuracy in the radiologic survey of the surgical site (the slice thickness is 0.3 to 1 mm), and the images are free of magnification, superimposition of neighboring structures, and other problems inherent to a panoramic radiographic survey. As this technology becomes more widely accepted and more of these scanners are put to use in dental offices, both dental practitioners and patients will benefit from the convenience, ease of interpretation, and improved diagnostic utility of the resulting data.

CBVT and cone beam computed tomography (CBCT) scanners have been available for craniofacial imaging since 1999 in Europe and 2001 in the United States. These scanners use a cone-shaped x-ray beam rather than a conventional linear fan beam to provide images of the bony structures of the skull. Conventional medical CT scanners use a single row or a series of solid-state detectors (4, 8, 12, 32, 64 and now, 128) paired with a fan-shaped beam to capture the attenuated x-ray; CBCT scanners use a square, two-dimensional array of detectors to capture the cone-shaped beam. The medical CT scanner, therefore, provides a set of consecutive slices of the patient, whereas the CBCT scanner provides a volume of data. Reconstruction software is applied to the CBCT volumetric data to produce a stack of two-dimensional, gray scale–level images of the anatomy.

CBCT and CBVT maxillofacial imaging is indicated in a number of cases, such as for (1) assessment of the facial bones for infection, trauma, and congenital or developmental deformities; (2) quantitative and qualitative assessment of residual bone for primary implant stability, because there is no tissue superimposition and no image distortion (i.e., 1 to 1 scale images allow for accurate measurements); and (3) visualization of the mandibular condyle and the articulating components in the assessment of temporomandibular joint (TMJ) conditions.

All cone beam scanners have preinstalled software for image manipulation and added image functionality. For example with multiplanar reformatting (MPR), three-dimensional volume data

usually are acquired in the axial plane (top to bottom slices). MPR creates sagittal, coronal, and transverse images from those axial images (basically, front view and side view slices). The images are displayed in formats that allow effective visualization of section to section change in the scanned structure. MPR images are available in all preinstalled cone beam scanner software. The software also allows the practitioner to take measurements on the slices and measure density in Hounsfield units.

Some scanners have user-friendly software targeted to dental problem solving and virtual implant planning through intuitive integration of the diagnosis, computer-aided therapy planning, and precise intraoperative implementation. Some implant planning software is able to virtually place the proposed implant, in the appropriate size, in the host site and evaluate it in all three dimensions. Important anatomic structures, such as the inferior alveolar canal and maxillary sinus, can be accurately localized and identified before surgery. Fabrication of surgical guides for implant surgery, based on the virtual implant planning, also is possible.

A radiographic bite plate contains fiduciary radiopaque reference markers and produces a patient-customized scan stent (Fig. 4-14). The dental technician manufactures a scan stent by fusing the radiographic bite plate with a vacuum-form pickup of the radiopaque die (25% barium sulfate)–impregnated cold-cure acrylic prosthetic mockup. This radiographic template is worn by the patient during a scan and is based on the bite plate and a diagnostic prosthetic workup on the gypsum model (Fig. 4-15). After the scan, the scan volume is reconstructed on the computer (Fig. 4-16). Based on the patient's three-dimensional radiography, the implantologist can do the implant planning with the included (i.e., GALILEO Simplant) or third party (i.e., Materialize-Simplant, Nobel Biocare–Procera) right on the computer.

If the procedure will involve the lower jaw, the implantologist may want to mark the inferior alveolar nerve as the first step (Fig. 4-17). The implant planning data then are stored on a removable computer medium (e.g., CD-ROM). The planning data, the scan stent, and the gypsum model of the surgical area, along with clear, detailed written instructions on the surgical drill guide order form, are sent to the laboratory that will fabricate the surgical drill guide (e.g., SiCat, Nobel Biocare, Biomet-3I) (Fig. 4-18).

The laboratory manufactures a surgical drill guide based on the implant planning data and the scan stent. The guide is equipped with a pilot drilling system, a sleeve-in-sleeve system, or the outer sleeves of established surgical systems (Fig. 4-19).

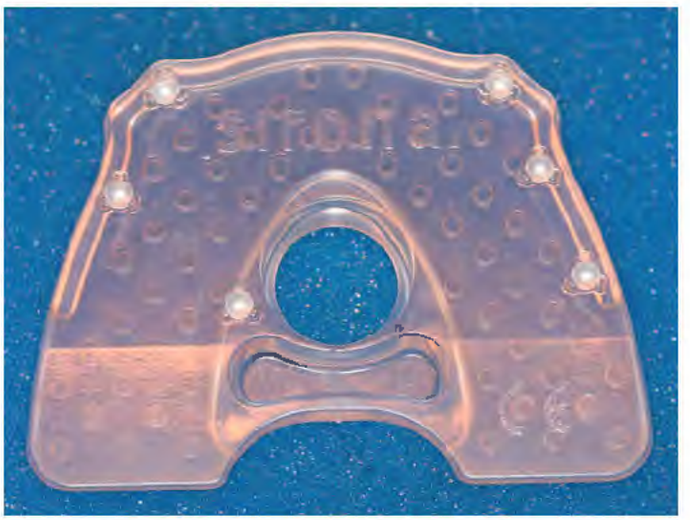


FIGURE 4-14. Galileos radiographic bite plate with spherical fiduciary radiopaque markers.

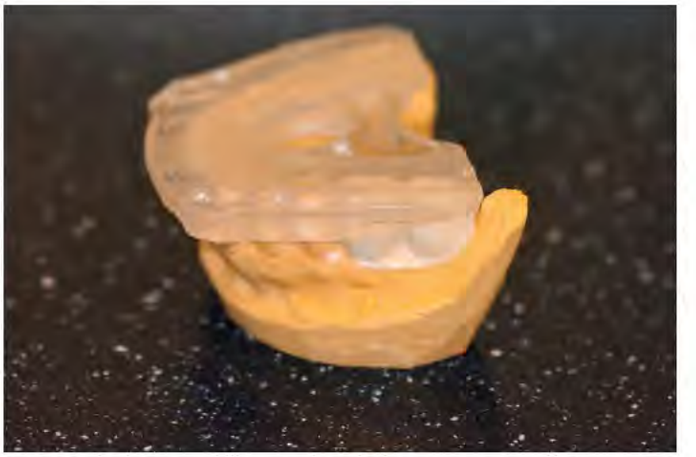


FIGURE 4-15. Galileos radiographic template sitting on the study cast as it would in the patient's mouth.

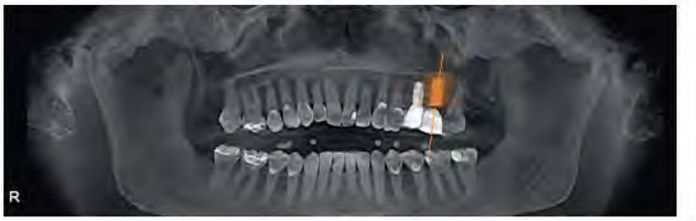


FIGURE 4-16. Panoramic view of the radiographic guide in place; notice the spherical radiopaque fiduciary markers of the radiographic bite plate. A virtual implant has been placed in the area of missing tooth #14 using the radiopaque acrylic mockup of the final prosthetic as a guide.

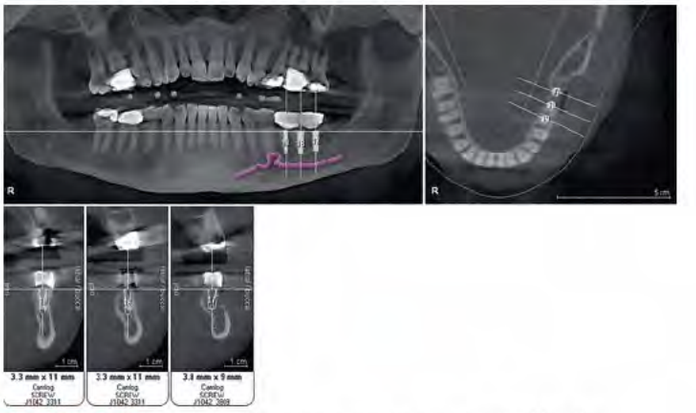


FIGURE 4-17. Implant planning report as generated by the Galileos Implant planning software after the relevant vital anatomy in the surgical field has been identified and highlighted and the virtual implants placed as per the restorative or the surgical doctor's preferences. This report can be shared with the entire implant team as well as with the patient as part of their education process.

RADIOGRAPHIC EVALUATION

Airway Space Analysis

The CBCT scanner has a compact size, is easy to use and allows easy patient positioning, has a fast acquisition speed (6 to 14 seconds), and involves a relatively low dose of radiation; all these factors make

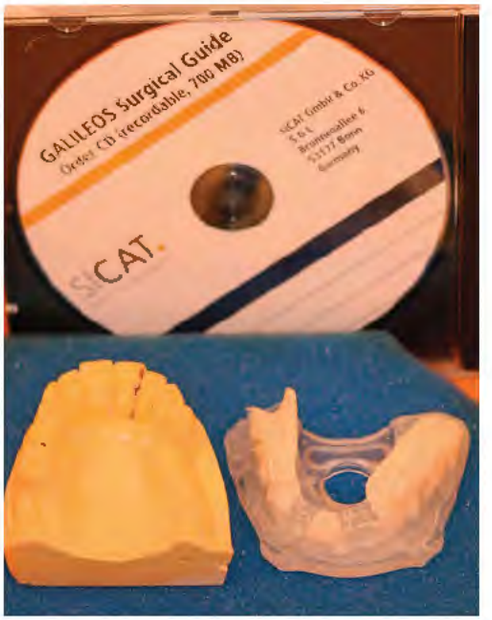


FIGURE 4-18. Items submitted for the fabrication of the surgical guide include the study cast of the jaw where the implants will be done, the radiographic template, the CD-ROM with the implant planning loaded onto it and the prescription form for the fabrication of the surgical guide.

The amount of bone beneath the maxillary sinus and nasal cavity may be charted for width and height, and the density of bone may be assessed. In the mandible, the exact location of the mandibular canal in even its most tortuous course may be plotted before surgery.

This information enables the clinician to plan the proper implant types, numbers, sizes, and locations. Presurgical scanning minimizes the chance that the surgeon will have to inform the patient, midway through surgery, that the individual is an unsuitable candidate for implants.

Preferably, the patient should be sent to a radiologist who has a GE 9800 or GE 8800 CT unit. The radiologist also must have software that can create a three-dimensional reconstruction of the maxilla and mandible, such as the Columbia Scientific (3D Dental) program.

The scanner produces a series of images made from horizontal slices (Fig. 4-20). Each exposure is 0.5 mm wide. When the series of cuts is completed within the prescribed perimeters, they are stacked by the computer. The program uses this reconstituted three-dimensional structure to supply images made in the cross-sectional (Figs. 4-21 and 4-22), panoramic (Figs. 4-23 and 4-24), and occlusal modes (Figs. 4-25 and 4-26). These images may be interpreted, area by area, so that the arch in which the implants have been planned can be plotted to the millimeter in width and depth. In addition, exact locations of all vital structures are readily identified by using the images, which the process presents in 1-mm sections.

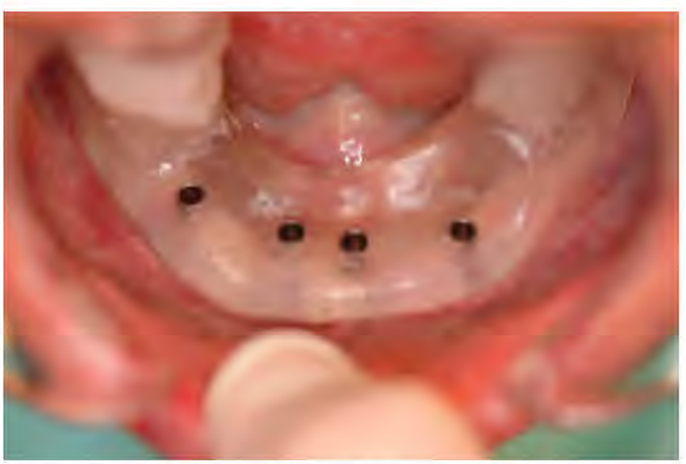


FIGURE 4-19. Galileos surgical guide with sleeves for pilot drill.

FIGURE 4-20. With the patient lying on the gurney, the computed tomography (CT) scanner makes horizontal radiographic cuts 1.5 mm wide. Each image is overlapped by 0.25 mm to permit accurate continuity and the presentation of views that are 1 mm wide.

it ideally suited for imaging of the craniofacial region, including dental structures. This modality is emerging as the imaging standard of care for a number of diagnostic assessments of bony components of the face.

Computed Tomography

Three-dimensional imaging allows visualization of any area within the parameters of the scan. CT scanners provide a variety of views by making 0.5-mm slices through the bone, which are stacked by the program's software like a deck of playing cards. When the three-dimensional subject is complete, the computer reformats it into coronal, cross-sectional, or panoramic images, which also are sliced. This program ensures that the surgeon is not confronted with any surprises during surgery. The amount of available bone (or lack of it) may be plotted to the millimeter.

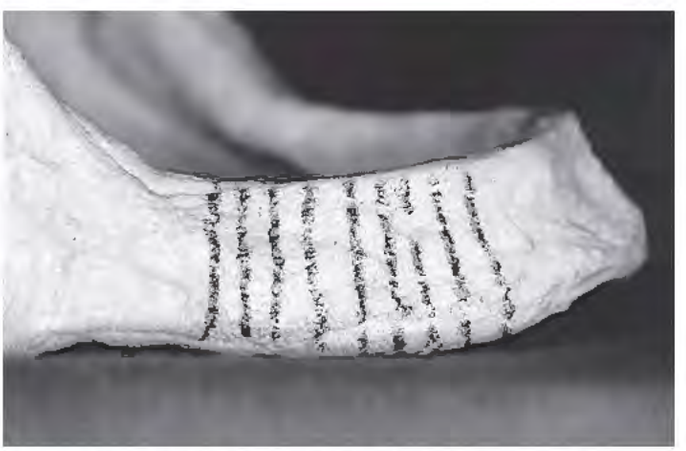


FIGURE 4-21. The vertical lines indicate the cross-sectional planes, or "cuts," the CT software makes available.

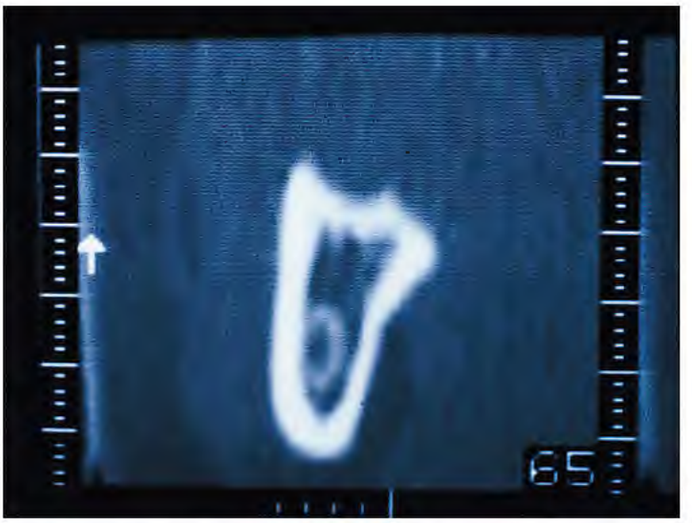


FIGURE 4-22. A typical cross-sectional view of the mandible produced by CT scan dental software. Vital structures (e.g., the mandibular canal, cortical plates, and inferior border) can be reviewed clearly. With some systems (life-sized imaging), measurements can be made directly from the film.

FIGURE 4-23. A panoramic view is another valuable image produced by CT scanning. Usually five slices are made available, from buccal to lingual. This mandibular model shows the middle level of the five slices marked by pencil (see Fig. 4-24).

If no such software programs are available, the radiologist may take a conventional scan of the patient on almost any CT scanner, and the resulting DICOM-compatible digital data can be sent to the Columbia Scientific Corporation. The company can translate such data into images containing the requisite three-dimensional information.

Currently, software systems are available (Dentascan, Galaxis) that allow the dentist to reformat axial images in the office and superimpose appropriately sized implants on them (Fig. 4-27).

Before the patient is referred to the radiologist, intraoral splints designed to immobilize the lower jaw must be made if this area is to be scanned. However, this is not an absolute requirement for the maxilla. The splints are fabricated with three objectives in mind: immobilization, disocclusion, and orientation. The fixation devices are fabricated with the jaws in the resting position to allow the patient to keep the mandible comfortably immobilized for up to 30 minutes. Immobilization is necessary, because any movement causes blurring or distortion of the images.

If teeth are present in the maxilla and mandible, the splints should disocclude them so that a space is created on the images. No metal should be allowed to remain in the teeth or incorporated into the splint of the jaw being scanned, because metal (except for titanium) creates scatter (noise) and other masking artifacts on the images.

The proper plane of occlusion is established in the splints, and nonmetallic radiopaque markers (gutta percha or barium sulfate 25%) are placed parallel to and at the plane of occlusion. These markers tell the radiologist how to orient the patient's head for the study. They also ensure that the angle at which the cross sections are reformatted through the scanned arch is 90 degrees to the occlusal plane. The accuracy of measurements taken from the scan depends on the orientation of the preliminary film, or scout film. Consequently, accurate placement of the opaque occlusal plane markers is essential. The radiography technician must position the patient's head so that the scout film demonstrates its orientation lines parallel to the marker (see Fig. 4-42).

Methods of Radiographic Splint Fabrication

Each tooth represented in the template should have a 10-mm vertical gutta percha or barium sulfate marker processed into it, or the entire tooth can be fabricated with cold-cure acrylic mixed with barium sulfate in a 25% concentration. These are demonstrated in the occlusal, cross-sectional, panoramic, and transaxial images. When the template is placed in the patient's mouth, each gutta percha marker can be traced to the images, so that anatomic localization is coordinated. This is particularly valuable during surgery, when planned host site dimensions can be pinpointed by relating them directly to the appropriately labeled cross-sectional views.

Edentulous Arch

The following steps make up the process for a patient with an edentulous arch.

1. Make an alginate impression of the arch to be scanned and pour a diagnostic cast.
2. Fabricate acrylic base plates with wax rims.
3. Adjust the rims to the patient's correct vertical dimension, centric relationship, and lip length and prominence; set the teeth for final functional satisfaction and esthetic appearance.
4. Try in the final wax dentures and confirm esthetics (Fig. 4-28).
5. Record the patient's centric relationship position at the resting vertical dimension and mount the trial dentures on an articulator.
6. Complete the dentures and replicate them in clear, self-curing acrylic using a Lang denture duplicator flask (Fig. 4-29). After preliminary polymerization, the acrylic replicate is fully cured in a pressure pot for 30 to 45 minutes (Fig. 4-30).
7. Seat the replicated acrylic trial dentures on the original cast and fill the space between them (freeway space, created by mounting casts at the resting vertical dimension position) with additional self-curing acrylic resin, creating an interarch index. If the opposing arch contains teeth, the duplicated trial denture may be luted to an opposing acrylic replica of the arch at the patient's resting vertical dimension.
8. Cut a groove in the labial acrylic facings of each of the teeth on the appliance with a No. 6 round bur; the grooves should be 1 mm deep, 1 mm wide, and 10 mm long. These grooves are

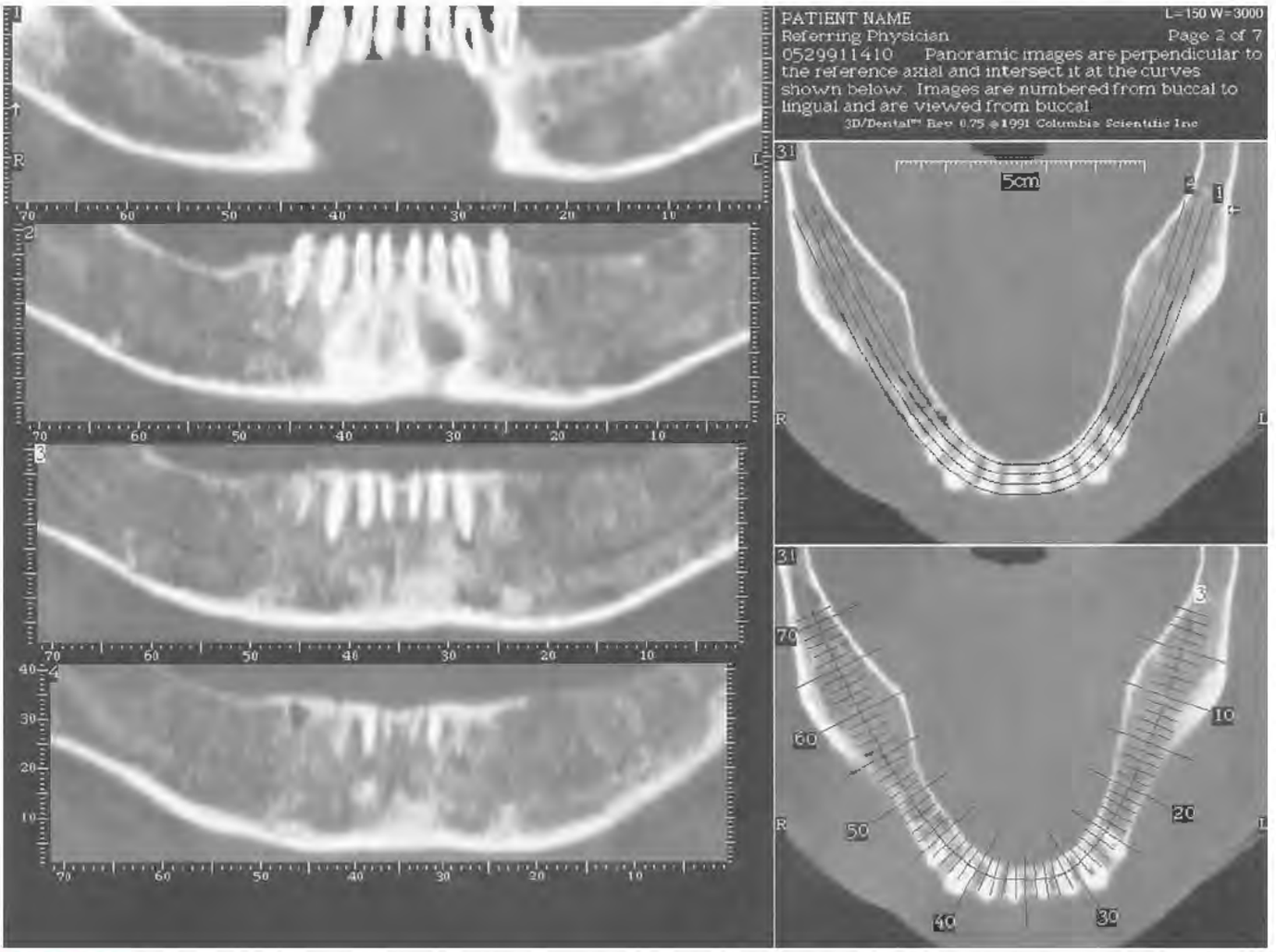


FIGURE 4-24. Panoramic images at four buccolingual levels (view 31) on the right top are demonstrated in the panoramic reproductions (1 to 4) on the left. The lucent area in view 1 does not represent a lytic lesion. Line 1 in view 31 *(upper right)* (the most labial cut) shows that the scan passed through an area just anterior to the symphysis.

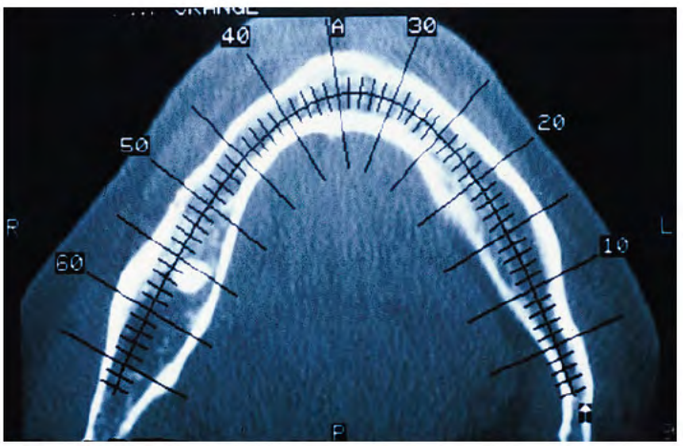


FIGURE 4-25. An occlusal view made in the midmandible. The numbered cross-hatching indicates the cross-sectional images, each 1 mm wide (see Figs. 4-22 and 4-43).

refined and cut perpendicular to the established occlusal plane with a diamond point (Fig. 4-31).

9. Pack the grooves with well-condensed gutta percha or a mixture of barium sulfate and acrylic. For creating evenly reproducible radiopaque markers, a heated gutta percha gun offers greater ease and more reliable placement of the material. Alternatives to gutta percha that result in reliable marker placement include a composite restorative material (which when used alone does not present a particularly sharp image) or a mixture of barium sulfate powder (one part) and acrylic powder (three parts), which produces a well-defined image and can easily be painted into the grooves using monomer (Nealon's technique) (Fig. 4-32).
10. Create air holes for breathing and a suction hole for attachment of an aspirator if the occlusion is extremely close or the patient produces a great deal of saliva.
11. Try the appliance in the mouth to make sure the patient can wear it comfortably during the scan.

Partly Edentulous Arch

The steps for a partially edentulous are as follows.

1. Make alginate impressions of the mandible and maxilla and mount diagnostic stone casts (Fig. 4-33).
2. Replicate the models and fabricate a diagnostic setup of the planned final restored case (Fig. 4-34).
3. Replicate the wax setup by making an impression of it and pouring it in stone (Fig. 4-35).
4. Make an Omnivac replica by molding 0.02-inch clear material over the stone model (Fig. 4-36).

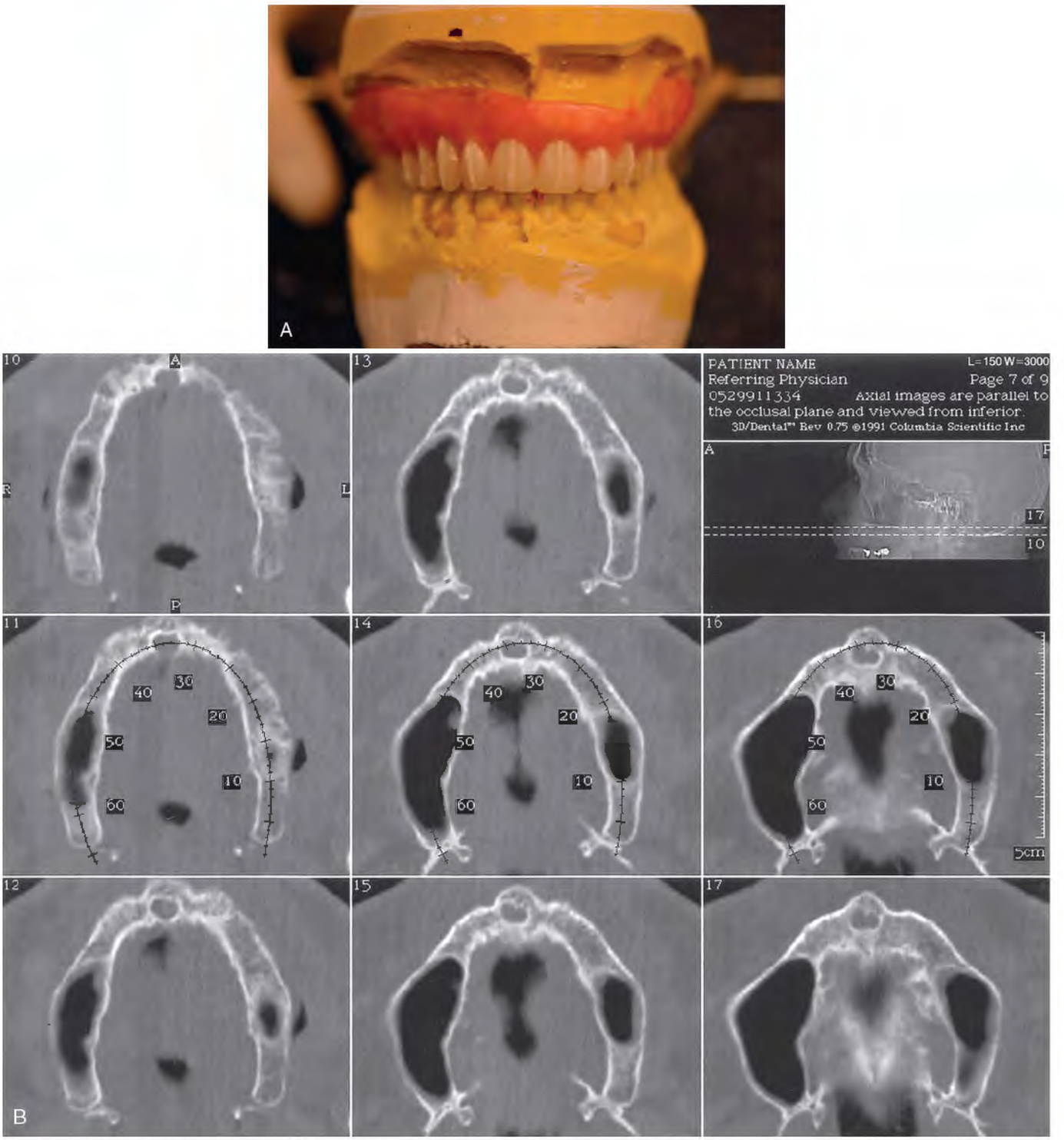


FIGURE 4-26. **A,** Diagnostic waxup of a full denture with vertical radiopaque markers for radiographic identification of implant sites. **B,** Transaxial (occlusal) views are used for the maxilla as well as the mandible. These eight images, numbered 10 through 17, offer dramatic representations of this geometrically complex structure at evenly spaced intervals (1.5 mm apart). The image at the upper right, marked *A,* known as a *scout film,* presents the inferior to superior perimeters of the numbered images.

5. Trim the Omnivac material so that it covers the height of contour of all teeth and extends down to the alveolar ridge in the areas where the teeth have been waxed (Fig. 4-37).
6. Remove the Omnivac shell from the stone model. Fill the areas in the shell where the teeth had been set with a doughy mix of clear, self-curing acrylic. Reseat the Omnivac shell on the original stone cast (with the edentulous areas) and cure it in a pressure pot (Fig. 4-38).
7. After curing is complete, trim the excess acrylic.
8. Cut grooves (1 mm wide, 1 mm deep, and 10 mm long) through the labial surfaces of all the natural tooth sites with a No. 6 round bur so that these grooves run perpendicular to the newly established plane of occlusion.
9. Fill all grooves and holes with well-condensed gutta percha (Fig. 4-39).
10. Try the appliance in the patient's mouth.
11. Roughen the occlusal surfaces of the Omnivac appliance and lubricate the patient's opposing dentition.

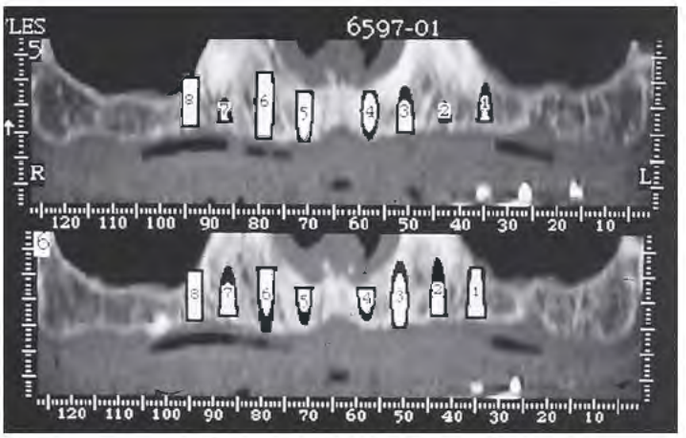


FIGURE 4-27. The Dentascan program allows computerized superimposition of implants of specific dimensions directly on images. The computerized implants may be placed on both cross-sectional and panoramic views (see also Fig. 4-54).

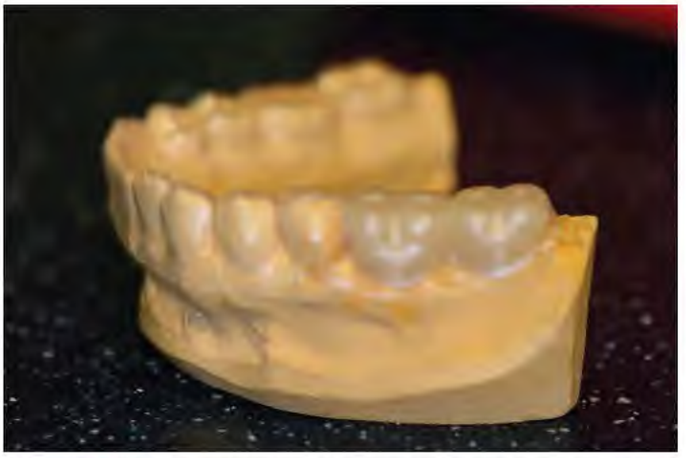


FIGURE 4-28. For a completely edentulous patient, trial dentures are placed with the teeth set in wax to check for esthetics and function and to locate the appropriate positions of significant teeth. These relate to potential implant sites on the scan.

FIGURE 4-29. The waxed trial denture is placed in a Lang duplicating flask with alginate impression material. Replication is completed in clear, self-curing acrylic by closing the flask.

FIGURE 4-30. In the curing of acrylic denture replicates, the pressure pot is filled with hot water to the point of overfilling and then closed tightly; this allows the acrylic to cure fully and without bubbles.

FIGURE 4-31. Grooves are drilled in the clear acrylic template to prepare for placement of radiographic markers in each of the 14 teeth of the surgical template. Each groove is made at a right angle to the occlusal plane marker, and the grooves are then filled with a radiopaque medium.

12. Place a doughy mix of self-curing acrylic on the occlusal surfaces of the appliance.
13. Have the patient close into a centric relationship but stop at the resting vertical dimension (Fig. 4-40). The patient opens and closes the mouth to this position while the acrylic hardens. Complete the curing in the pressure pot (Fig. 4-41).
14. Insert the appliance to assess patient comfort.

Fabrication of the radiographic template required to make a CAD-CAM surgical drill guide requires a completely different approach.

1. Make a full arch plaster model of the mandible or maxilla, depending on the arch that needs to be restored with one or more implants.
2. When the cast is done, make a diagnostic wax-up of the prosthetic teeth in their proper occlusion and proper mesiodistal and buccolingual dimensions.

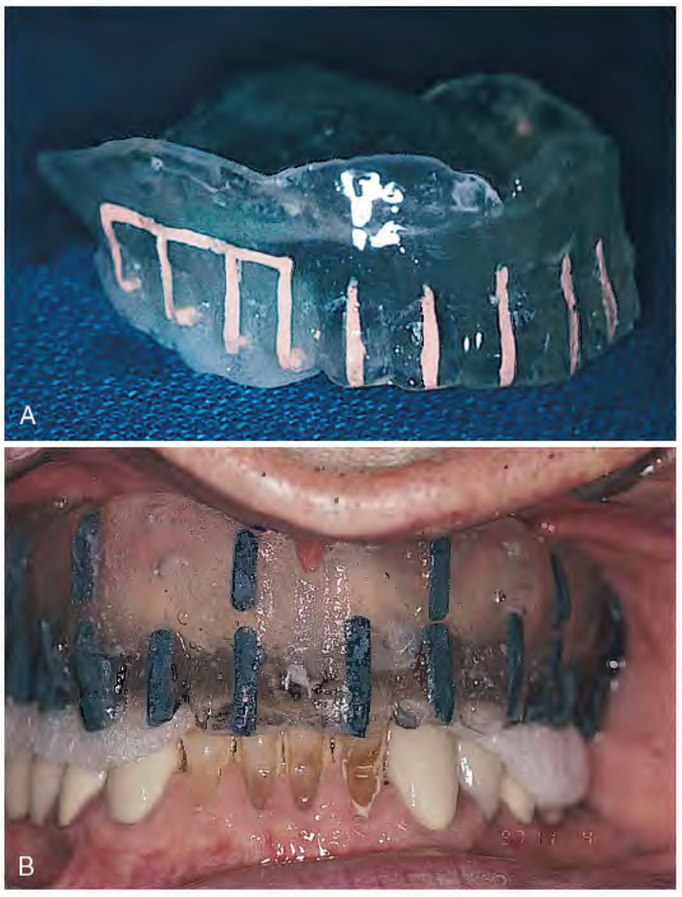


FIGURE 4-32. **A,** Gutta percha markers are inserted into the grooves of the radiographic or surgical template. Use of the Obtura device ensures a predictable density. **B,** Amalgam powder and acrylic powder (1:3 ratio applied with monomer and a paintbrush) is simple to insert into the grooves and creates a highly diagnostic image.

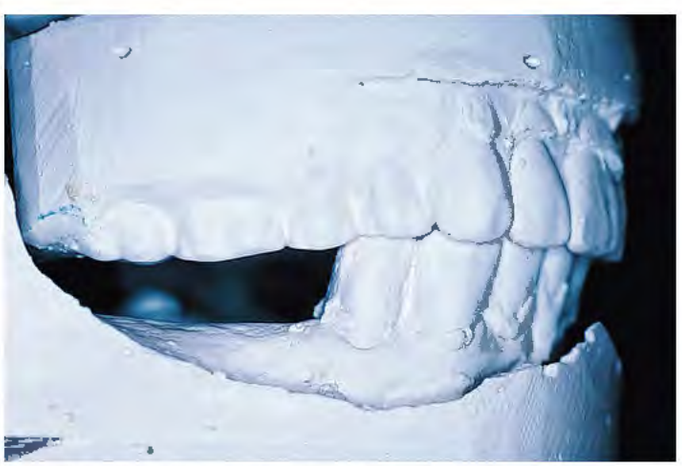


FIGURE 4-33. For a partly edentulous patient, preoperative study casts are mounted on the articulator.

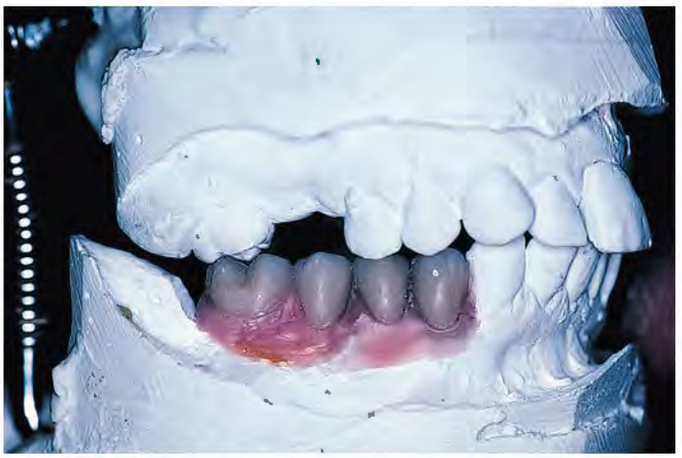


FIGURE 4-34. Denture teeth are waxed into the planned implant host site.

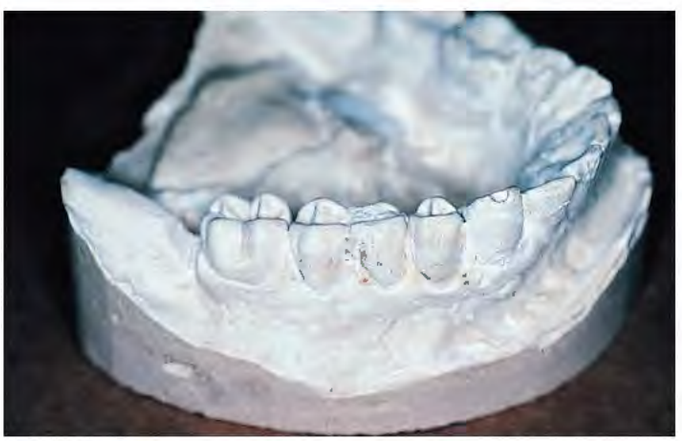


FIGURE 4-35. The cast with its newly placed denture teeth is replicated in stone.

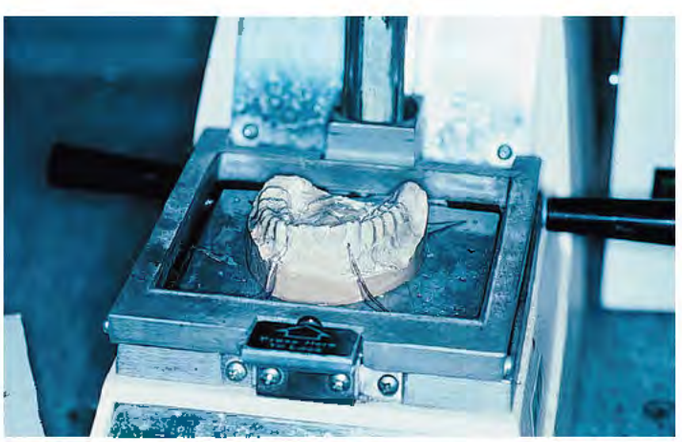


FIGURE 4-36. A 0.02-inch Omnivac template is prepared over the stone cast.

3. Make sure to produce a good-quality impression and plaster model; these are essential to the fit of the scan stent and the surgical guide and thus to precise implant placement.
4. On the plaster model and the wax-up, create a stent with a vacuum-form (foil thickness of 1 to 1.5 mm). Remove the wax-up from the stent.
5. Block out undercuts. Isolate with a separating varnish plaster/resin.
6. Mix cold-cure acrylic with 25% barium sulfate (relating to the weight of the polymer). Make sure the barium sulfate and acrylic are homogeneously mixed and that no clots are present.
7. Insert the mixture of barium sulfate and acrylic into the stent.
8. Ensure that the proposed restoration makes a perfect fit with the mucosa.
9. Mix some cold-cure acrylic (without barium sulfate) to a glue-like consistency. To etch the upper surface of the stent,

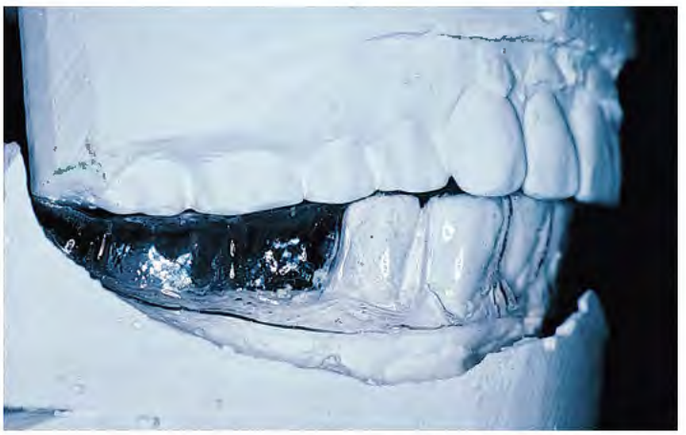


FIGURE 4-37. The Omnivac template is placed on the original cast after the teeth have been removed.

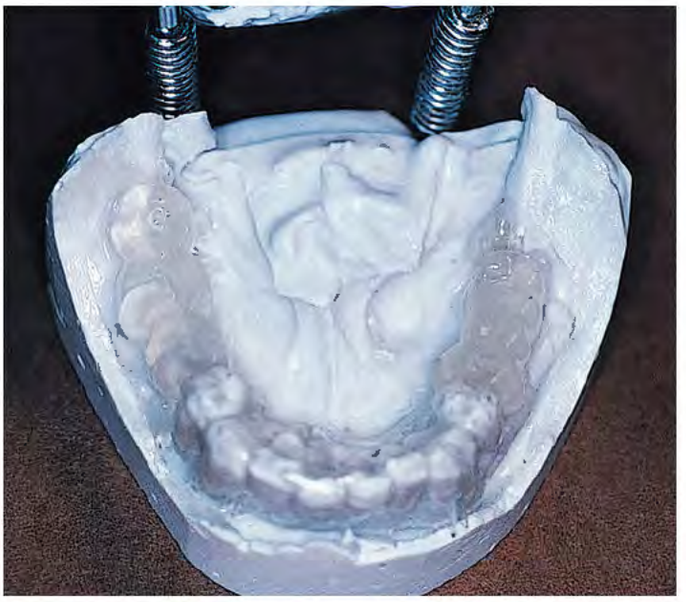


FIGURE 4-38. The hollow Omnivac template is filled with clear acrylic and cured in a pressure pot.

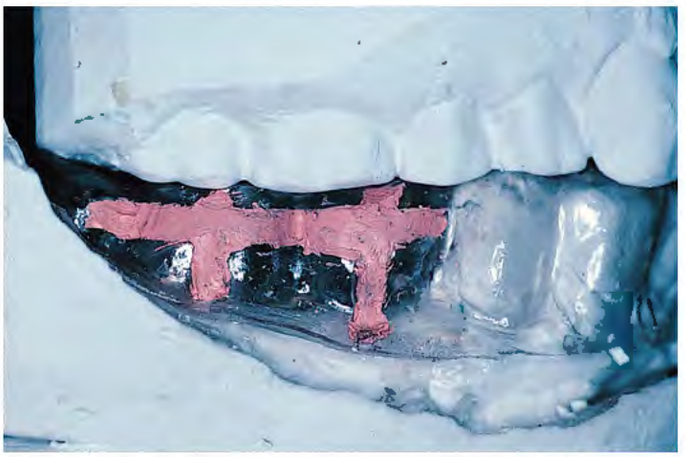


FIGURE 4-39. Diagnostic grooves are placed in strategic positions in the cured template. The grooves are filled with gutta percha points, which are compacted, and smoothed with chloroform.

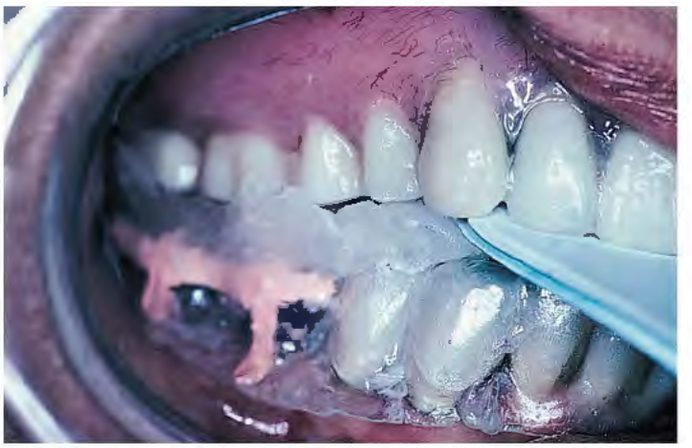


FIGURE 4-40. The completed appliance for the partly edentulous patient is put in position, and acrylic wafers are added to disocclude the mandible. Several tongue blades are used to open the bite.

FIGURE 4-41. The completed positioning device is given to the patient to wear during the scanning procedure.

brush it with the fluid cold-curing acrylic. Mix to a glue-like consistency. Pour the acrylic evenly onto the bite plate with the fiducial radiopaque markers built in.

10. Use sufficient acrylic, because it serves not only to bond the bite plate and the scan stent, but also to stabilize the stent.
11. Place the stent on the plaster cast, then press it into the acrylic on the bite plate until it is polymerized. Check that the scan stent is firmly positioned and definitely fits the plaster model.
12. The radiographic stent with the radiographic bite plate is ready to be fitted into the patient's mouth. Then, obtain a scan, from which implant planning can be done and a CAD-CAM surgical drill guide can be manufactured.

Importance of the Radiographic Template

Immobilization of the patient's jaws is facilitated by allowing the patient to remain comfortably in the rest position. Radiopaque lines or markers that represent the patient's occlusal plane can be seen on the scout film. The CT technologist must orient the patient's head so that these lines appear parallel to the two dotted, preset orientation and perimetric lines seen on this film (Fig. 4-42). These lines, made in the long axes of the teeth, represent the angulation of the proposed restorations as they relate to the angulation of the available bone at each proposed implant site (Figs. 4-43 and 4-44); they also localize each tooth, relating surgical sites to cross-sectional views.

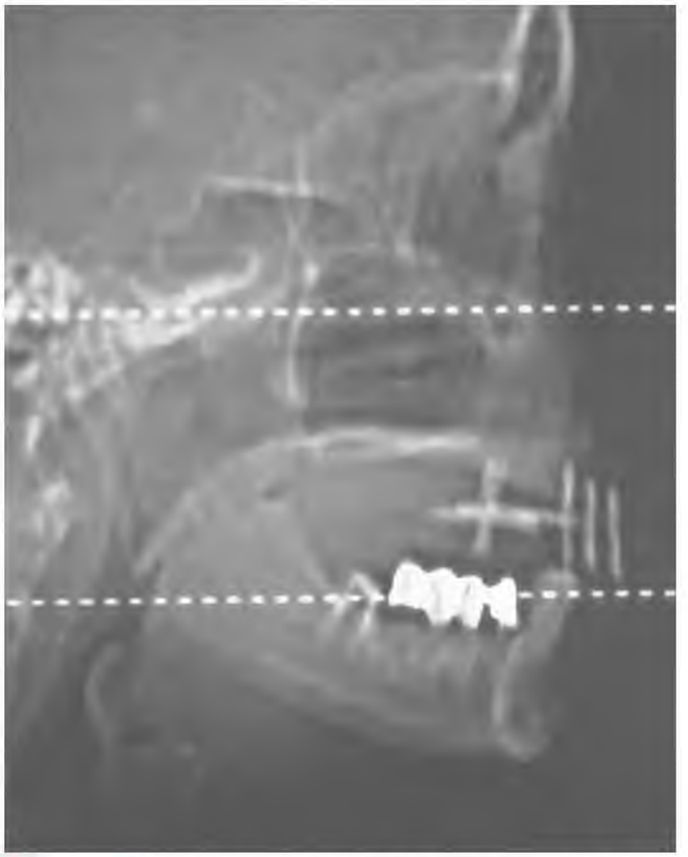


FIGURE 4-42. The first view taken by the CT scanner, the scout film, must show the radiopaque horizontal occlusal line parallel to the dotted perimeters.

Alternate Technique for a Radiographic Template

1. Place the patient's denture in the replicating flask and add alginate to both halves.
2. After removing the denture, fill the dentate portion of the alginate with a mixture of 25% Hypaque (a standard contrast material used in radiology) and 75% tooth-colored polymer–monomer mixture.
3. Complete the remaining (tissue borne) portion of the denture with regular self-curing acrylic (Fig. 4-45).
4. After the acrylic has set, remove the denture replica from the flask. Trim and polish the replica and give it to the patient to wear during the scan. The result presents the radiopaque dentition clearly outlined, tooth by tooth, in its relationship to the underlying bone structures (Fig. 4-46). The clinician may use this scan at the presurgical and surgical stages to localize sites and verify measurements and as a surgical template, coordinating it with the cross-sectional and panoramic views (Fig. 4-47).
5. The patient is now ready for the scan. Give the following instructions to the radiologist:
   - Start with a scout film. It should have orientation lines that are parallel to the patient's plane of occlusion, which will be marked by a radiopaque line.
   - Scan limits for the mandible (perimeters). The lowest cut should begin just below the inferior border of the mandible (if the scan just starts at the inferior border, valuable information will be lost). The superior limit should be above the occlusal plane of the teeth, which is marked by a radiopaque line processed into the splint.

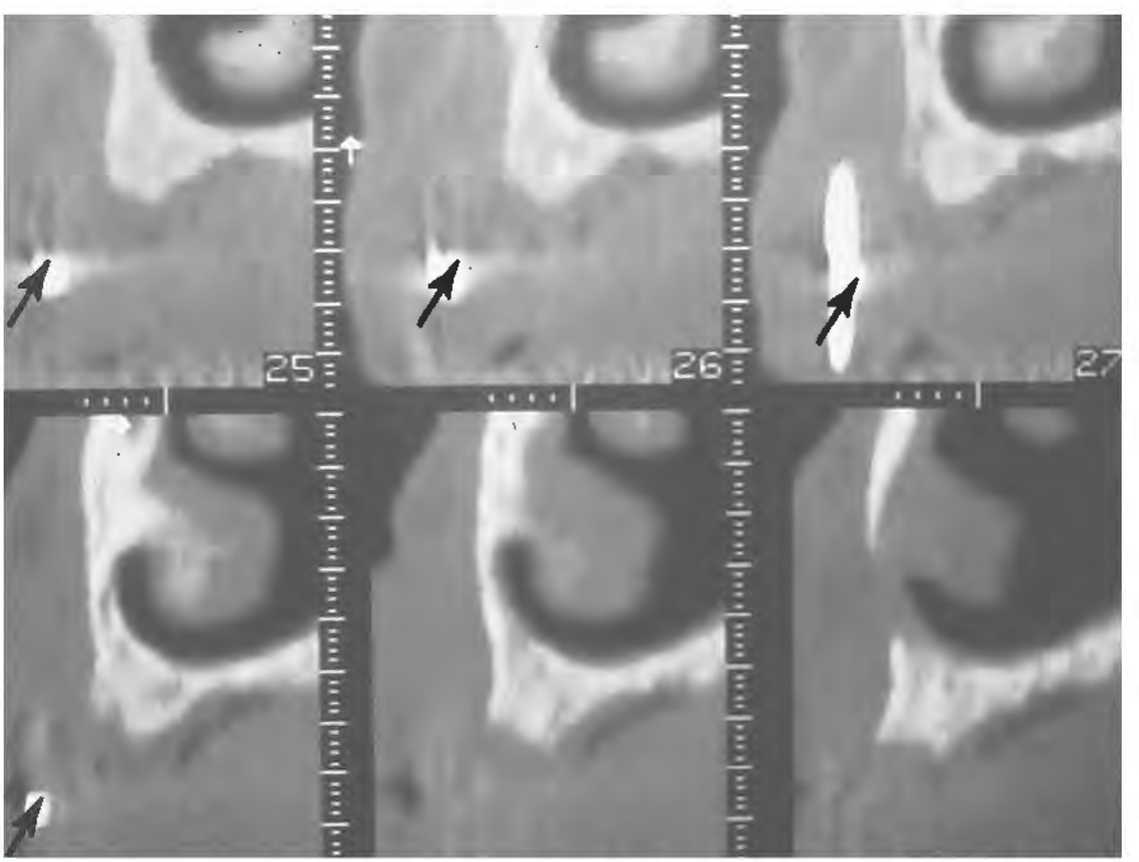


FIGURE 4-43. The cross-sectional views that show the radiopaque markers *(arrows)* identify anatomic locations and axial inclinations of proposed implants. These make implant placement more precise with regard to site and angulation when the template is used as a surgical guide during subsequent surgical visits.

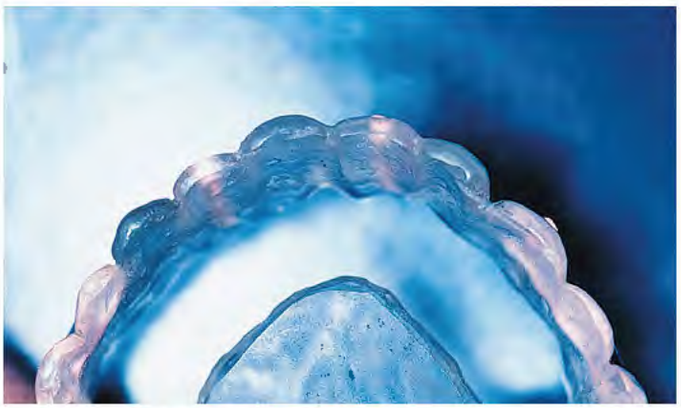


FIGURE 4-44. The surgical guide is prepared by removing a lingually placed trough of acrylic; this permits exposure of the ridge but allows the labial surfaces of the teeth to remain intact so that they can serve as indicators for implant placement and angulation.

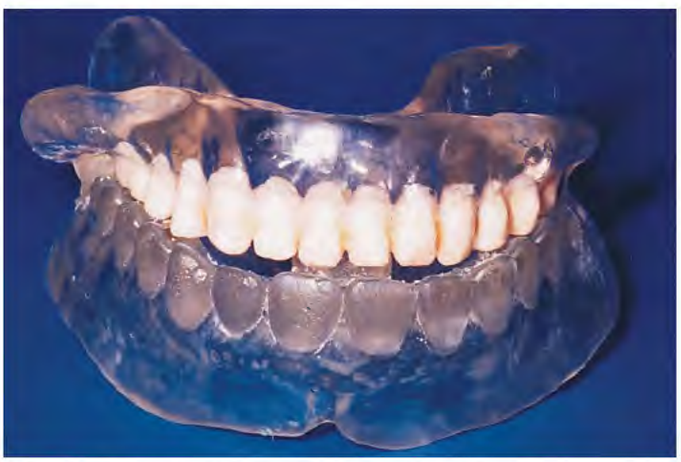


FIGURE 4-45. A guidance appliance with radiopaque teeth can be made for the CT scan by mixing Hypaque (available from a surgical supply company) with self-curing acrylic in a 25% to 75% ratio for the tooth portions of the denture replica. (Courtesy Dr. Milos Boskovic.)

- Scan limits for the maxilla. The superior border of the scan should be placed just above the infraorbital foramina, and the inferior border should be located just below the occlusal plane of the maxillary dentition, also marked by a gutta percha line in the splint.
- Take slices that are 1.5 mm thick at 1-mm intervals (this allows 0.25-mm overlapping of each cut and ensures greater accuracy).
- Make the images life size.
- Use the splint made for the patient.

IMPORTANT NOTE

Metals cause blurring of the image, and information will be lost or distorted by artifact (Fig. 4-48). Therefore, if metals are left in the patient's mouth, the resulting films may not be diagnostic or even readable. Because CT imaging programs are multiplanar, only slices that actually contain metal restorations will have artifacts. However, for the most accurate and diagnostic films, all metal restorations should be removed from the arch to be scanned and replaced with composite, acrylic, or other nonmetallic materials. Pure titanium doses not cause severe artifacts and affects the CT minimally, if at all. Titanium alloy causes some artifact, but the films produced usually are quite readable.

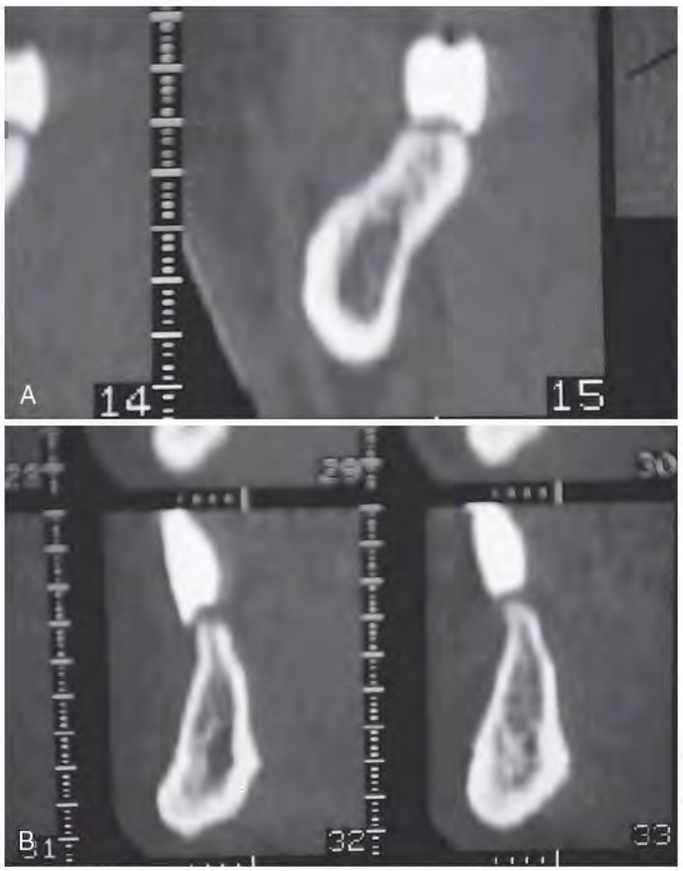


FIGURE 4-46. The images obtained with the appliance from Fig. 4-45 clearly show the position of each denture tooth as it relates to the underlying bone structure. This clarity is a result of the addition of Hypaque to each tooth indentation.

Ideally, the referring practitioner should be present for scans taken of the first few patients to ensure that all instructions are followed. The radiologist and the radiology technician may take a CT scan that is believed to comply with the requirements of the software program, but if the instructions are not followed carefully, the resulting films may be of little diagnostic value.

For patients who are claustrophobic, an anesthesiologist or the referring practitioner must be present (along with appropriate resuscitative equipment) to administer intravenous (IV) sedation as required (e.g., diazepam, 5 to 10 mg; midazolam, 1 to 3 mg). Such medication also is helpful for patients with neuromuscular disorders such as cerebral palsy, Parkinson's disease, or chorea.

Interpretation

The following instructions are specifically for scans taken with the Columbia Scientific software.

The scout film is a lateral, two-dimensional view of the head. Two parallel dotted lines may be seen that show the superior and the inferior limits (perimeters) of the scan. These dotted lines should be parallel to the plane of occlusion set by the horizontal grooves filled with gutta percha and not to the inferior border of the mandible or the alveolar crest of the maxilla. The prescriber should be present for the first several cases before the scanning is done, because this view can be seen on the monitor, and any corrections of the head position can be suggested before total irradiation is started (see Fig. 4-42).

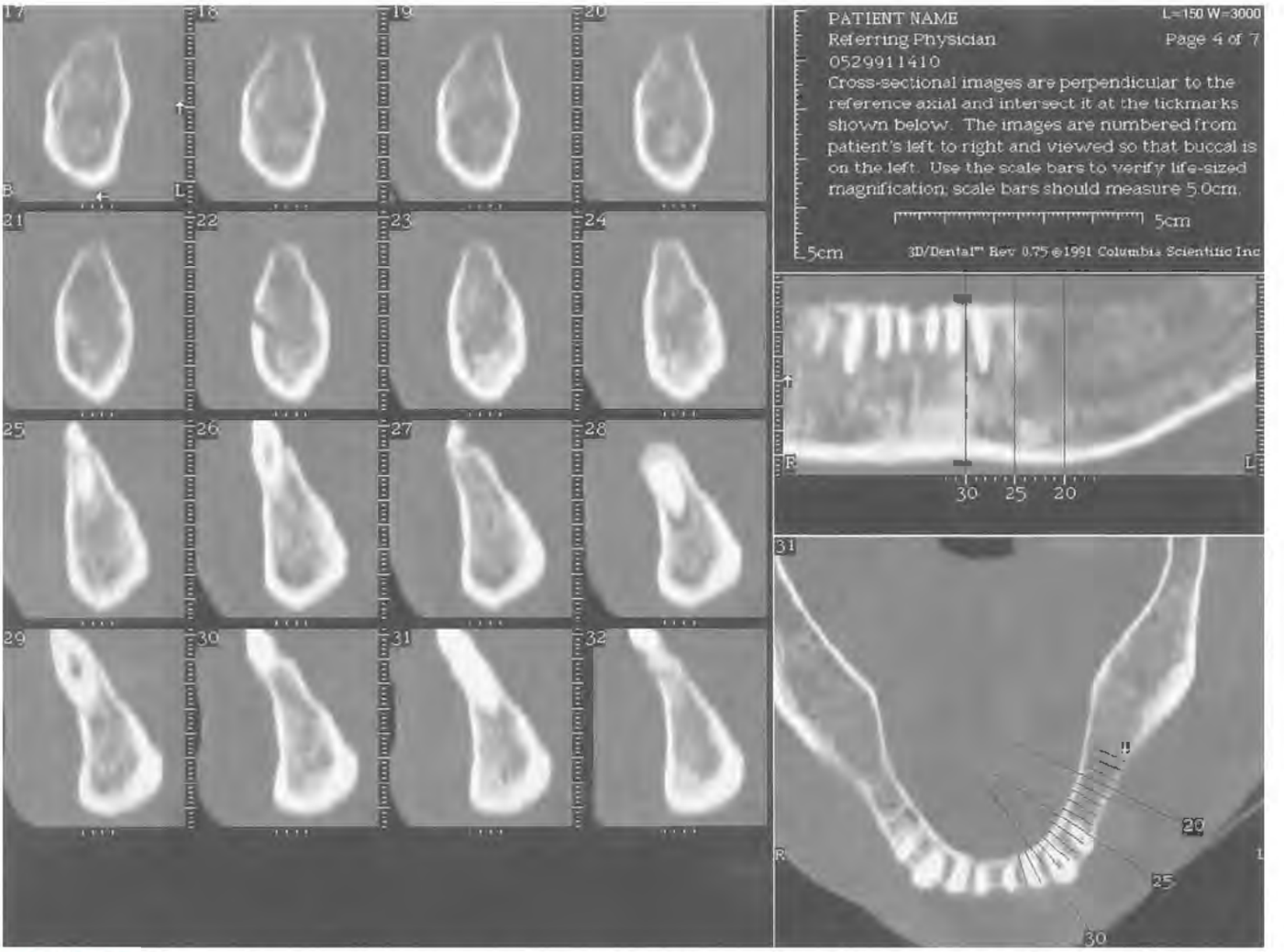


FIGURE 4-47. The (mandibular) transaxial occlusal view *(lower right)* includes cuts 17 through 32, of the total of more than 60 shown on the original image. Each of these lines refers to a single cross-sectional image, shown in the numbered boxes on the left. Box 22 shows the mental foramen; box 25 shows the most distal tooth, and box 19 shows the location and size of the mandibular canal. An additional dimension that may be used for substantiation is the panographic view *(upper right),* which is marked with the same cross-sectional numbers.

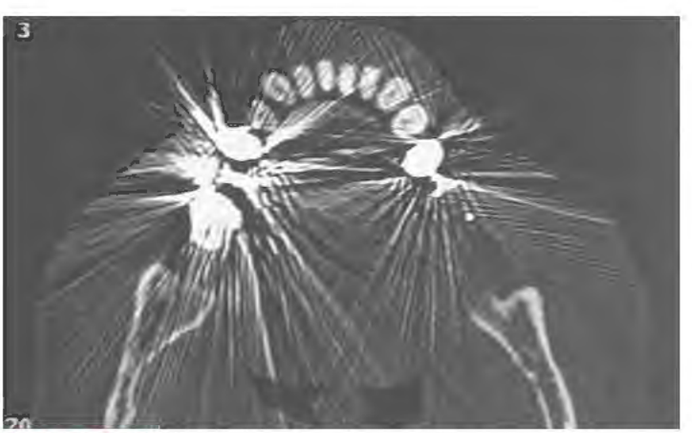


FIGURE 4-48. Scatter or artifact is caused by the presence of nontitanium metals in the teeth of the jaw being scanned. This phenomenon renders the image useless.

The next view is a single horizontal (occlusal) slice through the mandible or maxilla. In this view, a section through the entire arch may be seen. Lines are numbered approximately from 1 to 60, crossing from buccal to lingual. More or fewer lines are present, depending on the size of the jaw (see Fig. 4-25). These lines can be used to cross-reference a series of separate cross-sectional views, each in its own small box (Figs. 4-47 and 4-49).

The several horizontal (or occlusal) views are supplied with up to five orientation lines, which follow the jaw's contours and proceed from buccal to lingual. These black lines show the planes through which the five panoramic views were taken (Fig. 4-50).

Beneath each of the panoramic views are vertical lines that appear to be a scale. Each of these lines indicates the location of a cross section as numbered. These represent the same lines seen in the occlusal view and serve as references to the numbered cross-sectional views (see Fig. 4-47), as well as to the markings beneath the panoramic view (see Fig. 4-50).

The most important images for diagnostic use in planning the placement of endosteal implants are the cross-sectional views. Each is numbered for ease of cross-referencing. The number is at the bottom right corner of each image. For further clarification, a segmental, cross-referenced occlusal image appears to the side of each group of boxes to show which section of the mandible or maxilla the several cross sections represent.

Scans with radiopaque dental markers are particularly helpful for the diagnostic evaluation; because each marker is known to be

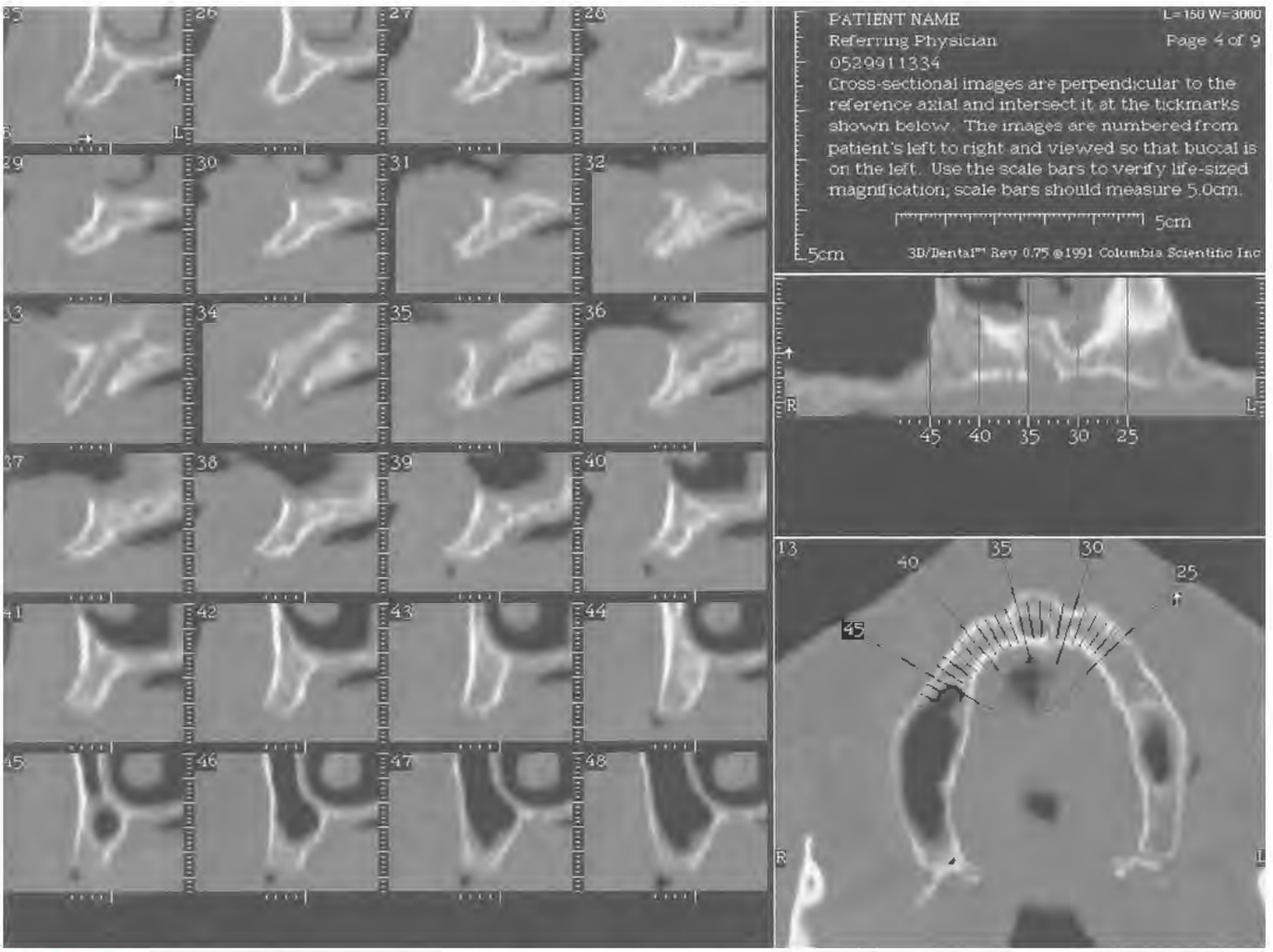


FIGURE 4-49. These views of the maxilla show slices 25 to 48. Included in the cross-sectional boxes are the incisive foramen and canal (33), the anterior nasal spine and floor (35), the anterior extent of the antrum (45), and the alveolar ridge and sinus floor relationship (48). Correlations may be seen in the occlusal views *(lower right)* and panoramic views *(upper right)*.

10 mm long, the practitioner can check the dimensional accuracy by measuring the markers on the images (Fig. 4-51).

The occlusal views clearly show the location of each marker (and therefore each tooth) as identified by the 14 dots and by the lines delineating the cross-sectional boxes (Fig. 4-52). These markers then can be seen in the appropriately numbered cross-sectional boxes (see Fig. 4-51).

After the flaps have been reflected during stage I surgery, the sterilized template is placed in position. The template's flange not only retracts the labiobuccal mucoperiosteal flaps, it allows the location of each marker to be transferred directly to the underlying bone (Fig. 4-53). As a result, at the time of surgery, the density, anatomy, and dimensions of each specific clinical-surgical site can be related to the associated cross section (see Fig. 4-51).

For extrapolation of accurate measurements, a pointing arrow shows where counting should begin (see Fig. 4-47). These images have vertical and horizontal scales in the upper right corner; both scales should be measured, and each should measure 5 cm. This confirms that the images are life size and can be measured in actual millimeters. If the scales do not measure 5 cm, the views do not represent life-size imaging. In such cases, the distance of interest should be measured on the image (MD); then, the 5-cm vertical scale (MSC) should be measured. These values (in millimeters) are used in the following formula:

$$\frac{\text{AD}}{\text{MD}} = \frac{50\text{ mm}}{\text{MSC}}$$

where *AD* is the actual distance and *50 mm* is the actual scale size. The equation then is solved for AD. This provides the actual distance, compensating for distortion.

Calipers also can be used to measure the distance in question. The calipers are opened to 5 cm, the caliper points are transferred to the 5-cm scale (see Fig. 4-47), and the lines between the caliper tips are counted as if they were millimeters; this is the actual distance. However, not all views are life size. Actual measurements may be taken only from the "master" (see Fig. 4-49). Other views can be used only for cross-referencing.

The Columbia Scientific software allows visualization of actual implant dimensions and locations directly on the CT scans in all three dimensions. Adding the values of three-dimensional imaging to the armamentarium provides the implantologist with great ease and accuracy and enhances technical skills. Three-dimensional images at several different angles (Fig. 4-54) show how the maxilla or mandible would appear if stripped of all soft tissues. They can

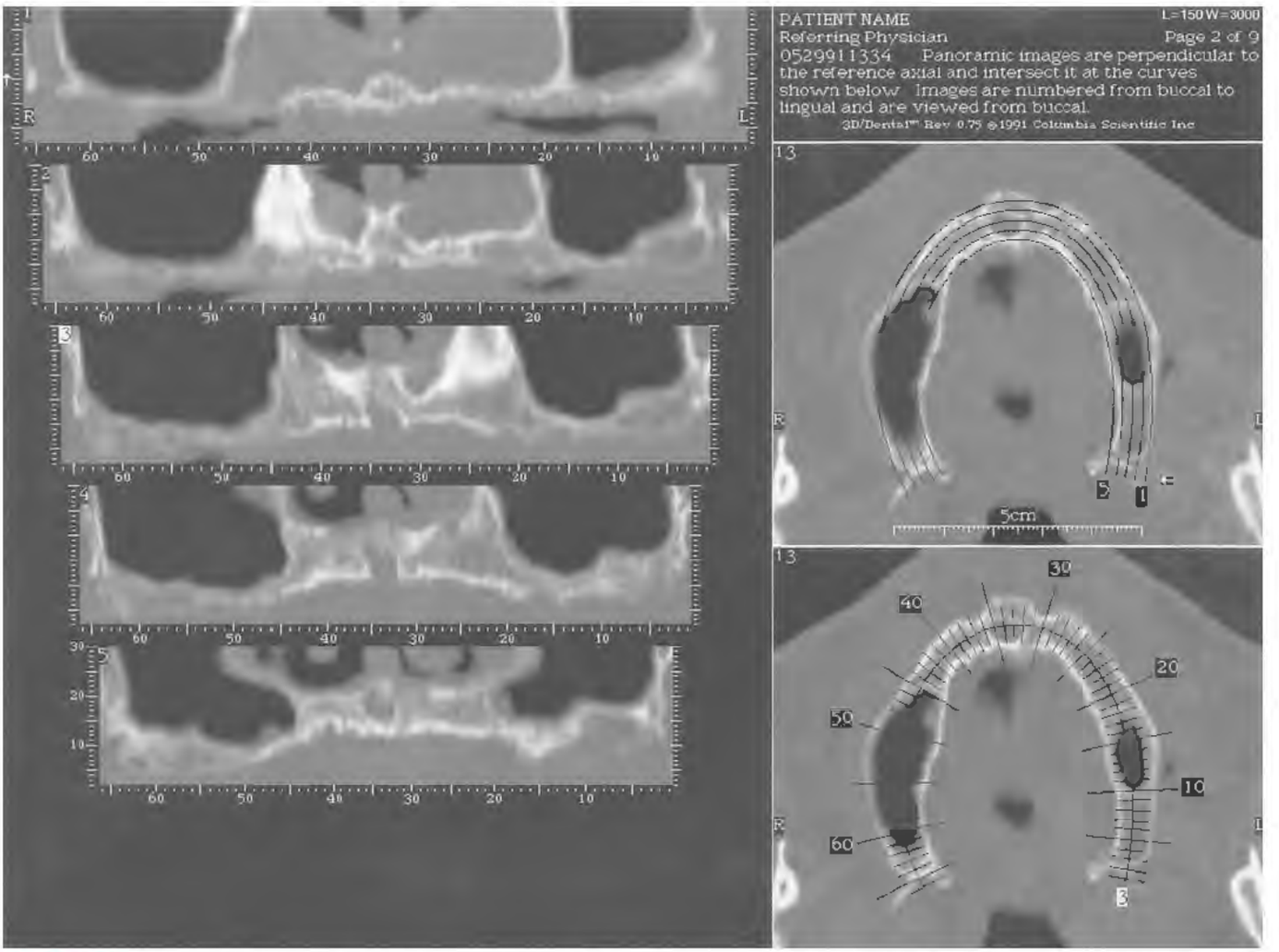


FIGURE 4-50. A maxillary transaxial (occlusal) view *(top right)* shows the five levels of cuts, from buccal to palatal, represented by the five panoramic images on the left. The crosscuts (1 through 67) on the transaxial image at the bottom right refer to cross-sectional boxes 25 through 48 shown in Fig. 4-49, as well as to the numbered vertical lines below the panoramic images.

give the surgeon a perspective on the operative areas, but they should not be used for measurements.

At this point, the visual, digital, bone sounding, interocclusal, radiographic, and photographic examinations have been completed; therefore, the most comprehensive evaluation of the potential host sites possible, short of exploratory surgery, has been performed. The information that has been gathered includes the ridge height, width, and anteroposterior length; the locations of the nasal floor, antra, foramina, and canals; the existing interocclusal distances; the periodontal status of remaining teeth; and the amount of healthy attached gingiva. Armed with this body of data and the prosthetic treatment plan, the surgeon may now select the best implant modality with which to restore the patient's dentition. (The implant selection charts in Tables 4-1, 4-2, and 4-3 offer invaluable help for the clinician in implant selection.)

CAVEAT

As radiologists become more comfortable with Dentascan, they offer increasing levels of assistance by selecting implants of specific dimensions and superimposing them at sites selected by them. Although this may be of ancillary assistance, the final decision as to the number of implants, their sizes, angulations, and locations must be left solely to the implantologist. Figs. 4-55 and 4-56, from an actual clinical case, present examples of the radiologist's suggestions and the actual sites of implantation. Not only were some of the sites inappropriate, but several satisfactory sites were overlooked. Essentially, images can be great aids to the surgeon; however, nothing can replace direct clinical views and intraoperative measurements and judgment.

IMPORTANT NOTE

A measurement is made (and recorded) between the ridge crest and one of the following four anatomic structures:

- Mandibular canal, including the mental foramen
- Antral floor
- Nasal floor
- Inferior border of the mandible (symphysis area; CT imaging helps)

If narrow crestal bone can be flattened to create a sufficiently wide plateau to allow placement of root form implants, depth will have been sacrificed and must be reassessed.

The diameters of root form implants range from 3.25 to 6.3 mm, and the implants range from 7 to 20 mm in length. (Most often, 1 mm of additional bone depth is required.) Table 4-2 describes each root form system according to available implant types and dimensions (Fig. 4-57).

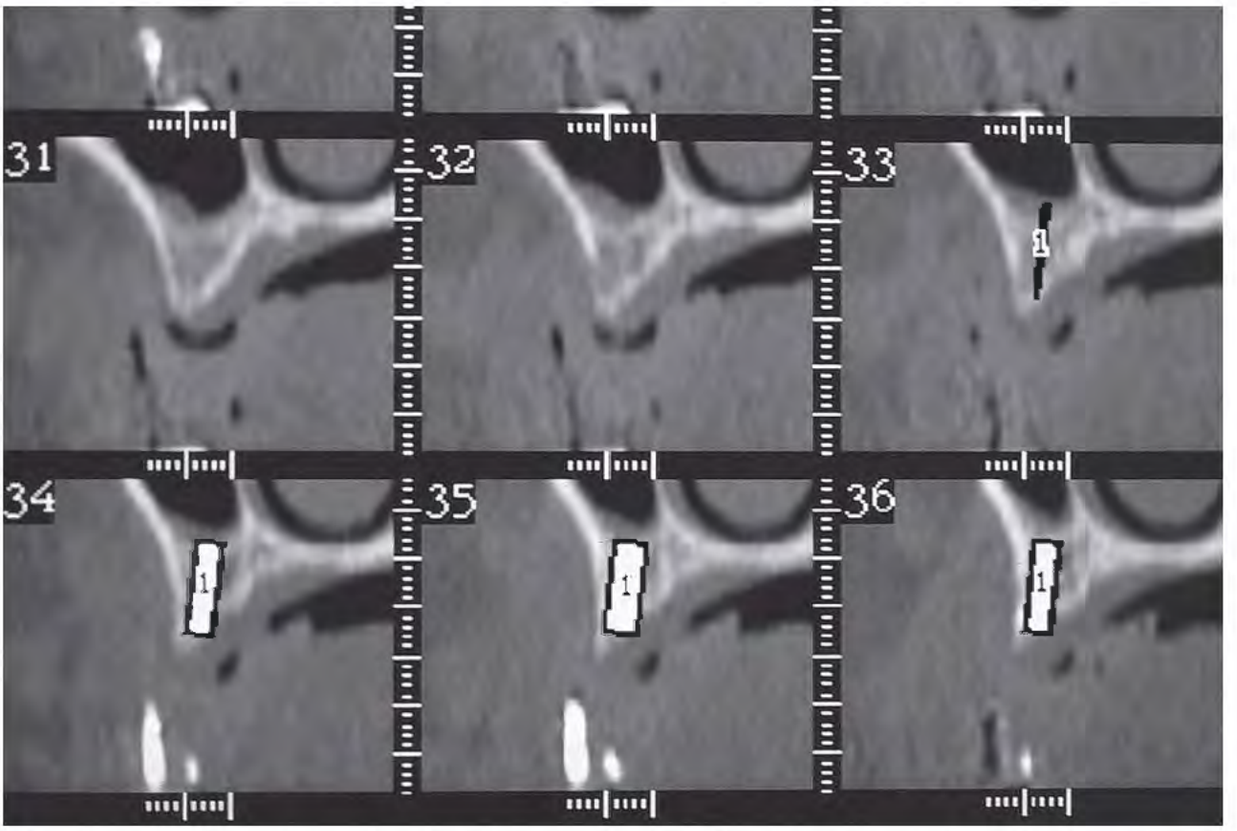


FIGURE 4-51. These cross-sectional views (e.g., box 35) serve as the final arbiters in the determination of operative sites and the localization of vital structures. They are identified by the presence of the markers and can be localized clinically using the surgical template over the exposed bone, thereby coordinating the entire system.

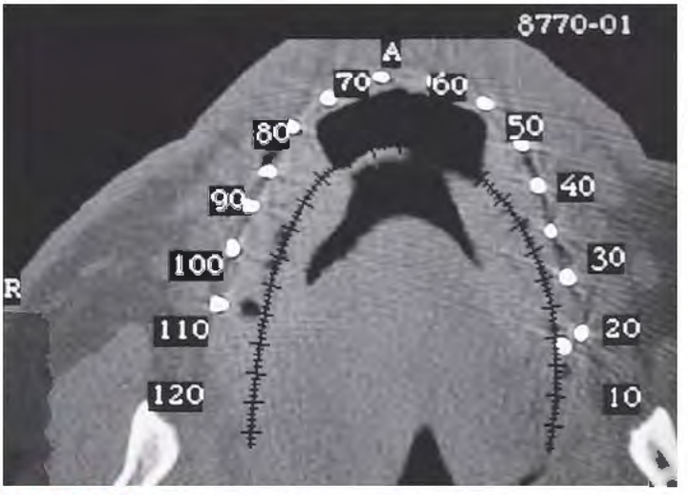


FIGURE 4-52. This occlusal image clearly marks the location of each of the 14 teeth, as indicated by the vertical radiopaque markings placed in the radiographic template (see well-defined dots). When this device is used as a surgical template, it is placed over the exposed bone, and any specific anatomic site can be localized and related directly to the cross-sectional views on the Dentascan, which will be seen to demonstrate the images of the same radiopaque markers.

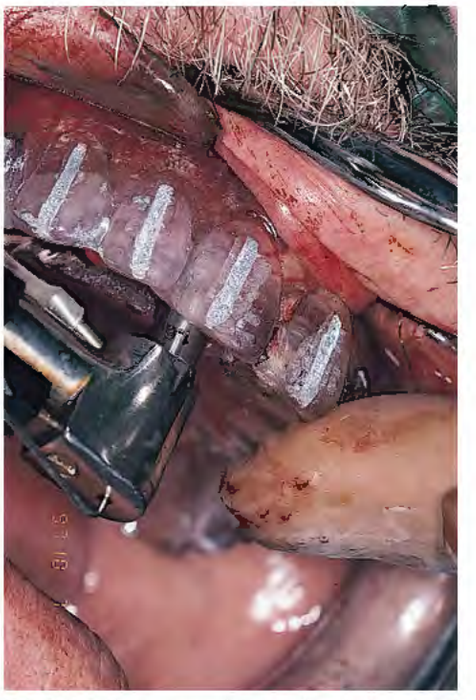


FIGURE 4-53. After the appropriate occlusal view has been localized by counting dots, the surgical template is positioned over the exposed bone and the site is identified clinically.

If the examination findings do not meet the bone requirements for root forms, see chapters 11 through 15 and 17 and 18 (which describe subperiosteal, blade, transosteal, Crête Mince, threaded dowels, and intramucosal insert techniques).

The spacing between root form implants should be 3 mm. A distance of 1.5 to 2 mm is required between natural teeth and root form implants to preserve or create the interdental papillae.

The maximum number of implants need not be placed. Subsequent chapters, on prosthetic designs, present information to aid the implantologist in choosing the appropriate number of implant. In less dense bone, the largest number of implants that available space permits should be used, even if the implants' diameters are of the smallest categories. Rough coatings (titanium plasma spray [TPS] and hydroxyapatite [HA]) also help by creating maximal interfacial areas.

Photography

A significant part of the preoperative workup must include intraoral and facial photography. Facial imaging should include lateral and full face views with a plain beige or light blue background. The practitioner should take care not to place the lighting such that a shadow of the patient's face and head is cast on the background.

Intraoral photography is best done using glare-proof, plastic lip retractors. A variety of views should be obtained to demonstrate each area of importance. Front surface mirrors, warmed to prevent fogging, are beneficial in recording palatal anatomy.

Intraoperative photography is valuable as a teaching aid and to document various phases of treatment for medicolegal reasons. For these purposes, dull-coated retractors offer the best photographic opportunities. because the strobe light of the photographic unit does not disturb the image with a blinding glare. Beaver tail and other retractors can be coated inexpensively with matte-finished Teflon.

Many well-known photographic units are available, but the simplest to use that produces a high number of successful pictures is the Canon 40D digital camera with a Ring and Point Flash and a Macro Zoom lens (Fig. 4-58).

SURGICAL ANATOMY

Implant surgeons must be knowledgeable about anatomy. Whether the plan is to insert an endosteal or a subperiosteal implant, certain critical landmarks and boundaries must be kept constantly in mind. This section lists and describes those foramina, canals and their contents, natural cavities, and other potential anatomic pitfalls that

Text continued on page 53

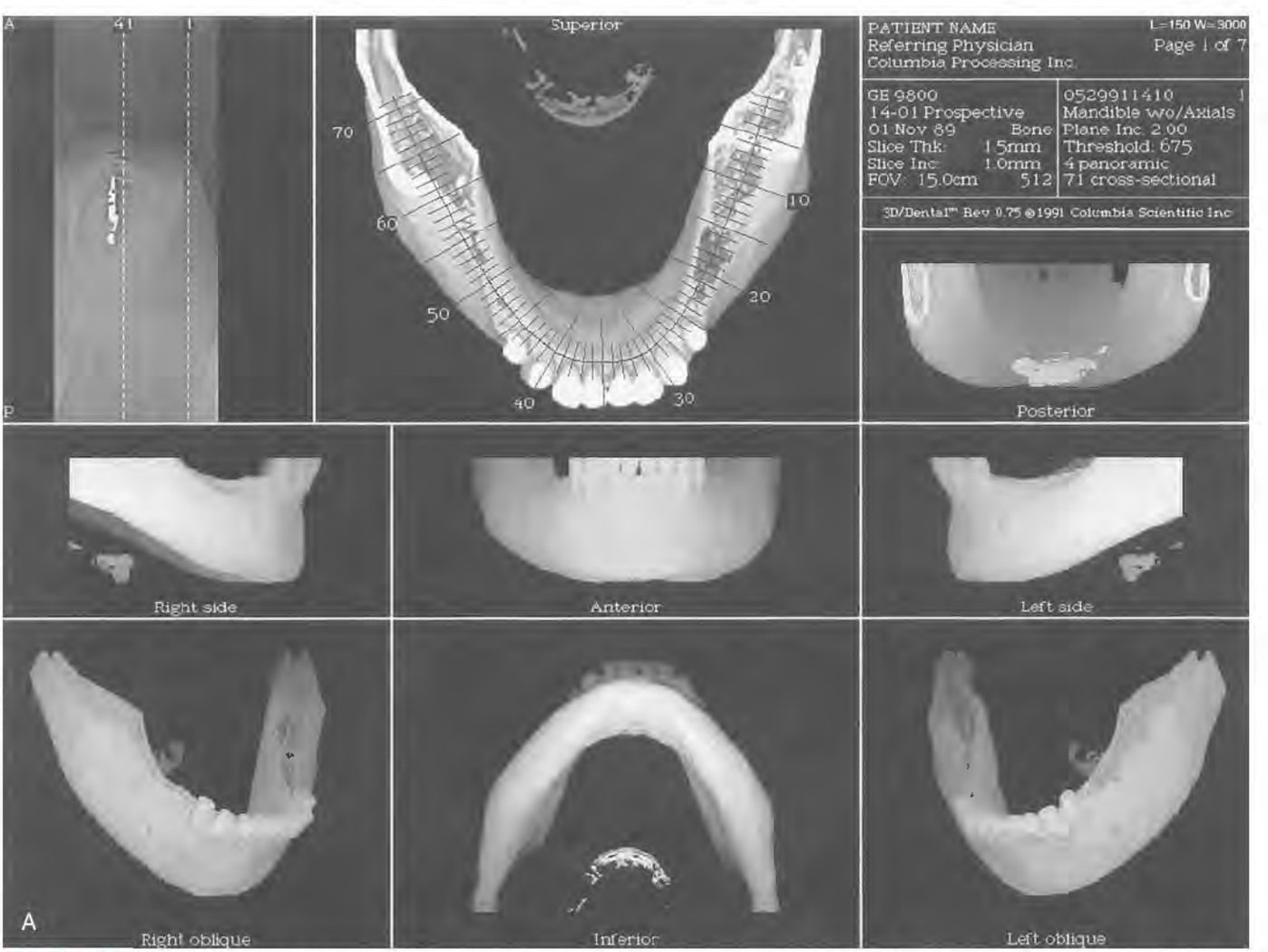


FIGURE 4-54. **A,** The software program reconstructs the scanner slices into three-dimensional views. Not only do the images represent the bony surfaces; as can be seen in the bottom row center (Fig. 4-54, *B*), they also offer a clear midstructural perspective through the maxillary sinuses and nose. These pictures, although not of value for making measurements, point out irregularities, imperfections, and other internal and external surface characteristics.

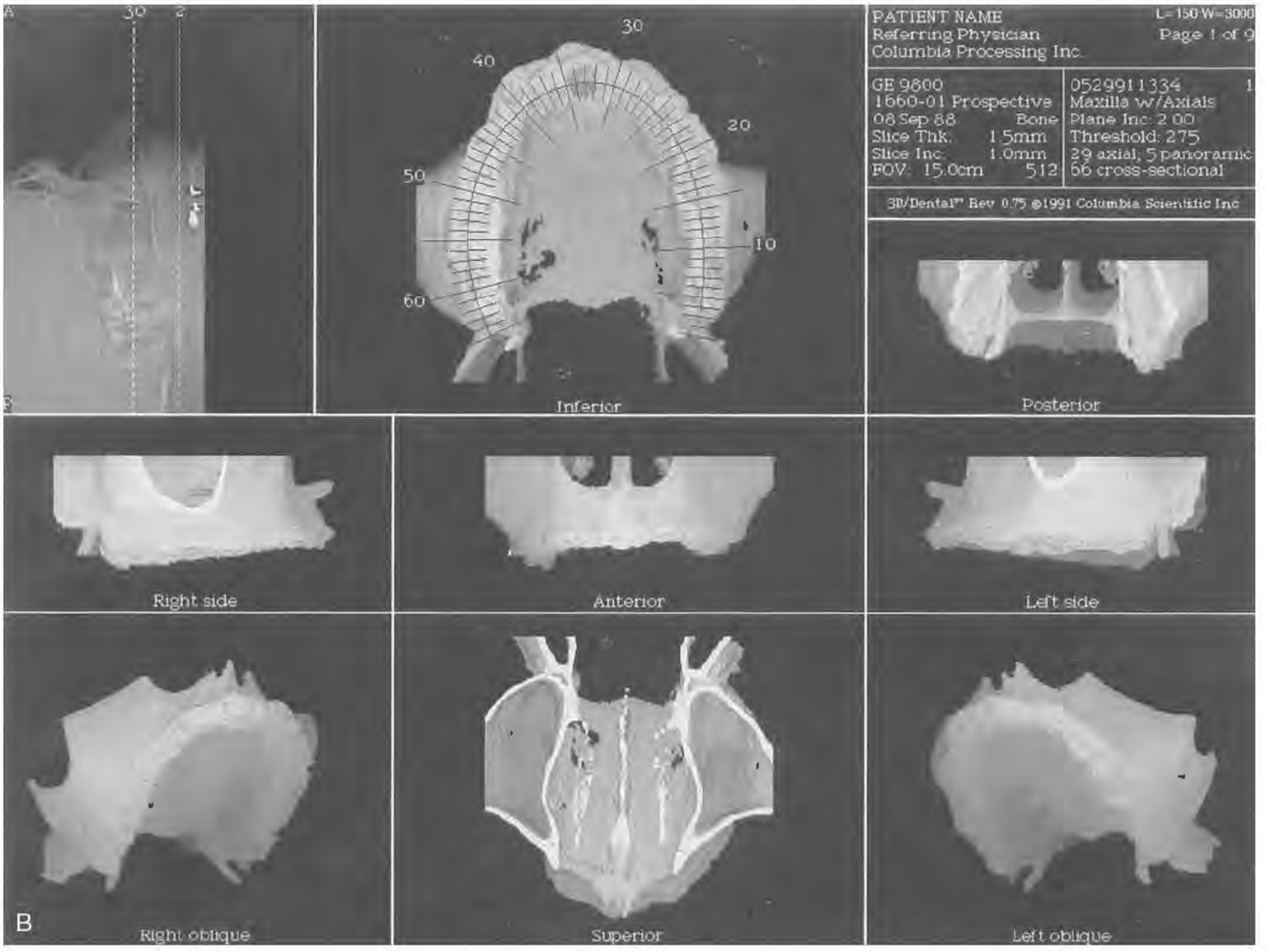


FIGURE 4-54, cont'd. **B,** Maxillary reformatting is important before soft tissue reflection and for verification of CAD-CAM model accuracy.

Table 4-1 Implant Selection Based on Available Bone and Bone Density

	Width (A)	Ridge Depth (B)	Length (C)	Implant Type Recommended
Available bone	0-3 mm	0-6 mm	0-7 mm	Subperiosteal D
	3-5 mm	>8 mm	>10 mm	Blade D
	>5 mm	>8 mm	6-25 mm	1 root form E
		>10 mm	16-23 mm	2 root forms
			24-31 mm	3 root forms
			>31 mm	1 root form for each additional 7 mm of ridge length F

Notes:

A. If narrow crestal bone can be flattened to create a sufficiently wide plateau to permit placement of a root form implant, the available depth must be reassessed (see below).

B. A measurement is taken and recorded between the ridge crest and one of four anatomic structures:
   1. Mandibular canal, mental foramen
   2. Antral floor
   3. Nasal floor
   4. Inferior border of mandible (symphysis area) (CT imaging helps)

C. The diameter of root form implants ranges from 3.25 to 6.3 mm, and the length ranges from 7 to 20 mm. (Most often, 1 mm of additional bone depth is required.) Table 4-2 describes each implant system according to the available types.

D. If the findings do not meet the bone requirements for root forms, see chapters 11 to 15 and 17 and 18 (these chapters describe subperiosteal, blade, transosteal, Crête Mince, threaded dowels, and intramucosal insert techniques).

E. The spacing between root form implants should equal the diameter of one implant.

F. The maximum number of implants need not be placed. Information to assist the practitioner in choosing the appropriate number of implants is presented in subsequent chapters.

G. In bone that is less dense, the implantologist should use as many implants as the available space permits, even if their diameters are of the smallest categories. Rough coatings (TPS, HA) help by creating maximum interfacial areas.

Table 4-2 Root Form Selection*

Company	Product Line	Material	Character	Mode	Stage	Surface	Primary Retention
Nobel Biocare							
	Nobel Active	Titanium oxide	Threaded	Microscopic Grooves	1 and 2	Ti-Unite	Threaded
			Tapered Walls				Surface Texture
	Nobel Replace tapered Groovy (Full coating)	Titanium oxide	Threaded	Microscopic Grooves	1 and 2	Ti-Unite	Threaded
			Tapered Walls				Surface Texture
	Nobel Replace straight Groovy	Titanium oxide	Threaded	Microscopic Grooves	1 and 2	Ti-Unite	Threaded
	(Full coating)		Straight Walls				
	Nobel Speedy	Titanium oxide	Threaded	Microscopic Grooves	1 and 2	Ti-Unite	Threaded
			Slightly Tapered				
	Replace Select Tapered (1.5 mm Machined collar)	Titanium oxide	Threaded	Microscopic Grooves	1 and 2	Ti-Unite	Threaded
			Tapered Walls				Surface Texture
	Branemark System MkIII Groovy	Titanium oxide	Threaded		1 and 2	Ti-Unite	Threaded
			Straight Walls				
3i							
	Certain Prevail	Titanium nitride	Threaded				
	Certain Prevail (Straight collar)				1 and 2	OSSEOTITE	Threaded
	Certain Prevail (Expanded platform)				1 and 2	OSSEOTITE	
	Certain Prevail (Straight collar)				1 and 2	NanoTite	
	Certain Prevail (Expanded platform)				1 and 2	NanoTite	
	Tapered Prevail				1 and 2	NanoTite	
	Certain						
	Certain				1 and 2	OSSEOTITE	Threaded
	Certain				1 and 2	OSSEOTITE	
	Certain				1 and 2	NanoTite	
	Certain				1 and 2	NanoTite	
	Tapered Certain				1 and 2	NanoTite	
	XP				1 and 2	OSSEOTITE	
	XP				1 and 2	OSSEOTITE	
	NT				1 and 2	OSSEOTITE	
Neoss	Implant Kit	CP Grade IV Titanium	Threaded, parallel walls		1 and 2	Bimodal surface	Threaded

EP, Extended platform; *HA,* hydroxyapatite; *RBM,* resorbable blast medium; *TPS,* titanium plasma spray; *UCLA,* universal custom laboratory abutment.
*See chapters 10 and 11 for specific information, illustrations, and directions for insertion.

Length (mm)	Diameter (mm)	Internal/External Cooling	Abutments	Restorative Options	Connection	Platform Switching	Immediate Load
8.5, 10, 11.5, 13, 15, 18	3.5, 4.3, 5.0	Internal	Standard Straight & Angled Prefabricated	All Indications	Internal	Yes	Yes
			Procera	Procera & Zirconia			
8, 10, 13, 16	3.5, 4.3, 5.0, 6.0	Internal	Zirconia	Individual Crowns	Internal	Yes	Yes
			Titanium Alloy	Fixed & Removable Bridges			
10, 11.5, 13, 15, (18)	3.5, 4.3, 5.0	Internal	UCLA	Fixed, Fixed Detachable, Removable Dentures	Internal		
10, 11.5, 13, 15, (18)	3.5, 4.3, 6.0	Internal			Internal		
10, 11.5, 13, 16, 18	5.0	Internal			Internal		
(8.5), 10, 11.5, 13, 15, (18)	3.5, 4.1, 5.1	External			External		
8, 10, 13, 16	3.5, 4.3, 5.0, 6.0	Internal			Internal	Yes	Yes
(8.5), 10, 11.5, 13, 15, (18)	3.5, 4.1, 5.1	External			External		
			Zirconia & Standard Straight				
8.5, 10, 11.5, 13, 15	4.0/4.1, 5.0/5.0	Internal			Internal	Yes	
8.5, 10, 11.5, 13, 15	3.25/4.1, 4.0/4.8, 5.0/5.8	Internal			Internal	Yes	
8.5, 10, 11.5, 13, 15	4.0/4.1, 5.0/5.0	Internal			Internal	Yes	
8.5, 10, 11.5, 13, 15	3.25/4.1, 4.0/4.8, 5.0/5.8	Internal			Internal	Yes	
8.5, 10, 11.5, 13, 15	4.0, 5.0, 6.0	Internal			Internal	Yes	
8.5, 10, 11.5, 13, 15, 18, (20)	3.25, 4.0, 5.0, 6.0	Internal			Internal		
(7.0), 8.5, 10, 11.5, 13, 15, 18, (20)	3.25, 4.0, 5.0, 6.0	External			External		
8.5, 10, 11.5, 13, 15, 18	3.25, 4.0, 5.0, 6.0	Internal			Internal		
(7.0), 8.5, 10, 11.5, 13, 15, 18	3.25, 4.0, 5.0, 6.0	External			External		
8.5, 10, 11.5, 13, 15	3.25, 4.0, 5.0, 6.0	Internal & External			Internal & External		
8.5, 10, 11.5, 13, 15	4.0/5.0, 5.0/6.0	Internal			Internal	Yes	
8.5, 10, 11.5, 13, 15, 18	3.25/4.1, 4.0/5.0, 5.0/6.0	External			External	Yes	
8.5, 10, 11.5, 13, 15	3.25, 4.0, 5.0, 6.0	Internal & External			Internal & External		
7, 9, 11, 13, 15, 17	3.5, 4.0, 4.5	Internal	Titanium Alloy & Gold		Internal with Hex Adapter	Yes	Yes
7, 9, 11, 13, 15	5.0						

Continued

Table 4-2 Root Form Selection—cont'd

Company	Product Line	Material	Character	Mode	Stage	Surface	Primary Retention
Astratech	OsseoSpeed	Titanium strile		Microthread	1 and 2	TiO_2-blasted and Fluoride enhanced	
BioHorizons	Internal		Threaded, parallel walls		1 and 2	Resorbable Blast Texturing or Hydroxyapatite	
	Single-Stage		Threaded, parallel walls		1 and 2	Resorbable Blast Texturing or Hydroxyapatite	
	External		Threaded, parallel walls		1 and 2	Resorbable Blast Texturing or Hydroxyapatite	
	Internal Tapered	Titanium alloy (Ti-6Al-4V)	Threaded, parallel walls		1 and 2	Resorbable Blast Texturing or Hydroxyapatite	
Straumann	Standard (2.8 mm Machined collar)	Grade 4 Titanium	Threaded, tapered wall		1 and 2	SLA	
					1 and 2	SLActive	
	Standard Plus (1.8 mm Machined collar)				1 and 2	SLA	
					1 and 2	SLActive	
	Tapered Effect (1.8 mm Machined collar)				1 and 2	SLA	
					1 and 2	SLActive	
	Bone Level				1 and 2	SLActive	
Keystone	XR1		Threaded		1 and 2	Sand blasted, acid-etched	
	PrimaConnex	Grade 5 Titanium	Threaded, tapered		1 and 2	Resorbable Blast Media	
		Grade 5 Titanium	Threaded, straight		1 and 2	Resorbable Blast Media	
	PrimaSolo	Grade 5 Titanium	Tapered		1	Resorbable Blast Media	
	Restore (RBM Threaded)		Threaded		1 and 2	Resorbable Blast Media	
	Restore (Titanium Threaded)		Threaded		1 and 2		
	Restore (HA Threaded)		Threaded		1 and 2	Hydroxyapatite (HA)	
	Renova		Threaded, tapered		1 and 2	Resorbable Blast Media	
			Threaded, straight		1 and 2	Resorbable Blast Media	
	Stage 1		Threaded		1 and 2	Resorbable Blast Media	
Bicon	Short Implant		Threaded		1 and 2	NanoTite	

Length (mm)	Diameter (mm)	Internal/External Cooling	Abutments	Restorative Options	Connection	Platform Switching	Immediate Load
7, 9, 11, 13	5.5						
11, 13, 15	3.0S	Internal			Internal double hexagon	Yes	
8, 9, 11, 13, 15, 17, 19	3.5S						
6, 8, 9, 11, 13, 15, 17, 19	4.0S						
9, 11, 13, 15, 17, 19	4.5, 5.0, 5.0S						
9, 10.5, 12, 15	3.5, 4, 5, 6				Internal		
7, 9, 10.5, 12, 15	3.5, 4, 5, 6				Internal	Yes	
9, 10.5, 12, 15	3.5, 4, 5, 6				External		
(7.5), 9, 10.5, 12, 15	3.8, 4.6, 5.8	Internal			Internal		
(6), 8, 10, 12, (14, 16)	3.3 RN, 4.1 RN, 4.8 RN, 4.8 WN	Internal			Internal	Yes	
(6), 8, 10, 12, (14, 16)	3.3 RN, 4.1 RN, 4.8 RN, 4.8 WN	Internal			Internal		
(6), 8, 10, 12, (14, 16)	3.3 NN, 3.3 RN, 4.1 RN, 4.8 RN, 4.8 WN	Internal			Internal	Yes	
(6), 8, 10, 12, (14, 16)	3.3 NN, 3.3 RN, 4.1 RN, 4.8 RN, 4.8 WN	Internal			Internal		
(8), 10, 12, 14	3.3 RN, 4.1 RN, 4.8 WN	Internal			Internal	Yes	Yes
(8), 10, 12, 14	3.3 RN, 4.1 RN, 4.8 WN	Internal			Internal		
8, 10, 12, 14	3.3 NC, 4.1 RC, 4.8 RC	Internal			Internal	Yes	
(6), 8, 10, 12, 14	3.3, 4.1, 4.8	Internal	Solid, Index, UCLA abutment, Locator		Internal	Yes	
10, 11.5, 13, 15	3.5, 4.1, 5.0	Internal			Internal		
(8), 10, 11.5, 13, (15)	3.3, 4.0, 5.0	Internal			Internal		
10, 11.5, 13, (15)	3.0, 3.5, 4.1, 5.0						
8, 10, 11.5, 13, 15	3.3, 3.75, 4.0, 5.0, 6.0	External			External		
8, 10, 11.5, 13, 15	3.3, 3.75, 4.0, 5.0	External			External		
8, 10, 11.5, 13, 15	3.3, 3.75, 4.0, 5.0	External			External		
(8.5), 10, 11.5, 13, (14.5)	3.75, 4.5	Internal			Internal		
8, 10, 11.5, 13, 16	3.75, 4.75	Internal			Internal		
8, 10, 12, 14, (16)	3.3, 4.1, 4.8, 5.5, 6.3	Internal			Internal	Yes	
8, 11 6, 8, 11	3.5, 4.0 4.5	Internal			Internal	Yes	

Continued

Table 4-2 Root Form Selection—cont'd

Company	Product Line	Material	Character	Mode	Stage	Surface	Primary Retention
Zimmer	Tapered Screw-Vent		Threaded, Tapered		1 and 2	MTX Microtextured Surface or MP-1 HA Coating	
	Advent		Threaded, Tapered		1 and 2	MTX Microtextured Surface or MP-1 HA Coating	
	One-Piece		Threaded, Tapered		1		
Sybron	Pro XRT		Threaded, Straight		1 and 2	Resorbable Blast Media	
	Pro TL (Collar 1.8 mm)				1 and 2	Resorbable Blast Media	
	Pro TL (Collar 2.8 mm)				1 and 2	Resorbable Blast Media	
	Endopore		Pressfit-Tapered & Threaded-Straight		1 and 2	Porous	
					1 and 2	Porous	
	Pitt-Easy	Pure titanium	Threaded, Straight		1 and 2	Vacum titanium plasma spray	
Camlog	Screwline		Threaded, Straight		1 and 2	Promote suraface (Abrasive-blasted and acid-etched)	
	Rootline		Threaded, Tapered		1 and 2	Promote suraface (Abrasive-blasted and acid-etched)	
	Cylinder		Pressfit, Straight		1 and 2	Titanium-plasma-sprayed (TPS)	
	ScrewCylinder		Pessfit-Threaded, Straight		1 and 2	Promote suraface (Abrasive-blasted and acid-etched)	
Imtec	Endure	Grade IV CP Titanium	Threaded, Tapered		1 and 2	Triple Micro Threading	
	Hexed-Head		Threaded, Straight		1 and 2	Sandblasted, Large grit, Acid-etched (SLA)	
	Hexed-Head		Threaded, Straight		1 and 2	Hydroxyapatite (HA)	
	Hexed-Head		Threaded, Straight		1 and 2	Titanium plasma sprayed (TPS)	
	MTI	Titanium alloy	Threaded, Tapered		1		
Dentsply	Ankylos	Uncoated pure titanium (Grade2)	Threaded		1 and 2		
	Frialit-plus		Threaded		1 and 2	Gritblasted/ acid-etched surface	
			Threaded		1 and 2		
	XiVE plus		Threaded		1 and 2		
	XiVE TG		Threaded		1 and 2		

Length (mm)	Diameter (mm)	Internal/External Cooling	Abutments	Restorative Options	Connection	Platform Switching	Immediate Load
5, 6, 8, 11	5.0						
5, 5.7, 8	6.0						
8, 10, 11.5, 13, 16	3.7, 4.1, 4.7, 6.0	Internal			Internal		Yes
8, 10, 13, 16	3.7, 4.7	Internal			Internal	Yes	
10, 11.5, 13, 16	3.0, 3.7, 4.7				Internal		
9, 11, 13, 15	3.3, 4.1, 4.8	Internal			Internal	Yes	
7, 9, 11, 13	3.3, 4.1, 4.8	Internal			Internal	Yes	
6, 8, 10, 12, 14	3.3, 4.1, 4.8	Internal			Internal	Yes	
7, 9, 12	4.1, 5.0	Internal			Internal		
(5), 7, 9, 12	3.5, 4.1, 5.0	External			External		
8, 10, 12, 14, (16)	3.25, 3.75, 4.0, 4.9, 6.5	Internal			Internal		
9, 11, 13, 16	3.3, 3.8, 4.3, 5.0, 6.0	Internal			Internal		
9, 11, 13, 16	3.3, 4.3, 5.0, 6.0	Internal			Internal		
9, 11, 13, 16	3.3, 3.8, 4.3, 5.0, 6.0	Internal			Internal		
9, 11, 13, 16	3.3, 4.3, 5.0, 6.0	Internal			Internal		
9, 11, 13, 15, (17)	3.5, 4.3, 5.1	Internal			Internal		
(5), 8, 11, (13, 15, 18, 20)	3.75, 4.0, 4.7, 5.2	External			External		
8, (10, 11,) 13, (15, 20)	3.75, 4.7	External					
8, (10, 11,) 13, (15, 20)	3.75, 4.7	External					
10, 13, 15, 18	1.8, 2.1, 2.4			O-ring			Yes
8, 9.5, 11, 14, (17)	3.5, 4.5, 5.5, 7.0	Internal			Internal		
11, 13, 15	3.4, 3.8	Internal			Internal		
(8), 10, 13, 15	4.5, 5.5, 6.5	Internal			Internal		
(8, 9.5), 11, 13, 15, (18)	3.0, 3.4, 3.8, 4.5, 5.5	Internal					
(8), 9.5, 11, 13, 15, 18	3.4, 3.8, 4.5	Internal					

Table 4-3 Blade Selection

Name	Material	Stages	Surface	Modifiable	No. Heads
Park Startanius	Titanium CP	2	Fine texture	Yes	1 or 2
Park PD	Titanium CP	1	Stippled	Yes	1, 2, or 3
Miter Titanodont	Ti, Va, Al	2	Smooth	Yes	1 or 2
Ultimatics	Titanium CP	1 and 2	Textured	Yes	1, 2, or 3
Omni B-Series	Titanium CP	2	Sand-blasted	Custom designed	1
Oratronics	Titanium CP	1 and 2	Tissue-textured finish	Yes	1 and 2
Calcitek Bioblade	Titanium CP	2	HA coating	No	1 and 2
Core-Vent	Titanium CP	2	Acid-etched smooth	Yes	1
Sub-Vent					
Stryker	Ti, Va, Al	2	Plasma sprayed HA coating	Yes No	1 and 2
Denar	Ti, Va, Al	2	Machined smooth	Yes	1
Impladent	Titanium CP	1	Smooth Optional HA coating	No; blade is three-dimensional	1 and 2

CP, Commercially pure; *HA,* hydroxyapatite; *Ti,* titanium; *Va,* vanadium; *Al,* aluminum.

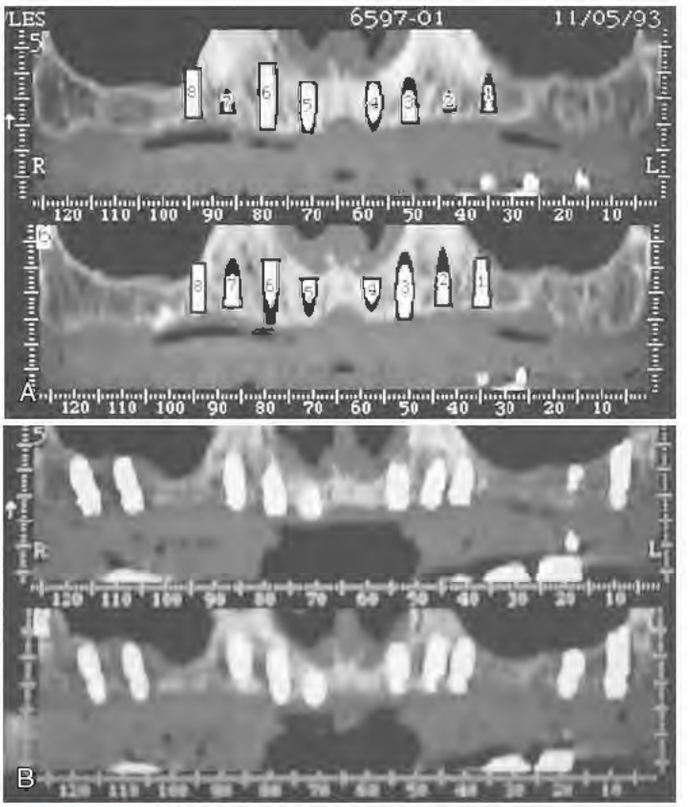


FIGURE 4-55. These two panoramic images produced by Dentascan were made 6 months apart. The first view indicates the sites and locations of eight implants recommended by the radiologist. After the unadorned preoperative cross sections were reviewed and then corroborated intraoperatively, only four of the recommended sites were selected for implantations, and none of the suggested sizes was chosen. Six sites that had not been recommended by the radiologist were used.

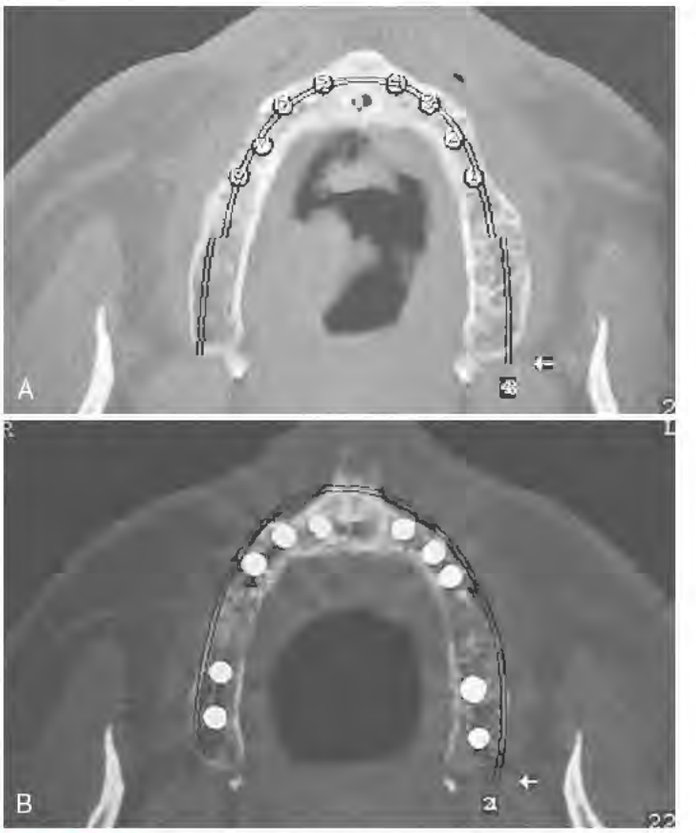


FIGURE 4-56. These occlusal images reinforce the selection of 10 sites **(A)** rather than 8 **(B)** and give a more satisfactory distribution of implant locations. The averages of dimension (width and length of implants divided by the number of implants) was 40% greater clinically than those suggested. **A** is the Dentascan with the suggested host site. **B** is the image obtained after placement of the actual implant.

FIGURE 4-57. A representative group of endosteal root form implants currently in use (see chapters 10 and 11).

FIGURE 4-58. A Digital SLR camera with synchronized external ring flash and a macro zoom lens.

can be responsible for complications and failure (Figs. 4-59 through 4-63). Chapter 9 presents information that can help the implantologist prepare for problems that may arise during surgery despite careful presurgical planning.

- Foramina
  - Infraorbital
  - Greater palatine
  - Lesser palatine
  - Incisive
  - Mandibular
  - Mental
  - Cervical colli
- Canals
  - Mandibular
  - Mental
  - Palatine
  - Incisive
- Fossae
  - Canine
  - Incisive
  - Submandibular
  - Sublingual
- Cavities
  - Nasal
  - Antral
- Nerves and neurovascular bundles
  - Mandibular
  - Greater palatine
  - Mental
  - Infraorbital
  - Incisive
  - Lingual
  - Long buccal

The anatomic structures described and illustrated demonstrate the most commonly found landmarks in the average adult patient. Of course, many variations exist, and the surgeon should be prepared for surprises, such as extra foramina (e.g., mental and lingual mandibular for cervical colli), double neurovascular bundles, deeper than average fossae, and plunging nasal or maxillary sinus cavities.

In addition, certain landmarks are important in the surgeries described in subsequent chapters. These landmarks are:

Anterior nasal spine
Zygomatic buttress
Hamulus
Lateral pterygoid plate
Medial pterygoid plate
Mental protuberance
Mylohyoid ridge
External oblique ridge
Mandibular angle
Sigmoid notch
Anterior border of ramus

Careful attention to the guidance offered in this chapter, coupled with a thorough knowledge of anatomy, puts the implantologist in the best position to perform the surgery with the fewest unexpected complications.

Anatomic Limitations

For successful implantation, the implant should be placed entirely in bone and away from vital anatomic structures (e.g., the antral floor, nasal floor, inferior alveolar canal, mental foramen, and roots of the proximal teeth). At least 1 mm of bone should be present on both the lingual and facial aspects of the bone, and the minimum distance between implants generally is accepted to be 3 mm. This space is needed to ensure bone viability between the implants and to allow for proper oral hygiene once the prosthetic reconstruction has been accomplished. Other guidelines include staying 2 mm above the superior aspect of the inferior alveolar canal; 6 mm anterior to the mental foramen, allowing for the anterior loop; 1 mm inferior to the antral and nasal floors; and 1 mm from the periodontal ligaments of the adjacent natural teeth (for that purpose, 2 mm of space should be left between implants and natural teeth).

After tooth loss, resorption of the ridge follows a pattern that results in the thinning of crestal bone and a change in the angulation of the residual ridge. These patterns of atrophy most often cause problems in the anterior mandible and maxilla. The irregular anatomy of the residual ridge can lead to problems achieving ideal implant angulation or adequate bone thickness along the labial aspect of the implant.

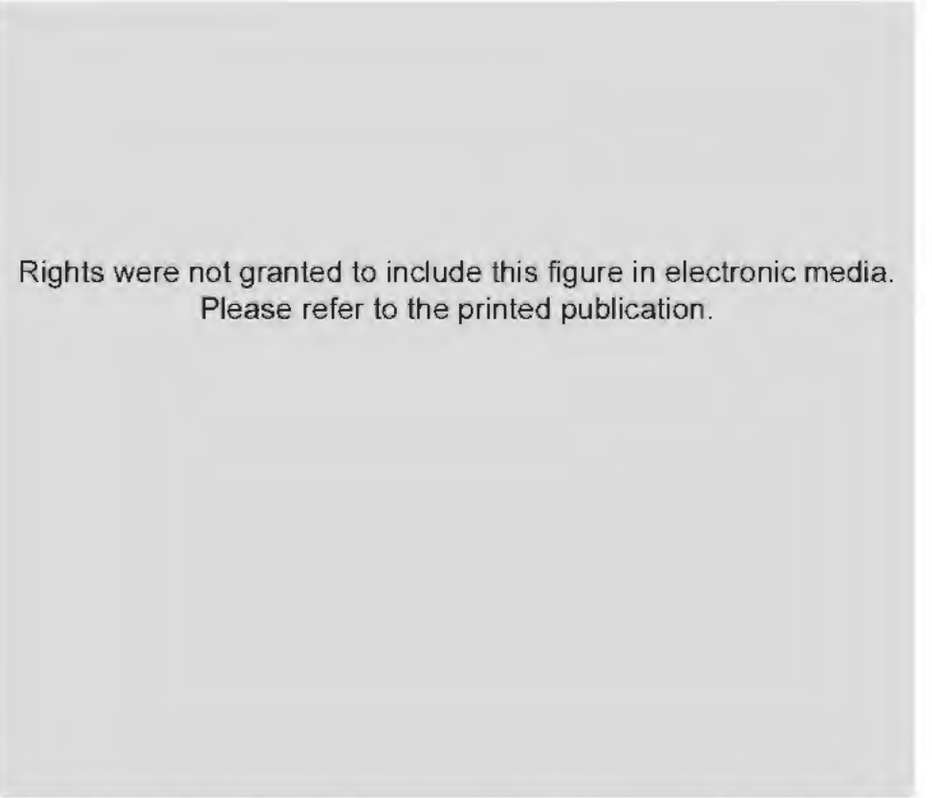


FIGURE 4-59. Frontal view of the skull. (Netter illustration used with permission of Elsevier Inc. All rights reserved.)

In the anterior maxilla, a minimum of 1 mm of bone should remain between the apex of the implant and the nasal vestibule. Because of the resorption of the anterior maxilla, the incisive foramen may be located near the residual ridge, especially in patients whose edentulous maxilla has been in function against a natural mandibular anterior dentition. Anterior maxillary teeth should be located slightly off midline, on either side of the incisive foramen.

Placement of implants in the posterior maxilla poses two specific concerns.

1. The bone is much less dense than in the posterior mandible and has larger medullary spaces and a thinner cortex, which can result in a longer healing time and the need for additional implants to support the prosthesis. Typically 6 months are required for adequate integration of implants placed in the maxilla. In addition, one implant for every missing tooth is recommended in the posterior maxilla.
2. The maxillary sinus is close to the edentulous ridge in the posterior maxilla. Because of the resorption of the bone and pneumatization of the sinuses, only a few millimeters of bone remain between the ridge and the sinus. There should be 1 mm of bone between the floor of the sinus and the apex of the implant so that the implant can be anchored apically into the cortical bone of the sinus floor. If ridge height is inadequate for implant placement and support, bone augmentation of the maxillary ridge in an apical direction should be considered, either through an intrasocket lift or a lateral window approach.

The anterior mandible is probably the area in which implant surgery proceeds in the most straightforward manner. In the premolar region, the surgeon must pay careful attention to the mental foramen and stay at least 6 mm anterior to it to allow for the anterior loop. The loop can be mapped manually by using the tip of the index finger to carefully massage along the superficial aspect of the mucobuccal fold, from the canine area to the first molar area, feeling for the areas where the patient reports pain or tingling An area will be felt that is approximately 1 cm long mesiodistally that bisects the mucobuccal fold and feels like a band of muscle.

Placement of implants in the posterior mandible poses three specific concerns.

1. The bone is less dense and has larger medullary spaces than the anterior mandible. Typically 4 months are required for adequate integration of implants placed in the mandible. Also, one implant for every missing tooth is recommended in the posterior mandible. If the restoration involves a missing molar site that is longer than 12 mm mesiodistally, the implantologist should consider placing two evenly spaced, narrow-diameter implants to replace the two roots of the molar; these should follow the interimplant and inter dento-implant space guidelines mentioned previously. This is done to mitigate the detrimental effects of the mesiodistal cantilevering forces of the occlusal load that occur if only one wide implant is used to restore such long space.
2. The inferior alveolar nerve and vascular bundle (IANVB) and canal are closer to the edentulous ridge in the posterior mandible. As a result of resorption, only a few millimeters of bone remain between the ridge and the superior aspect of the inferior alveolar canal (IAC). There should be 2 mm of bone between the roof of the IAC and the apex of the implant. If short implants (8 to 10 mm) are used, overengineering and placement of more implants than usual to withstand occlusal forces are recommended. If the ridge height is insufficient for placement and support of even the shortest implant, bone augmentation of the ridge vertically with onlay grafting, distraction osteogenesis, or nerve repositioning should be considered.

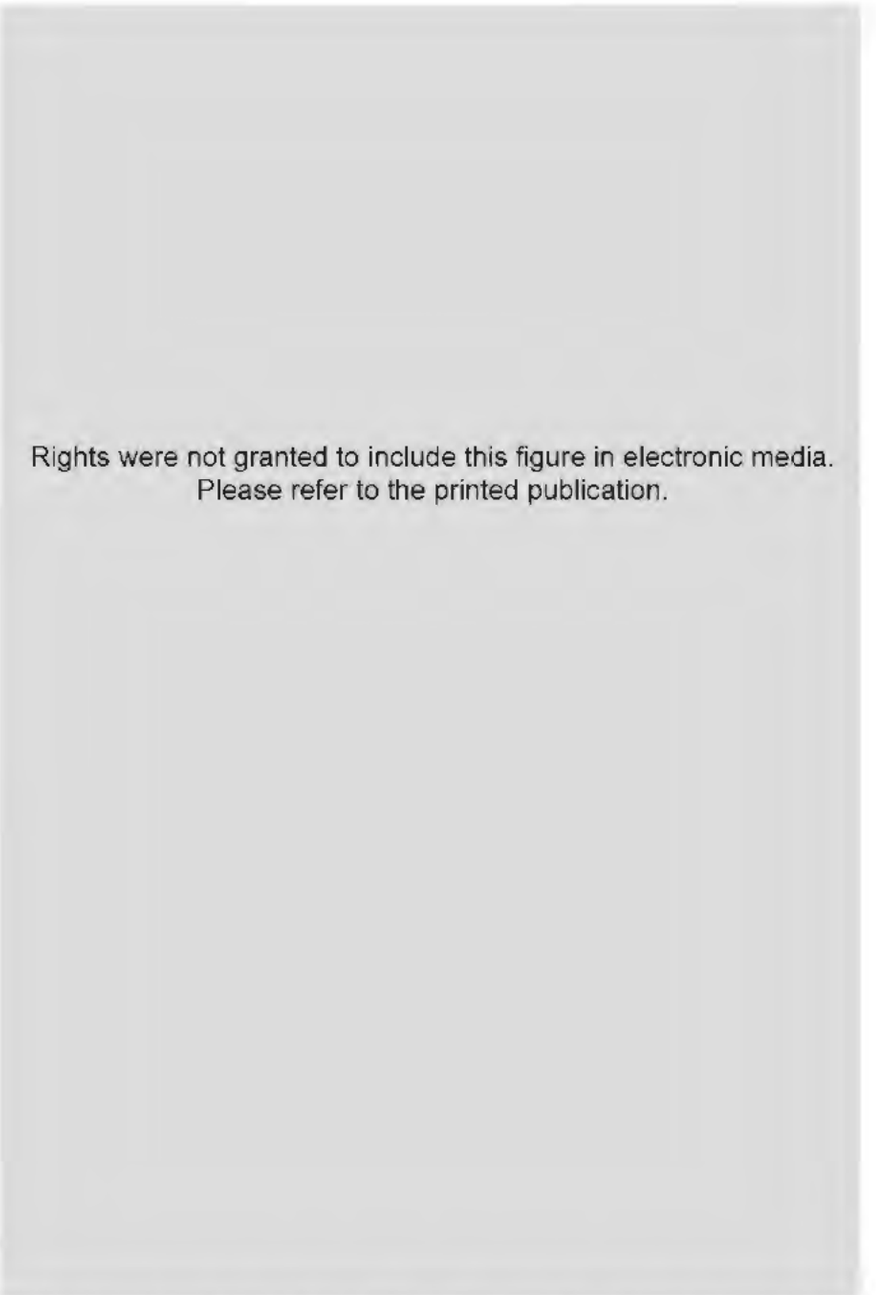


FIGURE 4-60. Inferior view of the maxillary and palatal bones. (Netter illustration used with permission of Elsevier Inc. All rights reserved.)

3. The width of the ridge also is a concern, because the attachments of the mylohyoid muscle and a deep lingual depression immediately below it can cause violation and perforation of the lingual cortex during surgery. Careful examination and palpation of this area, along with a radiologic cross-sectional view of the posterior mandible (Fig. 4-64), are the only ways to identify the depth and severity of this lingual depression.

STAGING

After a decision has been made on the implant system to be used, based on the thorough workup, treatment proceeds in an organized sequence of phases.

- Phase I
  - Introduction
  - Relief of pain
  - Elimination of acute pathologic conditions and acute infections
  - Extraction of hopeless teeth
  - Stabilization of occlusion

  Correction and construction of provisional restorations (fixed acrylic bridges with moderate crown preparations or transitional removable dentures), which establish proper vertical dimension, arch form, occlusal plane, function, and aesthetics
- Phase II
  - Preparation
  - Conservative periodontal therapy
  - Initial endodontic therapy
  - Preimplant surgery (ridge reduction, ridge augmentation, sinus lift) (see Chapter 6) unless it is to include implant placement
  - Fabrication of surgical templates

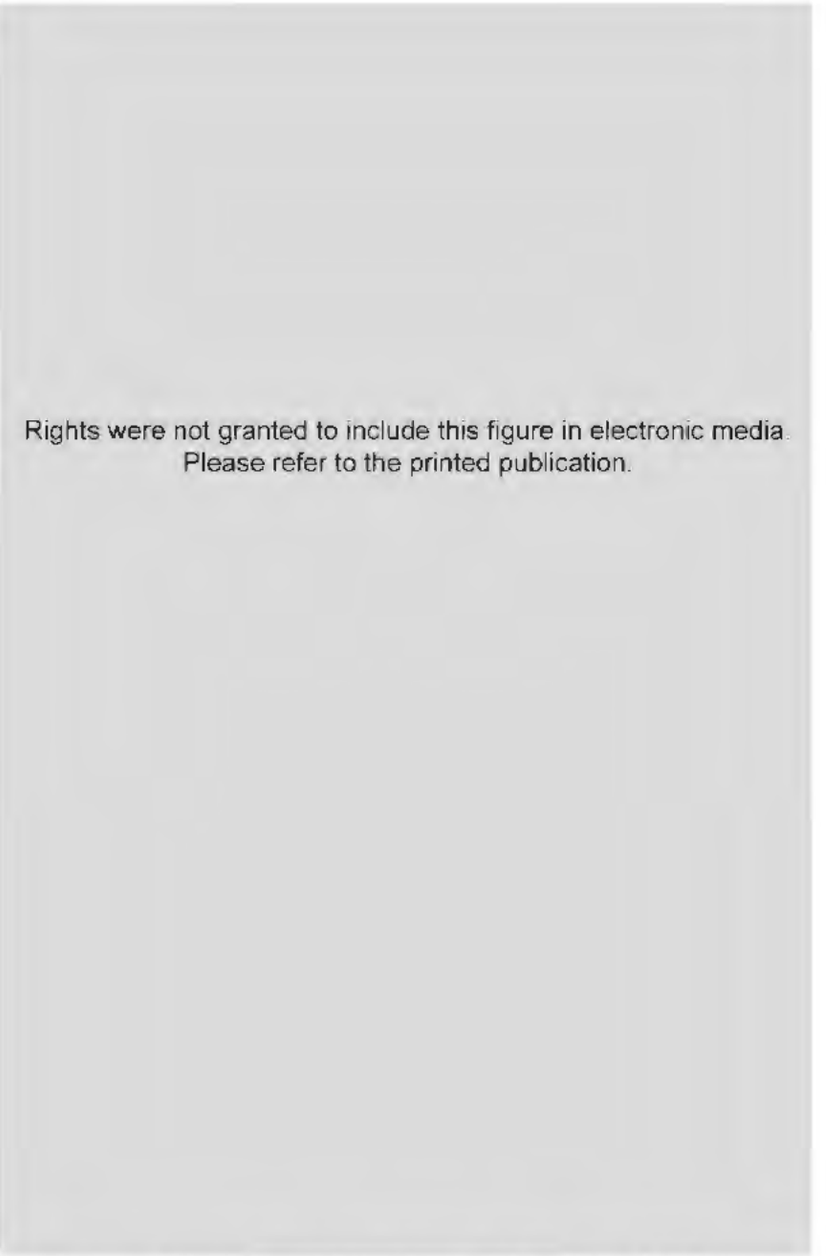


FIGURE 4-61. **A,** Superior view of sinuses. **B,** Lateral view of the cavities in the maxilla and midface region. (Netter illustration used with permission of Elsevier Inc. All rights reserved.)

- Phase III
  - Surgical I
  - Periodontal surgery (in nonimplant areas) (see Chapter 6)
- Phase IV
  - Surgical II
  - Implant surgery (which should include requisite periodontal surgery in these sites and adjacent regions) (see chapters 9, 10, and 11)
- Phase V
  - Healing
  - Completion of all periodontal therapy and continuation of maintenance procedures
  - Completion of all endodontic therapy, further crown preparations
- Phase VI
  - Abutment finalization
  - Uncovering of implants (if using two-stage systems, see Chapter 6)
  - Final healing of permucosal areas (for use of healing caps and/or abutments, see Chapter 21)
  - Re-evaluation and mandated extraction of any remaining natural teeth with guarded prognoses
  - Final preparation of teeth
- Phase VII
  - Prosthodontic (see chapters 20 and 21)
  - Impressions
  - Abutment completion
  - Placement of prostheses, selection of cementing medium (if any)
  - Occlusal equilibration (see Chapter 26)
  - Occlusal splint fabrication if indicated
- Phase VIII
  - Maintenance
  - Final maintenance, hygiene visits, and home care instruction (see Chapter 29)

FIGURE 4-62. **A** and **B**, Nerve supply of the oral cavity. (Netter illustration used with permission of Elsevier Inc. All rights reserved.)

FIGURE 4-63. Arterial supply of the oral cavity. (Netter illustration used with permission of Elsevier Inc. All rights reserved.)

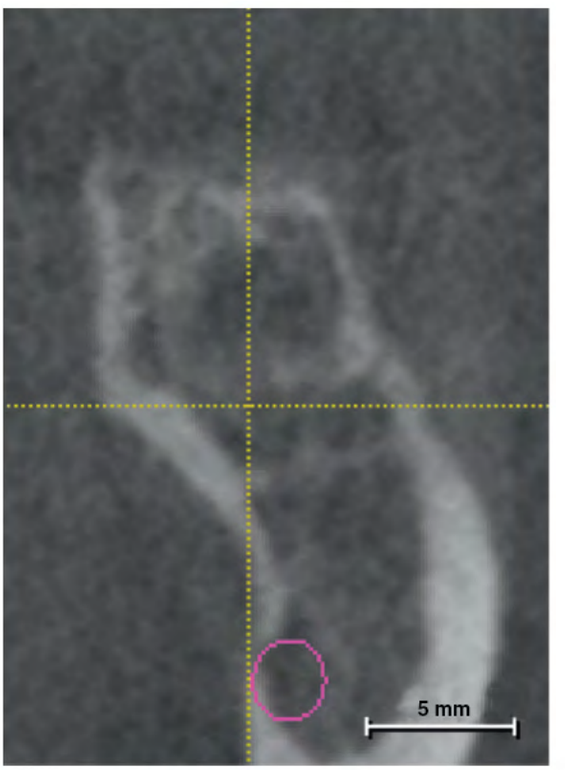


FIGURE 4-64. Cross section of the posterior mandible; shown outlined is the inferior alveolar canal. Also noticeable is the mylohyoid ridge.

Prosthetic Options That Influence Implant Selection

5
CHAPTER

Before the implant type, number, and location are chosen, a final prosthesis design must be selected. The principles outlined in this chapter can clarify these decisions. In subsequent chapters, the fabrication of each implant-supported modality is presented in greater detail.

The patient will have either a completely or partly edentulous arch. Either condition may be restored with removable, fixed-detachable (removable only by the dentist), or cemented prostheses, which are placed directly into or onto the implant or implants or onto a bar that has been attached to them. Implant-borne prostheses often consist of two separate parts: mesostructure bars and superstructures (Figs. 5-1 and 5-2). *Superstructures* are the final or tooth-bearing part of implant prostheses. They may be single crowns, complete overdentures, or any of the variety of prostheses in between, such as fixed bridges, fixed-detachable bridges, or combinations. Overdentures sometimes are attached to coping bar splints; these splints are called *mesostructures.* Mesostructures can be affixed to implants or implant-tooth combinations.

When planning the final restorations, the implantologist should determine whether the prosthesis is intended to replace teeth, teeth and soft tissue, or teeth, soft tissue, and bone. The more soft tissue and bone to be replaced, the greater the height of the restoration must be. Depending on the amount of hard and soft tissue that must be replaced, more implant support is required in direct relation to the size and height of the prosthesis. Restorations supported solely by implants always require a greater number of implants than do prostheses supported by both implants and soft tissue. Implant therapy allows for use of the prosthodontic options described later in Chapter 19.

SUPERSTRUCTURES

Overdentures

Overdentures can be classified into two types: those supported by soft tissue and implants or teeth and those supported purely by implants. Overdentures supported by soft tissue and implants or teeth are supported by the implants and soft tissues and retained by the implants. For this to be practical in the parasymphyseal area, the retainers (implants or teeth) must be in a position that allows construction of a straight bar (Fig. 5-3). With this arrangement, several internal clips can rotate around the bar, which allows the posterior overdenture saddles to be soft tissue borne, so that they may take some of the stress from the implants or teeth. If the bar is placed in the anterior region and, because of the location of the implant or implants, must be curved to conform to the shape of the arch, the overdenture does not rotate on the bar, and the posterior saddles may act as levers, tending to loosen the retaining screws, cement, abutments, or the implants themselves (Fig. 5-4).

From an engineering standpoint, splinting implants with bars and copings, rather then using them individually, is preferable. Mesostructure bars are available in various shapes and configurations, and the type used depends on the location, length, and number of implants to be placed; the percentage of surface area surrounded by bone (osseointegration); and the type of retention devices selected (e.g., Locators, clips, O-rings, Zest, Ceka, ERA). Bar-borne overdentures are both supported and retained by their bars (Figs. 5-5 and 5-6), which in turn should be supported by four or more root form implants 10 mm long or longer, by transosteals, or by subperiosteal implants.

Fixed Bridges

Fixed bridges may be supported completely by implants, or they may be used in conjunction with natural tooth abutments (Figs. 5-7 and 5-8). In both cases, construction begins after transepithelial abutment (TEA) placement (by spline, frictional fit, or threading) and is completed with the implantologist's preferred prosthetic techniques. Various attachments or interlocks between the implants and the natural abutments may be chosen (e.g., DE Hinges, Dalbo, Crismani, Mini Rest, Tube and Screw). These provide stress-breaking features that may be important, because the support mechanisms differ so dramatically between implants and natural teeth.

Fixed-Detachable Bridges

The fixed-detachable bridge is a prosthesis that can be removed by the dentist but not by the patient. Screws attach the bridge to the implants, to their abutments, or to an interposed mesostructure bar. These prostheses most often are completely implant

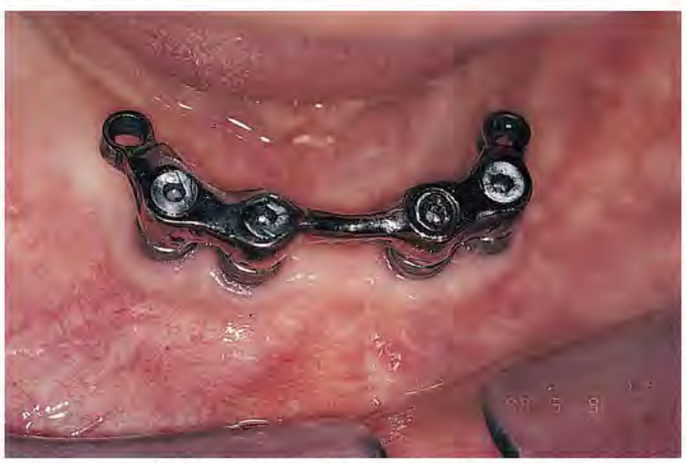


FIGURE 5-1. A fixed-detachable bar that uses root form implants for anchorage is designed to support and retain an overdenture.

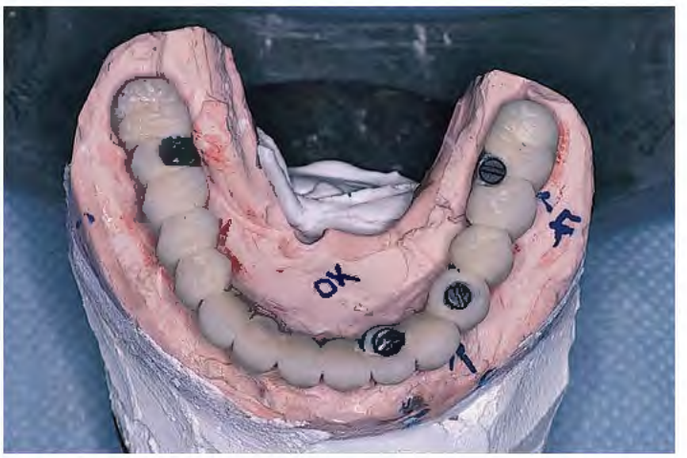


FIGURE 5-2. A fixed bridge prosthesis of porcelain fused to metal serves as a fixed-detachable superstructure. The natural teeth in this case are protected by cemented gold copings.

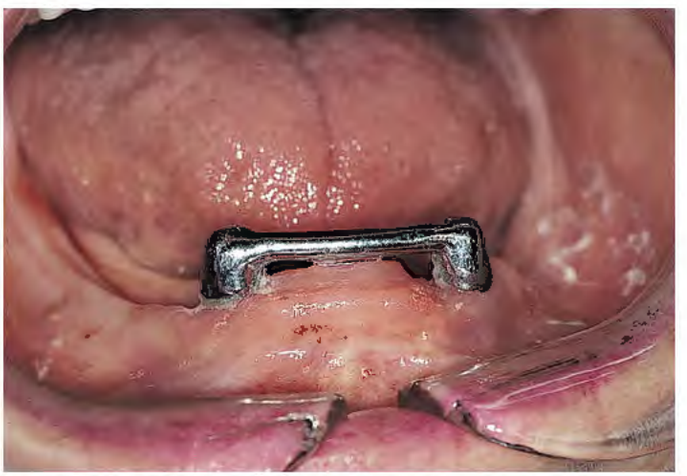


FIGURE 5-3. Two root form implants support this coping bar splint. To enable the superstructure-overdenture to distribute stress to the posterior ridges, the bar must be straight, allowing the Hader clip retainers to rotate during masticatory function.

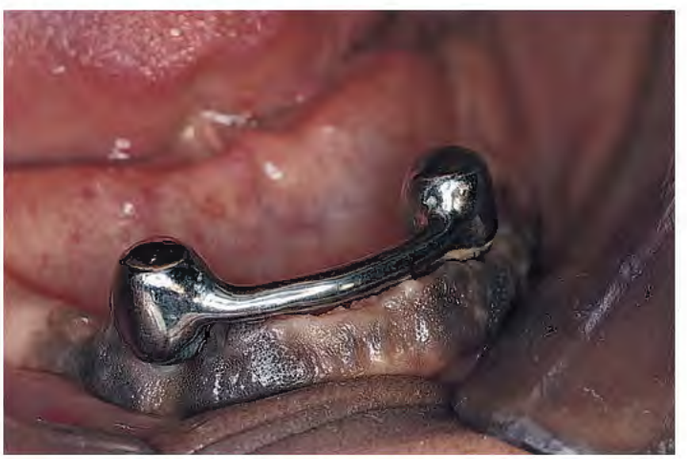


FIGURE 5-4. When splinting implants require a curved bar, the superstructure attachment must permit rotation (i.e., "sloppy fit") to allow for tongue space (see Fig. 5-15).

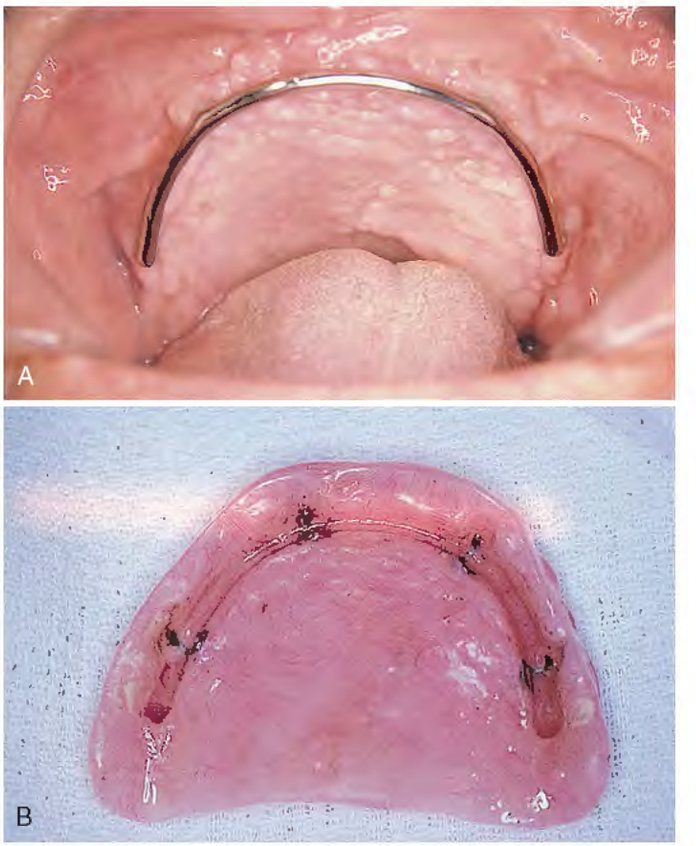


FIGURE 5-5. **A,** A maxillary pterygohamular subperiosteal implant designed with a Brookdale bar offers total implant-borne support of the superstructure. **B,** A denture superstructure designed to be bar-retained with internal clips.

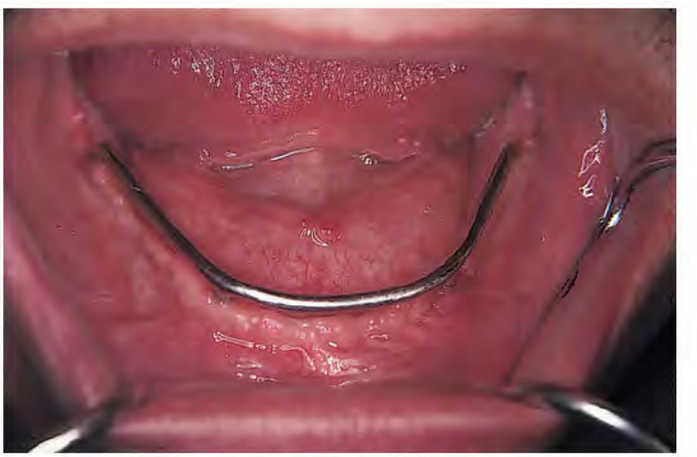


FIGURE 5-6. A mandibular subperiosteal implant with a Brookdale bar designed to offer full infrastructural support.

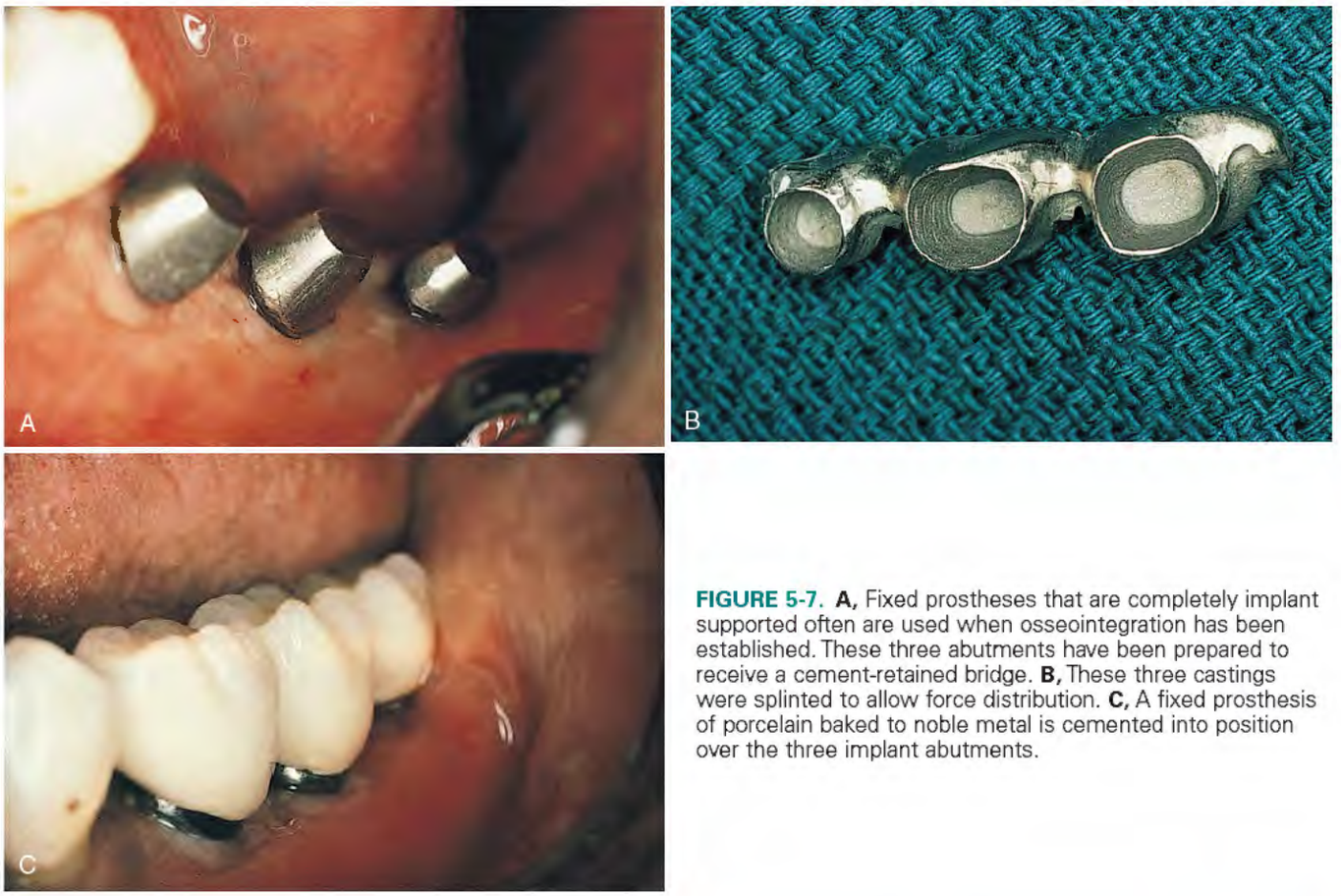


FIGURE 5-7. **A,** Fixed prostheses that are completely implant supported often are used when osseointegration has been established. These three abutments have been prepared to receive a cement-retained bridge. **B,** These three castings were splinted to allow force distribution. **C,** A fixed prosthesis of porcelain baked to noble metal is cemented into position over the three implant abutments.

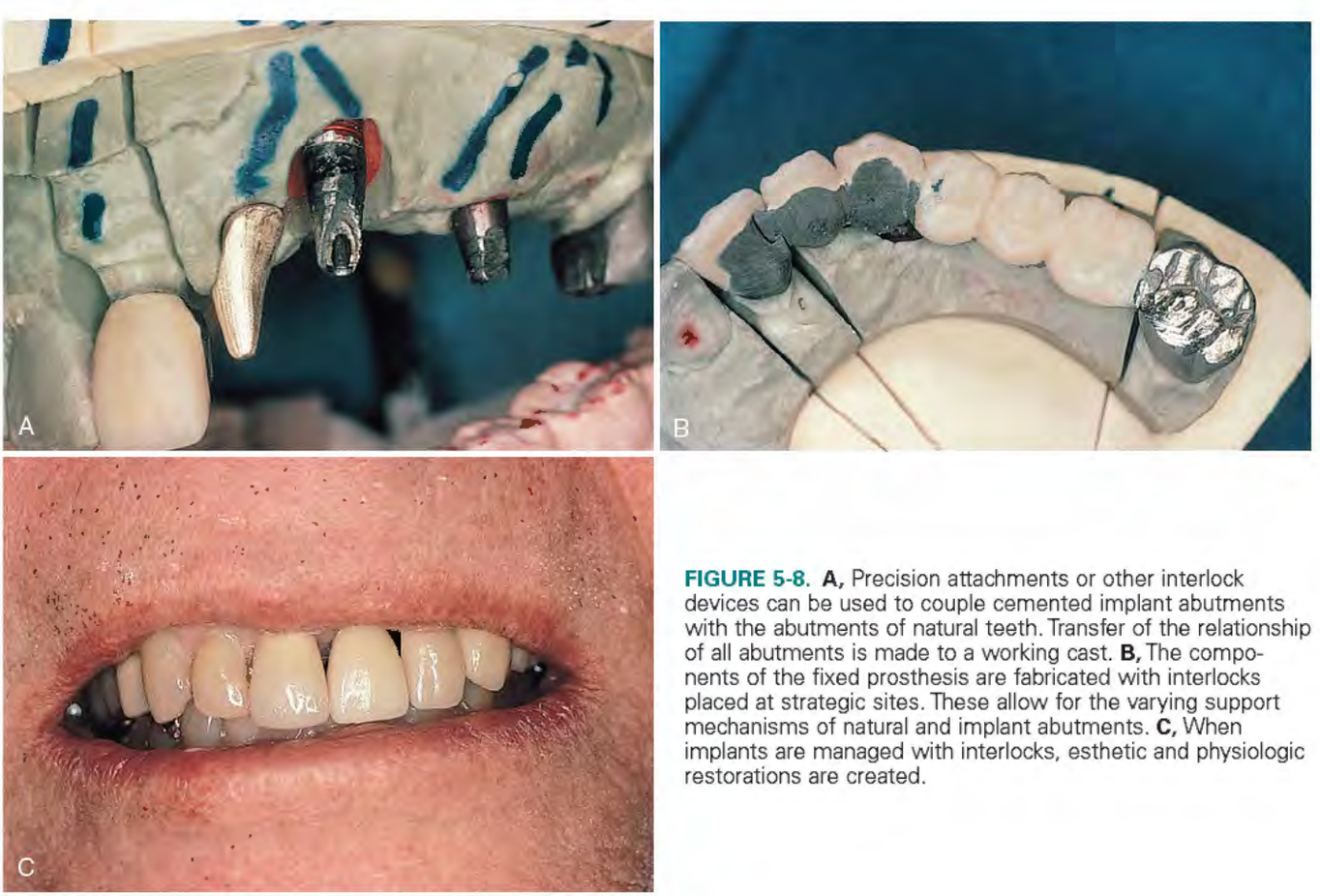


FIGURE 5-8. **A,** Precision attachments or other interlock devices can be used to couple cemented implant abutments with the abutments of natural teeth. Transfer of the relationship of all abutments is made to a working cast. **B,** The components of the fixed prosthesis are fabricated with interlocks placed at strategic sites. These allow for the varying support mechanisms of natural and implant abutments. **C,** When implants are managed with interlocks, esthetic and physiologic restorations are created.

borne (Fig. 5-9). However, natural tooth abutments may be incorporated into implant bridges through the use of semiprecision attachments or internally threaded telescopic copings (Fig. 5-10). The techniques used to produce fixed-detachable bridges are by far the most complicated, and the opportunities for error are numerous. (Before selecting this method, the implantologist should review chapters 22, 23, and 24.) The benefits of being able to remove these bridges must be balanced against the difficulties involved in their fabrication, the cost, the potential for postinsertion complications, and the restoring dentist's willingness to manage them.

Single Crowns

Single-tooth prostheses can be fabricated in one of two ways. An implant-borne crown should be made that does not involve rigid dependence on any of the adjacent teeth (Fig. 5-11); it must merely abut to a single implant. Such implants must have antirotational features (i.e., hex, spline, cold weld; see Chapter 10 . If adequate support is questionable, an implant-borne crown may be connected with a semiprecision attachment to one or even several adjacent crowns (Fig. 5-12). Fixed rigid attachment is discouraged, however, unless the natural abutments are protected with telescopic copings.

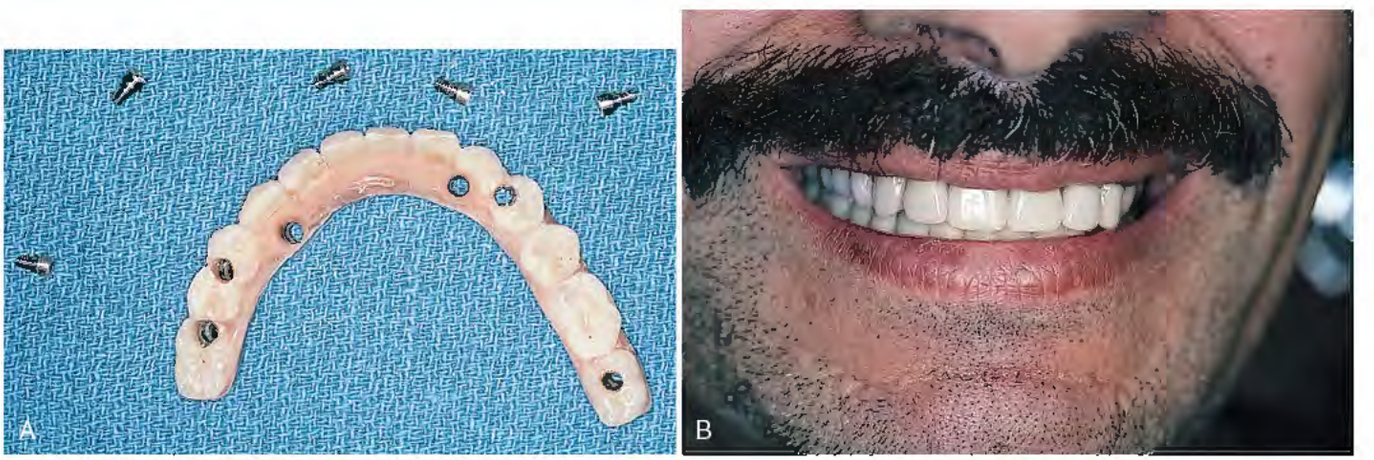


FIGURE 5-9. **A,** A fixed prosthesis completely supported by implants requires a minimum of six implant abutments in the mandible and eight implant abutments in the maxilla. Additional, evenly distributed support is beneficial. Cantilevering of 10 to 15 mm bilaterally may be allowed. This maxillary prosthesis meets these requirements. **B,** Fixed-detachable prostheses may be completed with composite materials or porcelain. Hygiene is facilitated by both abutment and pontic design and ease of removability.

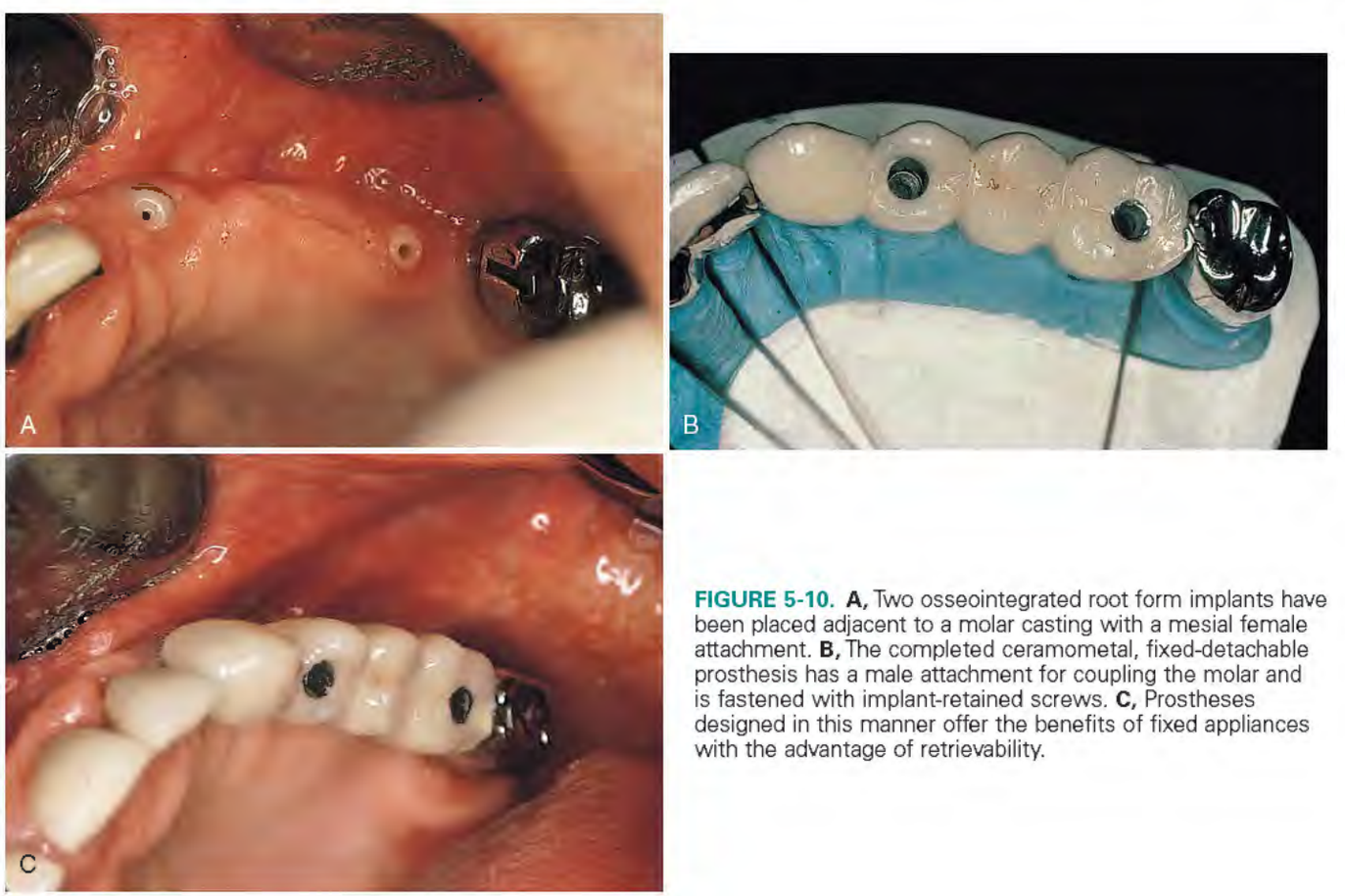


FIGURE 5-10. **A,** Two osseointegrated root form implants have been placed adjacent to a molar casting with a mesial female attachment. **B,** The completed ceramometal, fixed-detachable prosthesis has a male attachment for coupling the molar and is fastened with implant-retained screws. **C,** Prostheses designed in this manner offer the benefits of fixed appliances with the advantage of retrievability.

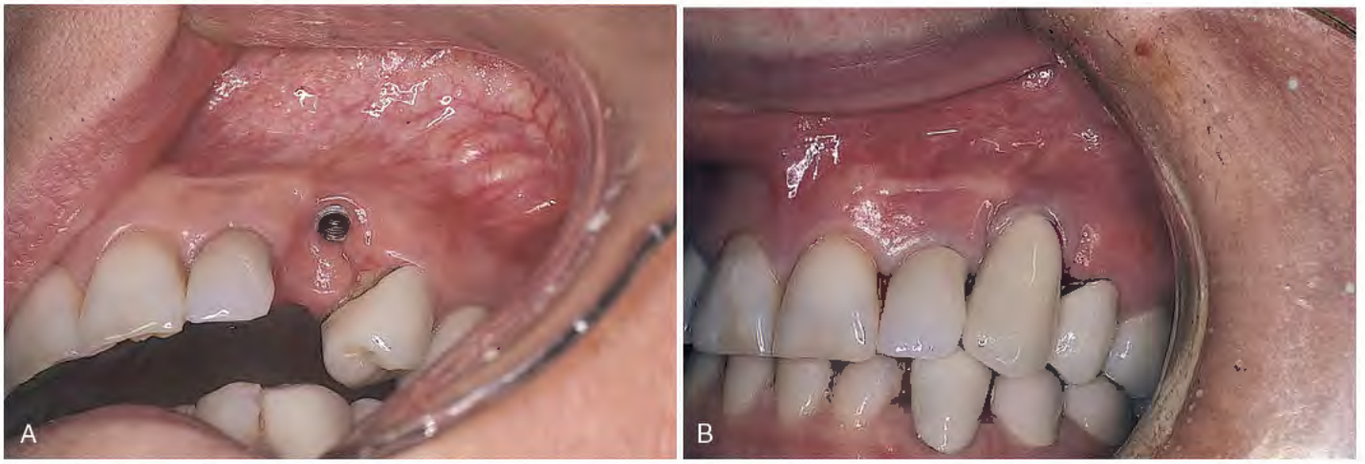


FIGURE 5-11. **A,** Single-tooth restorations may be placed on freestanding implants. The only requirement is an antirotational component, such as a hexagonal design. **B,** The completed casting is retrievable because it is screw retained.

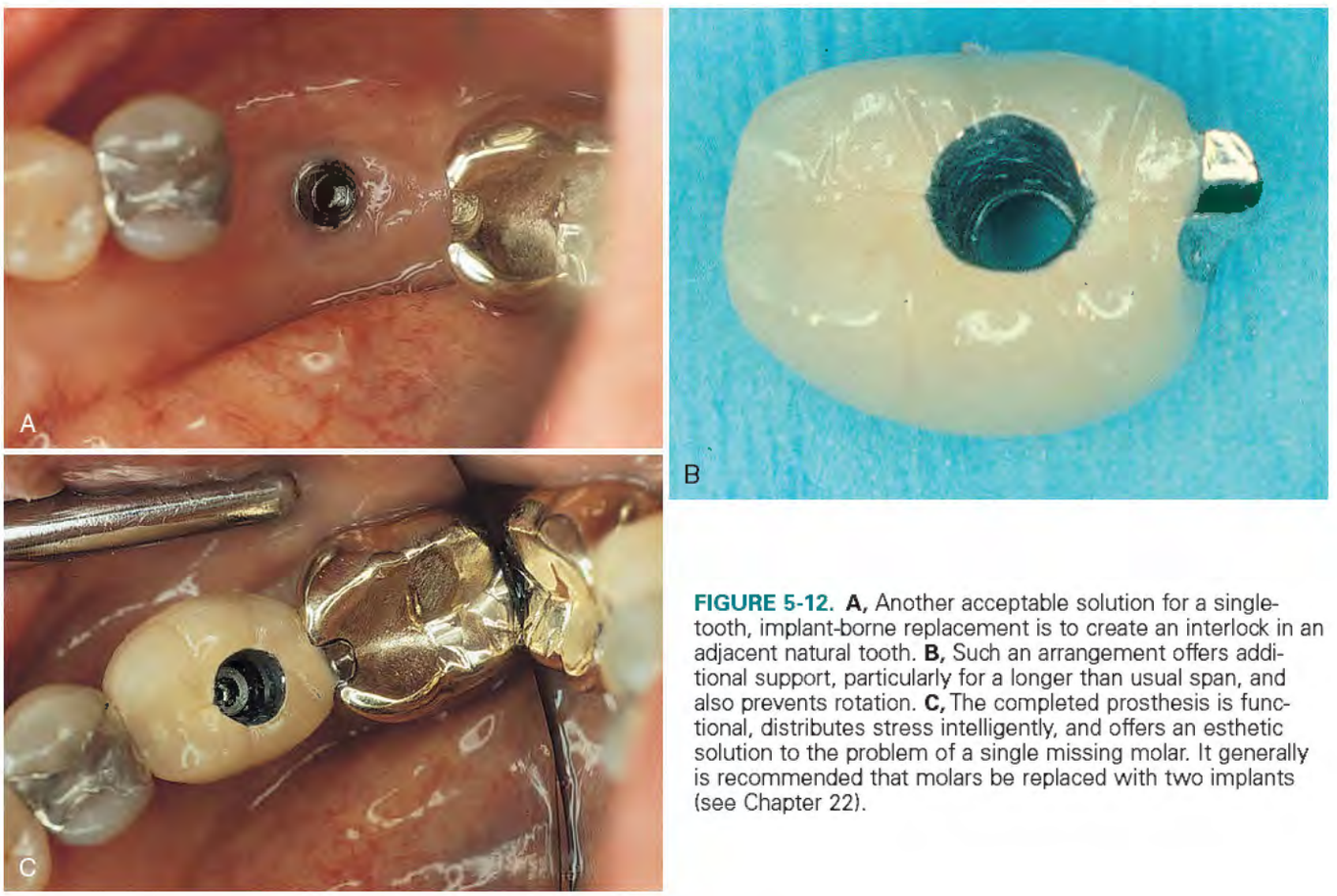


FIGURE 5-12. **A,** Another acceptable solution for a single-tooth, implant-borne replacement is to create an interlock in an adjacent natural tooth. **B,** Such an arrangement offers additional support, particularly for a longer than usual span, and also prevents rotation. **C,** The completed prosthesis is functional, distributes stress intelligently, and offers an esthetic solution to the problem of a single missing molar. It generally is recommended that molars be replaced with two implants (see Chapter 22).

When such placement is performed, the practitioner must be aware of the phenomenon of natural tooth root intrusion, particularly when temporary cements have been used.

MESOSTRUCTURE BARS

The mesostructure bar acts as a connector between the implant complex (infrastructure) and the superstructure. Not all reconstructions use such bars (Figs. 5-13 and 5-14). For example, if one or several implants have been inserted and the transepithelial abutments have been attached, crowns and pontics may be made in the classic manner. In fact, all the systems described in chapters 10 and 11 can use the common fixed bridge superstructure design, which, when the locations allow, may be made directly on their abutments without mesostructure devices. Multiple blade reconstructions, because they do not osseointegrate, often use coping bar and overdenture prostheses. Mesostructures can be designed in many forms, such as continuous bars or noncontinous bilateral bars, and a broad variety of shapes allows the use of internal clips, O-rings, or withdrawable pins (i.e., Lew attachments).

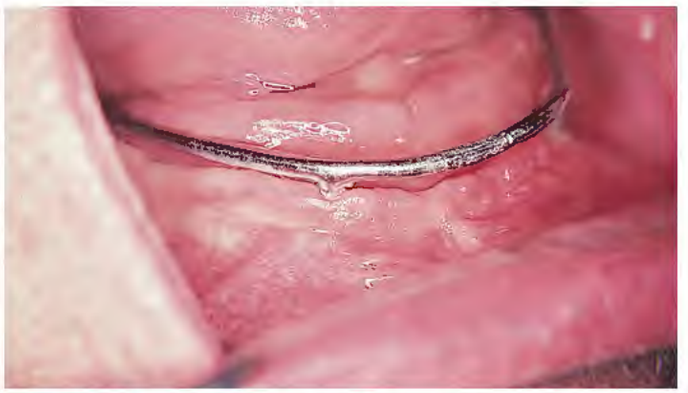


FIGURE 5-13. This mesostructure bar is an integral part of a mandibular subperiosteal implant and serves as a retentive device for a denture superstructure. Such bars distribute forces more evenly than individual abutments.

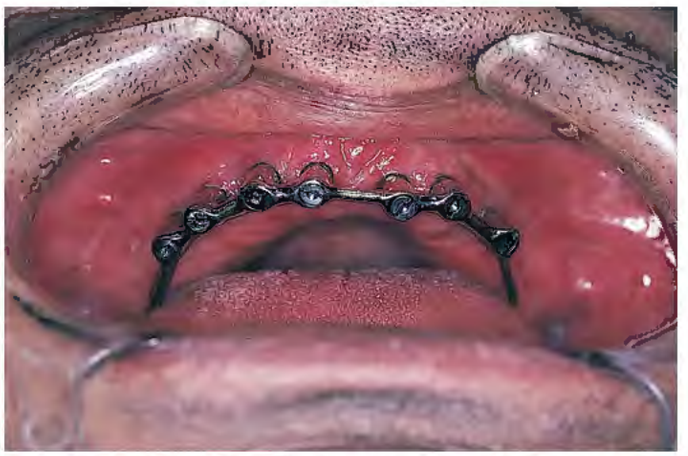


FIGURE 5-14. A maxillary fixed-detachable mesostructure bar that serves to retain an overdenture is attached to root form implants by screws.

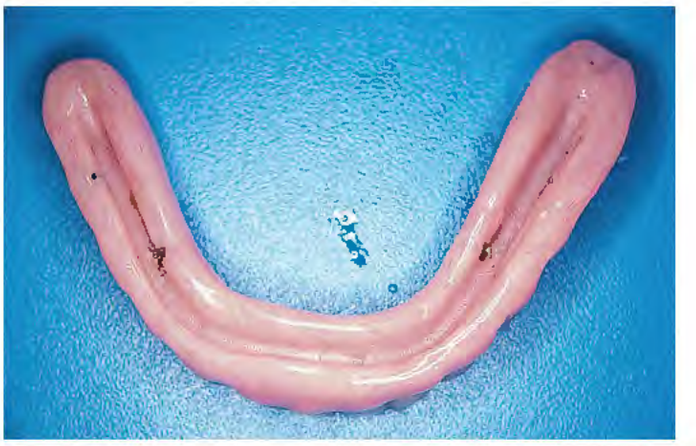


FIGURE 5-15. An overdenture, designed to fit over a Brookdale bar, gains additional retention by occasional relining directly in the mouth. Such relationships are termed *sloppy fit.*

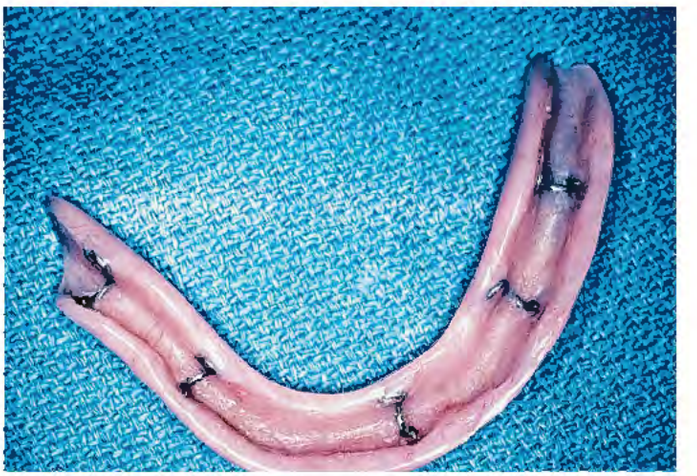


FIGURE 5-16. More precise bar relationships are achieved with the use of well-distributed, custom-made, high-tension steel clips (designed by Anthony Rosalia).

Continuous Bars

Continuous bars are available in different shapes, such as round, oval, rectangular, or square. The amount of implant support, the location in the arch of that support, and the type of retentive devices chosen determine the bar shape used. If a desired shape is not readily available, custom-casting is required. Superstructures may (1) simply rest on the bar (known as a *sloppy fit,* which requires occasional acrylic relining; Fig. 5-15); (2) they may be attached to the bar or locked under it by a variety of attachments, either custom-made or manufactured (Fig. 5-16); or (3) they may be secured by supplementary attachments incorporated into or onto the bar (e.g., O-rings, ERAs, or Zest attachments; Fig. 5-17).

Superstructures also may be used in conjunction with a fixed-detachable or cementable superstructure that was made because faulty implant angulation made fabrication of a fixed superstructure impossible to complete. In such situations, the double-bar technique may be used. For this technique, a mesostructure bar of the optimal shape and diameter should be cast and then screwed or cemented to the malaligned implant abutments or directly into the implants themselves. This first bar must have at least three (depending on its length) internally threaded housings soldered to it and protruding at prosthetically usable angles. A second structure bar of metal or acrylic designed to hold the teeth and to be screwed into the newly fabricated first, or mesostructure, bar is made. Properly positioned denture teeth are processed to the second bar. (Chapter 28 offers exact details on the construction of such a double-bar prosthesis.)

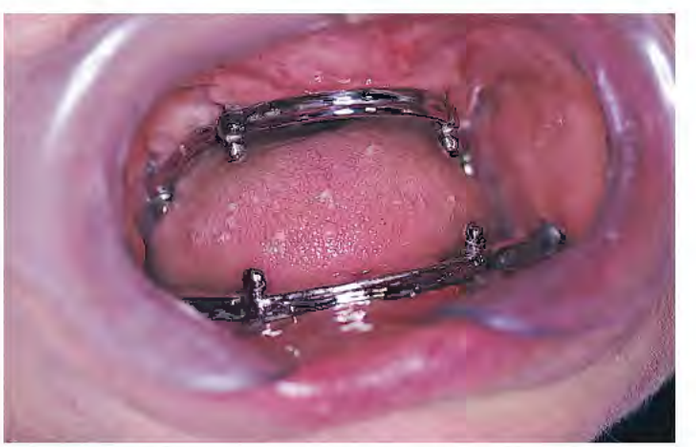


FIGURE 5-17. Components of these bars include round attachments designed for O-ring retention.

Noncontinuous Bars

Noncontinuous bars can be classified into several categories. For example, a mandibular subperiosteal implant with a continuous bar may have caused the patient pain on opening the mouth. In such cases the anterior (or transsymphyseal) component is cut, creating bilateral bars. Some clinicians prefer this design from the outset (Fig. 5-18).

Often, because of anatomic limitations, cost, or preference, implants are placed in the canine areas and only an anterior bar is needed. This may be curved or straight, depending on the implants' location, the plans for superstructure retention, and the need for stress breaking. These bars usually are round in cross section (Fig. 5-19).

Similarly, unilaterally placed implants, either original or residual (i.e., after other implants have been lost), may be restored with a single bar to provide splinting and to offer a retentive source for an overdenture. These partial bar structures may use any of the attachment devices with which the clinician is most comfortable.

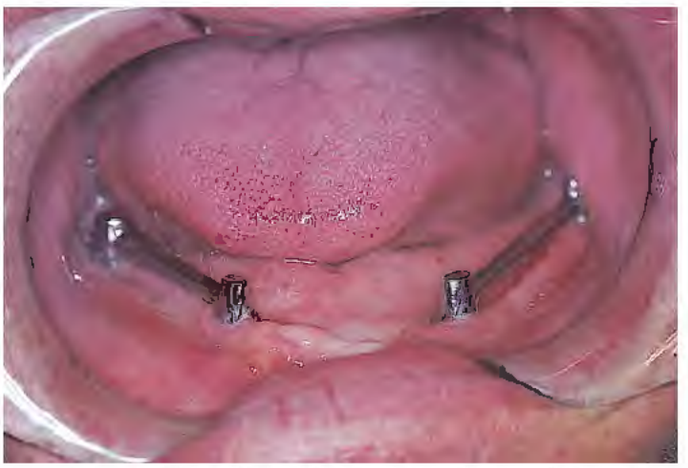


FIGURE 5-18. Bilateral Brookdale bars may be used for overdenture retention when mandibular flexion is considered a factor or for other design purposes.

FIGURE 5-19. Hader bars perform most favorably when they are straight. To make this possible, a small offset extension is placed on the right casting. This mesostructure complex, which is attached to two osseointegrated implants, is a single-piece casting.

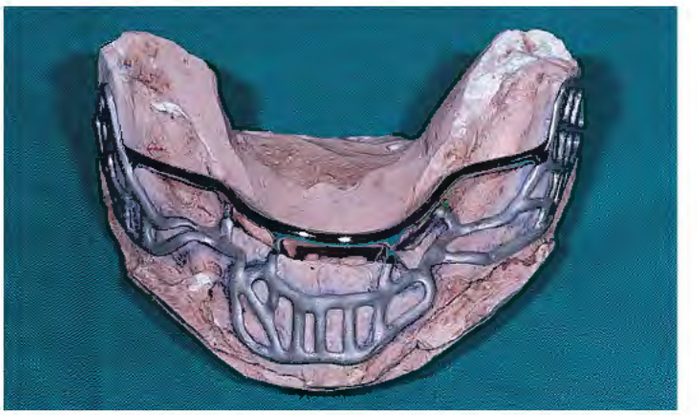


FIGURE 5-20. Although bars may be attached separately to subperiosteal implants, the usual method of construction is to cast them as a single entity with the infrastructure framework, as shown in this mandibular design.

Methods of Bar Fixation

In almost all cases of subperiosteal implant construction, and in all cases of ramus frames, the bar is part of the implant casting (Fig. 5-20). With a complete subperiosteal implant, options are available for bar design, diameter, and location; therefore the attachments may be selected before insertion. When a bar is prescribed for endosteal implants, it may be attached in the classic fixed-detachable manner (see Chapter 25) or by simple cementation. (Chapter 26 presents details on bars and overdentures.)

TYPES OF SUPERSTRUCTURE ATTACHMENTS

When multiple implants have been inserted and connected with coping bar splints, several methods of overdenture retention are available. These include magnets, custom clips, plastic or gold Hader clips, Dolder clips, Ceka attachments, Zest, Zag, anchors, Octalinks, O-rings, ERA attachments, pin locks, and Lew attachments (Figs. 5-21 through 5-25). An accurate elastomeric impression of the abutments (which vary slightly from system to system) is made, and from this impression, the implant prosthetic laboratory incorporates the selected attachments onto a cast bar. Table 5-1 presents the benefits and shortcomings of the more popular attachment systems.

TRANSEPITHELIAL ABUTMENTS

The independent transepithelial abutment (TEA) is available for one- and two-stage (submergible) endosteal implant systems, both the blade and the root form (Fig. 5-26). The TEA (sometimes called a *permucosal abutment*), attaches by threading directly into the implant. It often passes through the soft tissues into the oral cavity and acts as an abutment for either a mesostructure bar or an anatomic superstructure (Fig. 5-27). One-stage root forms, one-stage blades, and transosteal and subperiosteal implants are fabricated with the TEA attached.

With submergible implant systems, depending on the type being restored, the TEA is attached to the implant in one of two ways: (1) by screw, with or without antirotational internal or external

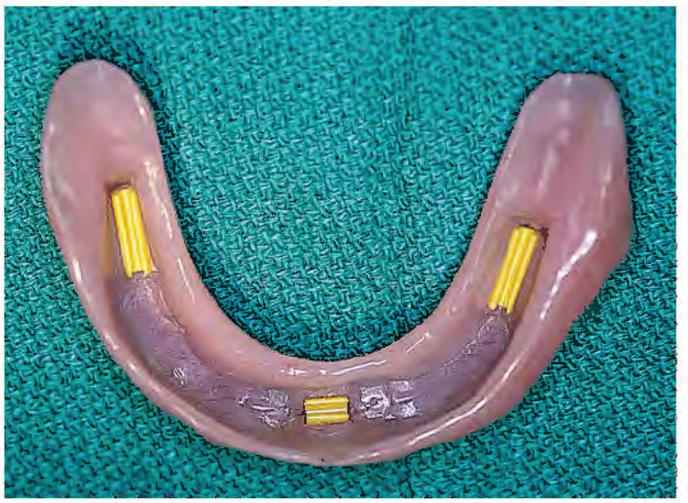


FIGURE 5-21. Attachment mechanics are supplied by plastic Hader clips in this overdenture. The clips are easily replaced when retention is lost.

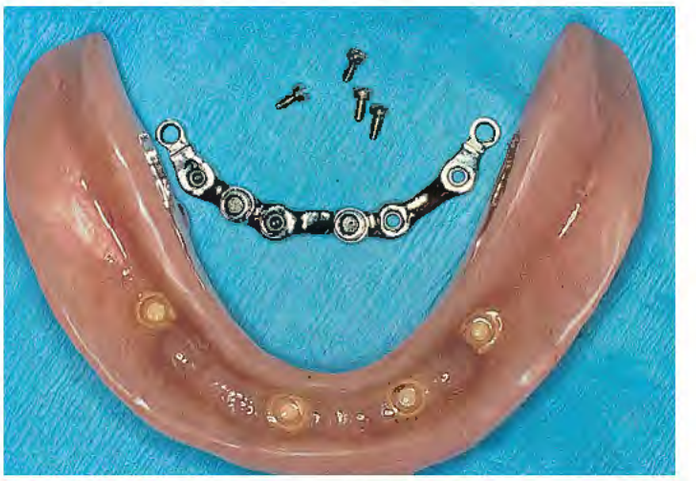


FIGURE 5-24. The ERA offers male attachment placement in the overdenture and female in the mesostructure bar. The value of these devices is that the implantologist may use four levels of retention by using different males, each of which is color coded.

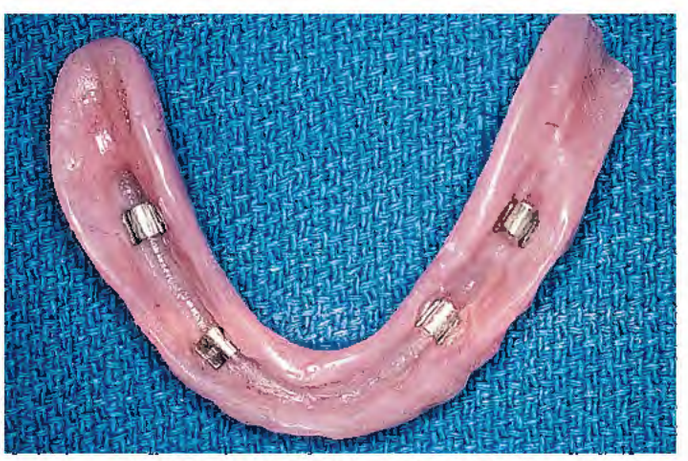


FIGURE 5-22. Gold Hader clips are more durable than plastic ones but more demanding to replace.

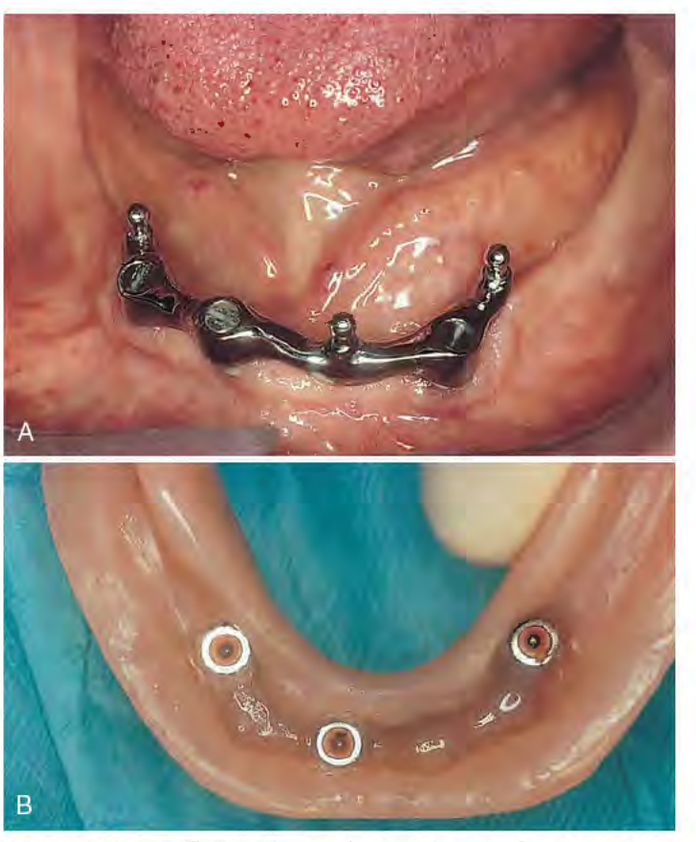


FIGURE 5-25. **A,** Ball castings, when made part of a mesostructure bar, offer excellent sources of retention for easily renewable O-rings. **B,** The rings are snapped into special receptacles that are processed into the tissue-borne surface of the overdenture.

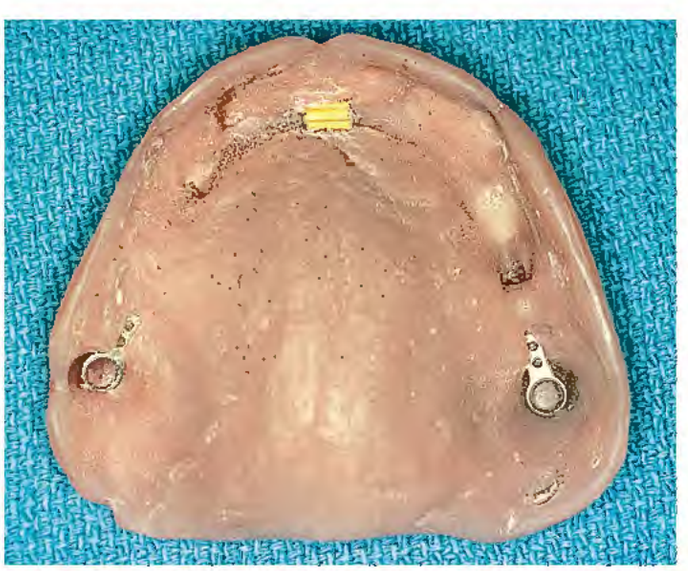


FIGURE 5-23. Combinations of attachment devices may be used, such as these anterior clip and bilateral posterior Rotherman attachments. These are particularly useful when limited intermaxillary space requires the use of short castings.

hex, or spline; or (2) by press or frictional fit, using the cold-weld, Morse-taper design.

The portion of the TEA that is within the oral cavity can take many shapes:

- Conventional crown preparation—straight
- Conventional crown preparation—angled (usually at 15 to 25 degrees but available at 30 degrees)
- Shouldered platform

Table 5-1 Advantages and Shortcomings of Different Types of Attachments

Type of Attachment	Advantages	Shortcomings
Magnets	Easy to use Easy to repair No stress relief	Questionable retention Poor lateral stability Corrosive Loosen or become unthreaded Expensive
Ceka, Octalink	Easy to use Easy to repair Good retention Stress breaking	Expensive Require frequent maintenance Loosen or become unthreaded
ERA	Adjustable retention Easy to replace Modest cost	Need to be replaced frequently
Zest, O-rings	Inexpensive Good retention Stress breaking Easy to use (O-rings)	Abutments must be parallel Less rigid than metal to metal Wear more quickly than metal
Hader, Dolder	Stress breaking Easy to maintain Easy to repair and replace	Expensive
Pin lock, Lew	Easy to maintain Easy to use	Expensive
Locator	Easy to place Easy to replace Adjustable retention force	Need to be replaced frequently

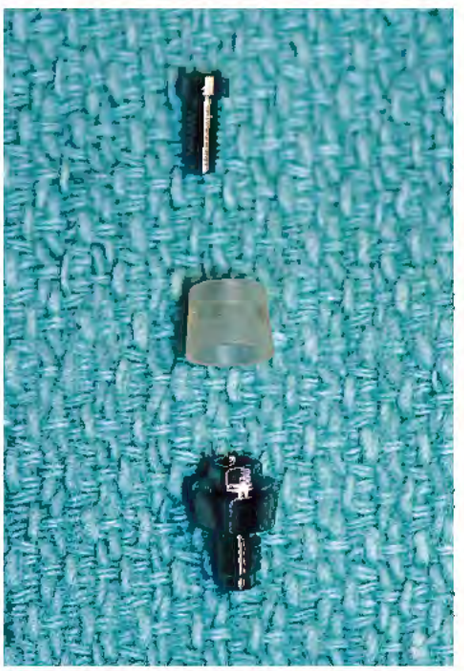


FIGURE 5-26. Transepithelial abutments offer the most significant mode of attaching mesostructure bars or superstructures to integrated implants. The selection of abutments depends on the design of planned restorations. The middle component (pictured) is the waxing sleeve of the superstructure that will be attached, after casting, to the transepithelial abutment.

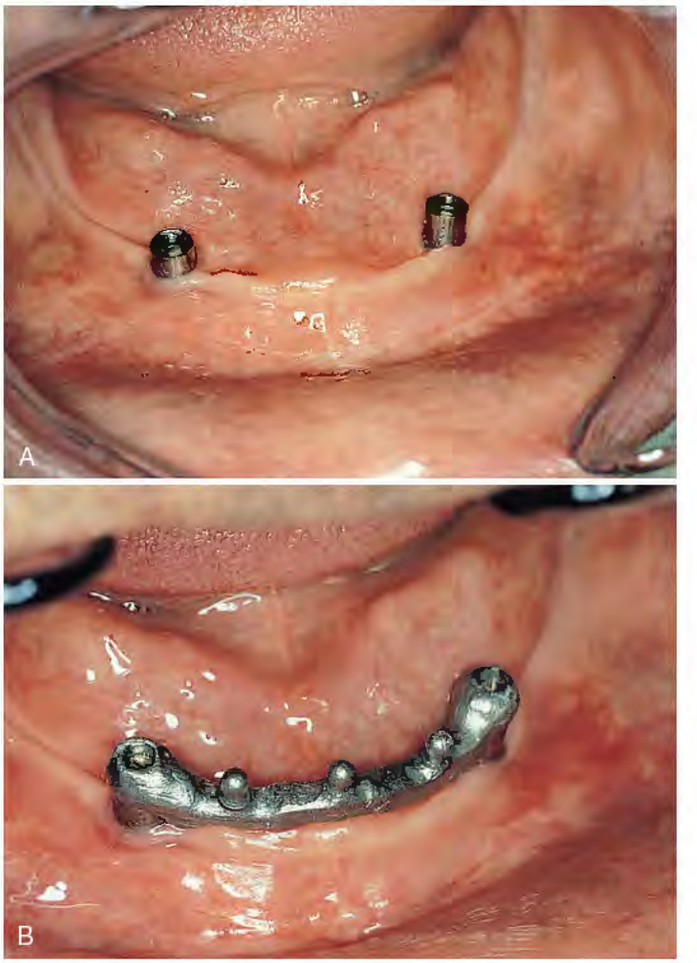


FIGURE 5-27. **A,** The transepithelial component or abutment, which is attached by a screw (see Fig. 5-26), gives the practitioner a variety of retention options. **B,** This mesostructure bar, one of the most frequently selected prosthetic solutions, may include any of a wide variety of attachment modalities, such as these balls designed for O-rings. The bar is fixed to its implants by screw retention.

- Shouldered platform with female attachment receptacle (e.g., Locator, Zest).
- Shouldered platform with male attachment (e.g., O-ring)
- Three-piece, including collars and fixation screws (e.g., Zimmer)

Transepithelial abutments for each type of implant are supplied by the implant's manufacturer. However, some TEA systems can be custom cast. In addition, several companies have made a variety of abutments available that are usable with and without adaptive fittings. Individual laboratories, using manufactured patterns, can cast attachments for a wide range of implants in any number of postures. Because of the overwhelming number of attachments and abutment designs available, practitioners should become adept at using a few of the more popular and versatile types.

Preparations for Implant Surgery

6
CHAPTER

ARMAMENTARIUM AND THE OPERATORY

Most of the chapters in this book begin with warnings or caveats. This is an instructional chapter; therefore the only warning offered is that the readers, even if they do not plan to perform implant surgery itself, should acquire an understanding of the basic principles of surgery before attempting to plan or place implants. Although implant surgery is less demanding and less complex than many other kinds of oral surgery presented in this chapter, the operative path can be filled with complications. A knowledge of management is required, therefore, before the practitioner can begin the practical endeavors in implantology. For those who do intend to perform the surgery, a gentle reminder is offered to check and replenish instruments and disposable supplies before any procedure is started. Although some of the items listed in the armamentarium may seem arcane or may appear unlikely to be required, their presence prepares the surgeon for virtually any unexpected occurrence (Fig. 6-1). Also, this chapter should be read slowly, at a time of leisure, so that the practitioner can learn its contents completely. Readers must have a clear knowledge of their skill level, so that they do not find themselves in a situation in which significant corrective procedures may be required.

Operatory

The bulk of implant surgery procedures are performed in the office operatory. The practitioner should try to assemble the equipment required for all planned procedures in this area or room, because this provides maximum convenience for the surgeon and staff and the greatest comfort for the patient. A commodious, complete operatory helps make the treatment of patients more enjoyable. Some basic concepts can be followed in the design of an implant operatory (Fig. 6-2).

Adequate space must be available for the surgeon and two additional staff members, an operating chair, cabinetry, and sedation, monitoring, and resuscitative equipment. The chair should have foot controls to raise, lower, and recline it so that hands are not required to change its position during surgery. High- and low-power suction facilities must be available, as well as an arm board if sedation is planned. Positive-pressure oxygen and nitrous oxide are necessary adjuncts, and nitrogen or compressed air is required for many drilling systems. High- and low-speed handpieces are mandatory, as is high-torque, low-speed implant drilling equipment.

Adequate lighting for surgery and appropriate side lighting for supportive procedures (e.g., mixing) should be an integral part of the design for an implant center. Another important feature is a well-placed view box or computer monitor where radiographs can be seen easily during surgery. A radiographic unit should be available so that intraoperative films can be taken without moving the patient.

A bracket table or Mayo stand large enough for all needed instruments must be a part of the facility. Adequate countertop and shelving areas are essential to accommodate the requisite implant equipment (e.g., console, motors, handpieces, irrigation bottles) and devices for monitoring vital signs (e.g., GE Dinamap, Criticare, noninvasive blood pressure, pulse rate, three-lead electrocardiograph, pulse oximeter). Standby instruments for implant surgery

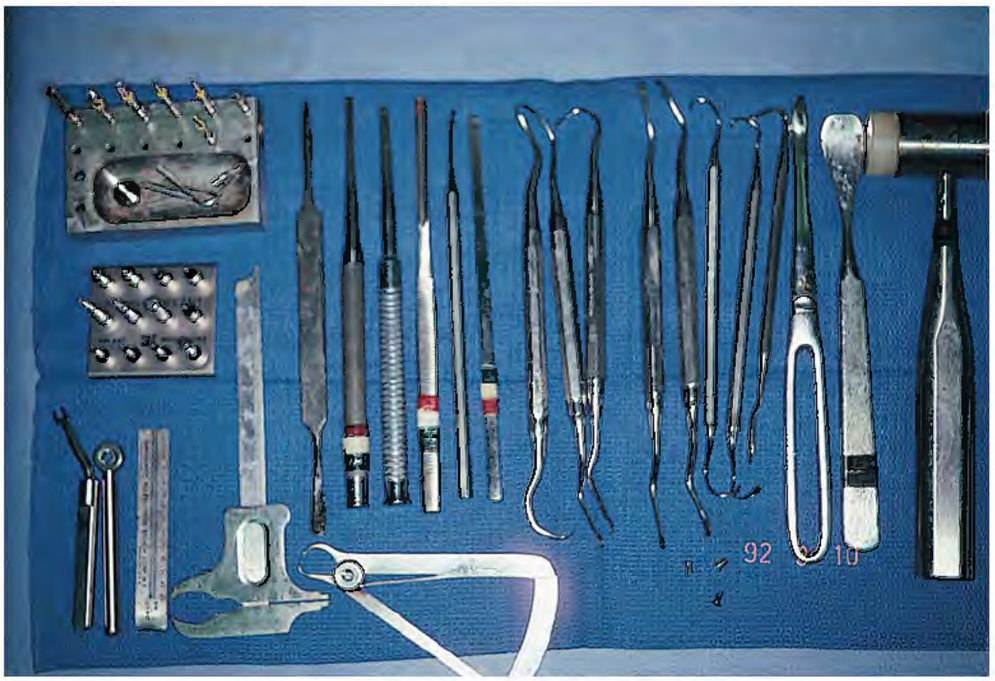


FIGURE 6-1. The instrument tray serves the surgeon best if mounted on a Mayo stand, which can slide beneath the chair so that delivery can be made over the patient's chest. In addition to standard operating instruments, fiberoptic retractors, bone filters on the suction apparatus, electrosurgical equipment, and a selection of fine-toothed forceps can make the surgeon's efforts more comfortable.

ARMAMENTARIUM

Acrylic, self-curing
Bone files
Burs: 700 L, 701 L, 2 L, 4 L, 6 L friction grip
Curettes: surgical and periodontal
Electrical surgical unit
Explorer/millimeter probe (preferably 15-mm periodontal probe)
Forceps
  Adson (toothed and nontoothed) pickup forceps
  Gerald (toothed and nontoothed) pickup forceps
  Kelly and tonsil (curved) hemostatic forceps
  Rongeur side- and end-cutting forceps
  Wire-twisting forceps, heavy duty
Gelfoam, surgical bone wax, Avitene
Handpieces: high and low speed, straight and angled, Impactair
Hemostats: mosquito, Kelly
Hypodermic needles: 18 gauge disposable, 1½ inch
Local anesthetic syringes, needles, and solutions
Mallet: nylon covered
Mirror (front surface)
3½-inch, 18-gauge spinal needle with stylet for the zygoma
1½-inch needle for the mandible
Needle holders
Nerve hooks (Teflon coated)
Osteotomes: curved and straight
Periosteal elevators
Pliers
  College pliers with plastic tips
  Titanium-tipped cone-socket pliers (2)
Polyethylene intravenous (IV) tubing
Prep tray for sterilizing the operative site
Retractors: sweetheart (tongue), baby Parker, blunt (Mathieu) rakes, large blunt rake, Army/Navy, beaver tail [Henahan], McBurney vein, Leahy
Sable paint brush (0-0)
Scalpel blades: No. 10, 11, 12, and 15
Scalpel handles (2), Bard-Parker No. 3 handles
Scissors: Metzenbaum, sharp tissue, and suture
Sponges: 2 × 2, 4 × 4
Suction tips: Yankauer, Frazier, plastic
Suture: 3-0 black silk, 4-0 dyed Vicryl, 3-0 plain gut, 4-0 chromic gut on tapered and cutting needles
Towel clamps
Wire: monofilament, No. 2 stainless steel, 12- to 18-inch lengths
Wire cutters, shears, and nippers

must be located conveniently and within clear visual range, and an emergency tray or crash cart should be available.

Other valuable features include foot controls or motion activation for the sink, a plentiful supply of electrical outlets (e.g., electrical strips) above the counter, storage space for stocking implants and prosthetic parts, a fiberoptic headlight, and adequate ventilation. All items and features that make for efficient, smooth, and safe treatment should be included in the plans for an implant operatory.

Surgical Delivery Systems

Perhaps the most misunderstood (and most necessary) of all implant equipment are the surgical delivery systems. Many terms, such as *consoles, motors, drills, contra-angles,* and *handpieces,* are commonly misinterpreted as synonyms for delivery systems. These devices actually are integral *components* of the equipment

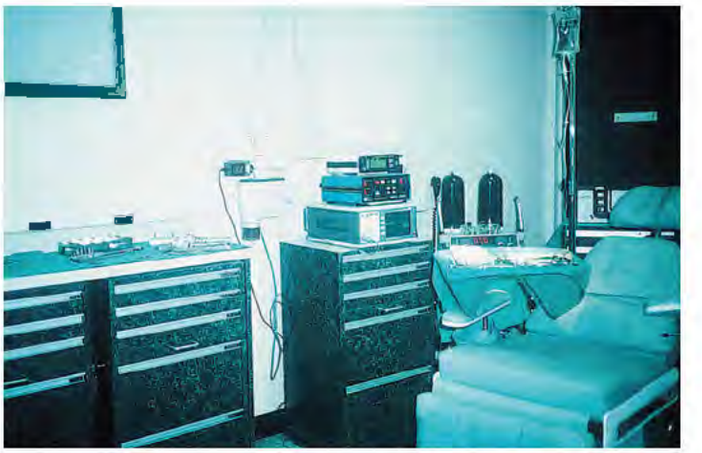


FIGURE 6-2. When possible, the operatory should be dedicated to implantology. Chair controls should be foot operated, and light handles should be sterilizable. Ventilation must be excellent, and duplicate rotary instrumentation should be available. Ample countertop and storage space is mandatory, and an abundance of electrical outlets and quick-release fittings for gas, air, water, vacuum suction, oxygen, and nitrous oxide provide convenience. Monitoring and resuscitation equipment, ceiling-mounted intravenous hooks, and anesthesia arm boards and accouterments are helpful.

that makes up an entire surgical delivery system. The more knowledge practitioners acquire about these components, the less time and money they will spend purchasing them, and the better chance they will have that the acquired equipment will satisfy their needs.

No single component is greater than the whole, and a better understanding on the part of the practitioner can make a difference during surgery, resulting in ease and efficacy or breakdown and failure. Despite the best maintenance, any component or system can fail. Every office, therefore, should have a backup unit.

Basically, surgical delivery systems are categorized into one of two classes, depending on the power supply. Most dentists use compressed air or nitrogen gas as the energy source for their regular high-and low-speed handpieces. Most surgical delivery systems for root form implants, however, are powered by electricity.

Electrical Delivery Systems

Until 1985, air- or nitrogen-driven systems were used to perform most root form and blade implant surgery. However, as root form implant systems became universally accepted, electrical surgical modalities, both rotary and piezosurgery, were introduced. Root form implant surgery requires high torque at low speeds, and this created a major problem with air- and nitrogen-powered systems: to receive more power, or torque, air- and nitrogen-powered handpieces require commensurately more speed. Electrical systems introduced higher torque at lower speeds.

An electrical surgical system has four basic components: a console, a motor, a handpiece, and burs or drill bits (or piezosurgical insert tips). In-depth examination of each component and its relationship to the others can help the practitioner understand the entire system. It is important not only to understand the intricacies of both electrical and air- or nitrogen-powered units, but also to comprehend the surgical demands made by the various implant systems. Some require higher speeds and less torque, whereas others require lower speeds and greater torque.

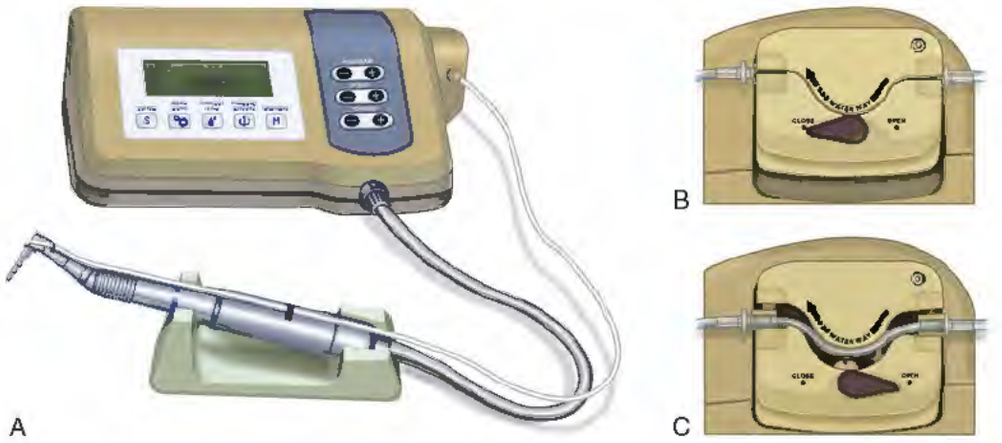


FIGURE 6-3. The console, an electrical housing for low-speed, high-torque drilling equipment, should show the speed in an LED readout. It also should have adjustments for controlling the equipment, the capability to pump irrigant to the drills and to signal reverse direction, and when available, the capacity for two motors.

Console

The console contains all of the electrical circuitry; the controls for speed, torque, irrigation pumps, and handpiece selection; the power source; and a light-emitting diode (LED) readout for revolutions per minute (rpm). Even the foot-controlled rheostat plugs into the unit and is powered by the console (Fig. 6-3).

Power is supplied to the console directly from any standard 110-V electrical wall outlet. Consoles are produced as solid-state electronic devices. They are explosion and spark proof and lightweight (weighing 7 to 11 pounds). If implant surgery is planned in a hospital operating room, a special shockproof attachment is required for the console, and its electrical safety must be verified for the institution's biomedical engineers. Either the manufacturer's or the hospital's engineering department can provide these services.

Electric Motors

The motor housing cord plugs into the front of the console and uses its voltage supply, much the same way a cassette or CD player uses a stereo amplifier (Fig. 6-4). The tiny motors inside the housing are commonly referred to as *micromotors,* and they are designed to run at different speeds.

The motors most commonly used for root form implants turn at 20,000, 30,000, and 40,000 rpm. However, some motors from the same manufacturer and even the same lot can run 2000 to 3000 rpm faster or slower than others. For simplicity, these motors can be grouped into any of the three rpm ratings categories (20,000, 30,000, and 40,000). It is critical that surgeons know the motor rating, for two reasons: (1) generally, a 20,000-rpm motor has more torque (power) for bone tapping at lower speeds, and even at equal speeds, than does a motor rated at 30,000 or 40,000 rpm; and (2) because all motors loose some speed when drilling bone, a 20,000-rpm motor may not be capable of delivering the speed required to maintain the power that a high-rated motor may have.

FIGURE 6-4. Electric motors are handheld and should be capable of a variety of speeds and torques. Backup equipment is recommended in case of motor failure during the procedure.

An example can clarify the second point: Implant company A recommends using no less than 1200 rpm to perform a certain procedure. Different handpieces are available that can motors of 20,000, 30,000, or 40,000 rpm to 1200 rpm. In dense bone, electric motors often lose as much as 50 to 300 rpm per 1200 rpm (up to 25%) while cutting. The actual top speed for a 20,000-rpm motor with a reduction handpiece might drop to as low as 900 rpm at full power, which might result in burnishing of the bone. However, if the same handpiece is used with a 30,000-rpm motor, the speed could be increased another 600 rpm (to as high as 1500 rpm), which would compensate for the loss caused by the dense bone.

As a simple rule of thumb, when speeds higher than 1000 rpm are needed, a 30,000- to 40,000-rpm motor should be selected. If most of a practitioner's procedures require less than 1000 rpm and many ultraslow procedures are expected (i.e., below 300 rpm), both a 20,000-rpm motor and a 40,000-rpm motor cut adequately at speeds well under 300 rpm; however, as may be seen in the following section, the practitioner should have many more speed-reduction handpieces.

The significance of the LED speed readout found on electrical consoles requires explanation. If a motor is rated at 20,000 rpm and a 10:1 reduction angle is chosen, the practitioner presses the 10:1 selector button on the console. The readout then shows a velocity of 2000 rpm. It is important to understand that the selector switch neither increases nor decreases actual speed; it simply calculates the change mathematically on the LED display. The only way to increase or reduce speed on any electrical or air- or nitrogen-powered system is to change the posture of a hand or foot rheostat.

Most practitioners who purchase an electrical delivery system buy the console and motor together, because one manufacturer's motor may not couple with the console of another manufacturer. To ensure greater accuracy in readings, one brand should be chosen for all components.

The practitioner also must choose between single-motor and double-motor systems. A single-motor system can accommodate one motor. A dual arrangement allows two independent motors to be attached to a single console. The main differences between the two systems are price and versatility. With a double-motor console, the surgeon may set the motor and the handpiece for different speeds independently of each other. Motor 1, for example, can be programmed to cut at a maximum of 1200 rpm for development of an osteotomy, and motor 2 can be set to cut at 15 rpm for bone tapping. Because they cannot work simultaneously, such features as LED readout, irrigant pumps, and rheostats work only with the motor in use. If the budget permits and more than one speed range is required for certain implant surgical procedures, a double-motor system is recommended. In addition, double units eliminate the wasted time spent changing handpieces and water spray cannulas. Because most system failures occur in the motor and not the console, an additional benefit of a dual drive is the assurance of a backup device if one motor fails.

Piezoelectrical Ultrasonic Surgical Unit

The piezoelectrical ultrasonic surgical unit is not new, but it currently is not as extensively used as perhaps it should be. The ultrasonic micro-oscillation motion of the root form diamond insert, which has a rounded end cutting tip and parallel side-cutting edges, immediately creates an osteotomy by virtue of a simple vertical sweeping motion. Also, the osteotomy can be expanded sequentially to the approximate desired diameter through use of insert tips of incrementally increasing diameter.

Troubleshooting

If any of the following are noted while the motor is in use, action must be taken:

- The practitioner feels a loss of speed with vibration of the handpiece head. (This can cause gear stripping and handpiece failure.)
- The bur wobbles or chatters during cutting. (This causes friction to the handpiece and can burn and injure the bone.)
- The sound of the motor changes, or the motor begins to growl or buzz. (This may indicate a drop in speed and power as a result of an internal problem in the gear housing.)
- The motor and handpiece begin to feel warm and get progressively hotter over time. (This may indicate a worn gear assembly.)

In such instances, the rheostat should be used to increase motor speed, because this may help reduce the difficulties. To prevent these problems, the practitioner should:

1. Make smaller increases in drill diameters (see Chapter 9)
2. Use new, sharp burs and drills at appropriate velocities and change them often (see the section on burs and drills in this chapter)
3. Stay within the proper handpiece power zones (see the following section on handpieces as well as Tables 6-1 and 6-2)

The sterility of electric motors is an issue involving cost and versatility. Most autoclavable motors cost three times as much as motors that cannot be autoclaved. Autoclavable motors usually are rated at no more than 20,000 rpm, and they run hotter than motors that cannot be autoclaved because they have no cooling vents. However, motors that cannot be autoclaved can be used with sterile, transparent drapes (e.g., Steri-Drapes, which are supplied with adhesive). These wraps are inexpensive and disposable and fit any standard electric motor (Fig. 6-5). They cover the connections at the console and allow the controls to be used through them.

Table 6-1 20,000 rpm Electric and 90 psi 20 k Air or Nitrogen Motors

Contra-Angle Reduction	Approximate Speed Range (rpm)	Approximate Power Range (rpm)
10:1	200-2000	1700-2000
16:1	78-1250	950-1250
17:1	70-1175	875-1175
18:1	60-1110	850-1100
20:1	50-1000	800-1000
64:1	25*-312	50-312
70:1	20*-285	50-285
100:1	18*-200	40-200
120:1	15*-166	25-166
256:1	10*-78	15-78
280:1	8*-70	15-78

*Minimum speed at which the bur will cut without stalling.

Table 6-2 30,000 rpm Electric and 90 psi 20 k Air or Nitrogen Motors

Contra-Angle Reduction	Approximate Speed Range (rpm)	Approximate Power Range (rpm)
10:1	300-3000	2500-3000
16:1	115-1875	1200-1875
17:1	100-1765	1150-1765
18:1	90-1660	1100-1660
20:1	75-1500	850-1500
64:1	50*-468	60-468
70:1	40*-428	50-428
100:1	25*-300	40-300
120:1	20*-250	25-250
256:1	10*-119	20-119
280:1	10*-107	15-107

*Minimum speed at which the bur will cut without stalling.

FIGURE 6-5. A disposable plastic sleeve, which is inexpensive and simple to place, permits motor and cord use without the need to autoclave them.

Handpieces

The term *handpiece* is one of the most misused words in dentistry. Simply defined, a handpiece is any apparatus attached to an electrical or an air- or nitrogen-powered motor that accepts a bur. There are two types of handpieces: contra-angle and straight (Fig. 6-6); these enable the practitioner to increase or maintain a motor's speed reliably.

FIGURE 6-6. Dental surgeons need both straight and contra-angle handpieces.

Handpieces that reduce a motor's top speed are referred to as *speed-reduction handpieces.* These are rated by the ratio of speed decrease they can achieve (e.g., a 16:1 reduction handpiece reduces a motor's top speed by 16 times). As speed is decreased, torque is increased by the same ratio. Conversely, reduction handpieces have more power at higher speeds than at lower speeds. This phenomenon is called the *handpiece power zone.* With a 16:1 reduction on a 20,000-rpm motor, power is greater at 1250 rpm than at 500 rpm. Table 6-1 shows that a 16:1 reduction handpiece has near-maximum power between 950 and 1250 rpm. Below 950 rpm, both speed and power are lost rapidly. If the same 16:1 reduction handpiece is used on a 30,000-rpm motor, the top speed increases to 1875 rpm, and the power zone is found at the 1200-rpm level. It is critical that the surgeon know the motor's top-rated speed and the handpiece power zone.

Universally, green stripes on a handpiece denote reduction capabilities. If a handpiece is not marked, the reduction ratio should be marked on its surface with a bur.

Instruments that increase a motor's highest velocity are referred to as *speed-increasing handpieces* and universally are marked with a red stripe. As speed is increased by a certain ratio, power is decreased by the same ratio. For this reason, speed increases are contraindicated for root form surgery; they should be used primarily for placing blade implants.

Both speed-increasing and speed-reduction handpieces require high maintenance and are up to three times more expensive than ordinary handpieces. Generally, the higher the reduction ratio, the higher the price.

Handpieces that do not increase or reduce speed are commonly known as *1:1 handpieces.* They are universally marked with blue stripes.

Power Ranges of Handpieces

Every handpiece has more power at higher speeds than at lower speeds. It is important for the practitioner to know the speed at which the torque of each system is highest. Most of the problems that occur during root form surgery happen because changes in drill diameter are not made in sufficiently small increments and because dull drills are not changed often enough. If the practitioner observes the following six simple rules, as well as the power ranges in Tables 6-1 and 6-2, the chances for problem-free surgery are greatly enhanced:

1. Allow for a one-third drop in top speed.
2. Increase speed if the handpiece begins to vibrate.
3. Increase speed if the bur wobbles (chatter).
4. Allow the bur several seconds to get up to speed before cutting bone.
5. Never apply pressure to the head of the handpiece during cutting procedures. This is a natural reaction if the handpiece begins to stall or slow, but it causes gears to strip, and thermal injury to the bur and bone results.
6. Hold the handpiece with a featherlike touch and let the motor, handpiece, and drill do the cutting. The surgeon's fingers should simply guide the handpiece.

Table 6-3 presents a list of currently available systems and some of their specifications.

If the desired cutting speed is 200 rpm, handpieces 1 to 8 theoretically offer 200 rpm. In reality, angles 1 to 5 stall at that speed. Looking at the Approximate Power Range column, angles 6, 7, and 8 have a capacity of 200 rpm with acceptable power. Because a one-third drop in speed must be accommodated, only angles 6 and

Table 6-3 Handpiece Selection

	Different Console Jacks for Different Speeds	Different Motors for Different Speeds	Different Contra-Angles for Different Speeds	Tapping Capability	Reverse Capability	Audible Alarm	Autoclavable Motor
1. Acteon	*	*	*	*	*	*	–
2. Aseptico	–	–	*	*	*	*	*
3. Bicon	*	*	*	*	*	–	–
4. Biomet-3I	–	–	*	*	*	*	–
5. Duo-Dent	–	–	*	*	*	*	–
6. Dynasurg	–	–	*	*	*	*	–
7. Medidenta	–	*	*	*	*	–	Air only
8. NobelBio	–	–	*	*	*	*	–
9. Osada	–	–	*	*	*	*	*
10. Osteomed	–	–	*	*	*	*	–
11. Physiotron	–	–	*	*	*	*	*
12. Steri-Oss	–	–	–	*	*	*	*
13. Stryker	–	*	*	*	*	*	*
14. Sulzer	–	–	*	*	*	*	–
15. W&H	–	–	–	*	*	*	*

*: Yes; —; no

7 would allow a one-third increase in speed at the high end of the speed range (285 to 312 rpm). If the desired speed is 1500 rpm, handpieces 1 to 5 should cut at that speed. From a practical point of view, only handpieces 2 to 5 have adequate power at 1500 rpm. Allowing for a one-third drop in maximum speed (so that speed may be increased if needed), only angles 2, 3, and 4 are good choices. Commensurate values can be extrapolated for motors rated at 40,000 rpm.

Burs and Drills

All burs and drills for either blade or root form implant surgery have an absolute minimum speed at which they cut. Because electric motors lose up to one third of their maximum speed, and air and nitrogen motors even more, burs should not be rotated at their minimum cutting speed.

Blade Implants

Most burs used for blade implants are friction-grip fissure burs that perform best at 30,000 to 100,000 rpm. These burs are used only with an external irrigant. They should always be new, and the motion should be a light, brushing one.

Some clinicians start blade osteotomies with wheels or disks (Paragon); others use oscillating minisaws. Minisaws are technique sensitive, but they establish a more precise outline in the cortical bone. These osteotomies must be completed with a high-speed bur.

Root Form Implants

Most category 1 pilot burs and category 2 twist drills (Fig. 6-7) are available with cannulas for internal irrigation, but they often are run with external coolant as well. They cut best at speeds of 300 to 1200 rpm. Those without provision for an internal coolant are used only with an external source.

The next of the three categories of burs are the most critical with regard to speed. Formerly, the common belief was that the slower the speed, the more protected the bone. Unfortunately, little was known about motor torque, handpiece power, and efficient cutting speeds. If a bur cuts too slowly, it may splinter bone, create chatter, and contribute to handpiece failure.

Drill progression according to size also is a factor in efficient cutting. A rule of thumb is, the larger the drill, the greater the speed required to cut. Dental surgeons should make it a practice never to increase diameters by more than 0.5 mm with each change, and small increases in speed also are warranted.

FIGURE 6-7. A reduction gear angled handpiece with a Brasseler fluted bone drill mounted. This system uses both internal and external irrigation. The drill has a sterile length marker (yellow Disposaboot) attached to its shank.

Category 3 drills are designed in saddle, bispade, and trispade shapes. Most are irrigated internally, but they also should be supplied with external saline sprays.

Air- and Nitrogen-Powered Systems

Systems of 90 pounds per square inch (psi) using 20 and 30 k air- or nitrogen-powered motors are the selections of choice. All motors are fully autoclavable. However, air- and nitrogen-powered systems do not offer accurate speed readouts. The surgeon should know the desired speed range, allow for a speed loss of one third to one half, select a proper handpiece power zone (see Tables 6-1 and 6-2), and run the handpiece at full speed. In other words, if a speed of 1200 rpm is required and a 30-k motor is used, the best handpiece would be capable of a ratio of 16:1, 17:1, or 18:1. If a 16:1 handpiece is selected, the top speed is 1875 rpm. At full speed, allowing for a one-third decrease in velocity, the safe range would still be maintained. Air- and nitrogen-powered motors have fewer moving parts and probably work longer than the electrical types before requiring service.

Internal Irrigation	Single Unit (1 Motor)	Double Unit (2 Motors)	Electric	Gas or Air	Variable Speed	Foot Control	Variable Irrigation Pump Flow	Output Display (rpm)
*	–	*	*	–	*	*	*	*
		Motor & piezo						
*	*	*	*	–	*	*	*	*
–	*	*	*	Air only	*	*	–	*
–	*	–	*	–	*	*	*	*
*	*	*	*	–	*	*	*	*
*	*	*	*	–	*	*	*	*
*	Electric only	Air only	*	*	*	Air only	*	–
–	*	–	*	–	*	*	–	–
*	*	–	*		*	*	*	*
*	*	*	*	–	*	*	*	–
*	–	*	*	–	*	*	*	*
*	*	*	*	–	*	*	*	*
*	*	–	*	–	*	*	*	–
*	*	*	*	–	*	*	*	*
*	*	–	*	–	*	*	*	*

Important Factors in the Selection of a Delivery System

The practitioner should consider the following important factors in choosing a surgical delivery system.

1. For safety's sake, either a double-motor system or two single-motor systems should be purchased.
2. If more than one implant type is to be used, if different procedures will be performed (e.g., bone tapping, countersinking, threading, cutting, and seating of implants), and if different speed ranges will be required, a double-motor system that offers variable torque control with a handpiece speed-ratio selection on the console is best. This allows the practitioner to read actual speeds rather than having to make mental conversions.
3. If handpieces are changed to a new manufacturer, the company that made the console motor should be able to recalibrate speed readouts on the console to conform to the newly acquired handpiece speed ratios.
4. Variable flow and good pressure from the water pump should be available.
5. All water tubing should be made of silicone.
6. If two different sizes of tubing are used, the connections should be watertight and placed at a reasonable distance from the console, so that if a leak occurs, it will not cause the pump motors to rust.
7. A foot-controlled rheostat should be chosen. Reverse and forward changes that can be made from the foot pedal are important features. An audible signal when the reverse mode is used is a significant requirement.
8. The practitioner should make arrangements with a colleague nearby who has similar devices so that equipment can be exchanged when necessary.
9. Two motors and two handpieces should be available, so that if one fails, the surgical procedure can be completed. Handpieces break down more often than all other components combined.
10. If saline is used as an irrigant (which is highly recommended), handpieces and silicone tubing should be flushed with water after each case is completed.
11. Equipment is mechanical, and as with all machinery, regular maintenance is essential. Staff members must be taught the maintenance procedures specified by the manufacturer.

IMPORTANT SURGICAL PRINCIPLES FOR THE IMPLANTOLOGIST

Preoperative Regimen

Routine care should include having a well-rested patient in surgery. An oral sedative given the night before (e.g., diazepam [Valium] 5 mg; zolpidem [Ambien CR] 6.25 mg) can help bring to the office a relaxed, receptive patient. If local anesthetics are to be used, a good breakfast is beneficial. (Patients will not be very hungry after surgery.) Scheduling procedures in the morning is best for the surgeon and the patient.

For a sensitive patient, 600 mg of ibuprofen (Motrin) given 30 minutes before surgery elevates the pain threshold. If the patient is to have sedation of any kind, including nitrous oxide or general anesthesia, the person should be instructed not to eat or drink for 6 hours immediately before surgery.

With regard to the prophylactic and therapeutic use of antibiotics, the American Heart Association (AHA) continues to review and revise its recommendations on prophylaxis for subacute bacterial endocarditis. Currently, for patients considered at normal risk (i.e., patients with the most common congenital heart malformations, rheumatic and other acquired valvular dysfunctions, hypertrophic myopathies, and mitral valve prolapse with valvular regurgitation), the AHA recommends no premedication (see Appendix M).

Phlebotomy skills are not difficult to acquire, and every implantologist should be able to perform such techniques. Patients with prosthetic valves and surgically constructed shunts require antibiotic prophylaxis; anticoagulant therapy also is an integral part of their regimens. These factors can contribute to a sufficient number of complications intraoperatively and postoperatively; therefore implants should be considered only for those patients in whom the need seems urgent. When implants are selected for patients receiving anticoagulant and antiplatelet therapy, the patient should be assessed as either at moderate risk (i.e., hypertension [HTN], transient ischemic attacks, and an international normalized ratio [INR] or prothrombin time [PT] of IB) or at high risk (i.e., prosthetic [but not porcine] heart valves in which discontinuation of anticoagulants for 3 days is dangerous).

The moderate-risk patient should be admitted to the hospital, where warfarin (Coumadin) is discontinued for 3 days, with monitoring of the patient, until surgery can be performed without risk of excessive bleeding. Primary closure and use of bovine thrombin and Avitene should provide adequate hemostasis. The surgical site is monitored for 12 hours postoperatively. After 12 hours, if a stable surgical site with stable clot formation is present, a bolus of 5000 units of heparin is given intravenously (IV), followed by 1000 units IV per hour until the partial thromboplastin time (PTT) reaches 60. After 3 days of heparin therapy, warfarin (Coumadin) can be started, with a 24-hour overlap of the two medications until the INR or PT reaches the presurgical therapeutic level.

Severe-risk patients are admitted to the hospital, and warfarin (Coumadin) is discontinued immediately. These patients should start receiving heparin (5000 units with IV bolus), followed by 1000 units IV per hour and should wear antiembolism stockings. When the PTT reaches 60 and the INR is 2, the heparin is discontinued. One hour later, surgery should be started if the immediate preoperative PTT remains at an acceptable level. Postoperative management is identical to that for the moderate-risk patient, with emphasis on bed rest until presurgical therapeutic coagulation values are achieved.

For a healthy patient with a good state of oral hygiene, antibiotic prophylaxis is unnecessary and may actually do harm by creating bacterial resistance, drug sensitivities or, worse, allergic anaphylaxis. If antibiotic therapy is thought to be important, one dose may be given preoperatively and a second (and final) dose may be given after surgery.

Methods of Anesthesia

Most practitioners feel comfortable using local anesthetics when performing implant surgery (see Chapter 4 for nerve blocking techniques). The use of mepivacaine (Carbocaine) without a vasoconstrictor is a poor choice, because the drug lacks depth and longevity. Experience has shown that trying to renew or supplement anesthesia during the course of a procedure is difficult at best. If a patient is not a good enough risk to be given lidocaine with 1:100,000 epinephrine, the individual should not be considered a suitable candidate for elective implant surgery in the ambulatory setting. For an average-size adult, the limit for at least the first 90 minutes is eight anesthetic cartridges. Therefore each one must be administered effectively and with care.

For placement of anterior mandibular (parasymphyseal) implants, infiltration into the vestibule is satisfactory, although the lingual side of the ridge also must be anesthetized. The mental foramen block must be avoided; infiltration in this area may result in a higher than expected number of long-lasting dysesthesias. Sound anesthesia can be achieved with an injection in the general area of the neurovascular bundle, but care must be taken to avoid the foramen itself.

In the posterior mandible, infiltration anesthesia is preferable to nerve blocks. Soft tissue and bone anesthesia can be achieved with satisfactory depth, but the lower lip will not become anesthetized. As a result, if rotary instruments approach the inferior alveolar canal, the patient can offer a warning: the lip will begin to tingle, or a sensation of heat may be felt. Infiltration, therefore, builds a significant safety factor into the procedure.

Nerve blocks are required for both mandibular and maxillary subperiosteal procedures, particularly for the first or impression-making stage. Practitioners should become comfortable with the Gow-Gates technique, in which the surgeon aims high for the medial surface of the condylar neck. In doing so, however, the internal maxillary artery can be entered, therefore the surgeon must be cautious and make sure to aspirate. If attempts at mandibular blocks repeatedly fail, it is important that the surgeon remember the benefits of infiltrating the lower lingual gingivae in the premolar area, with the hope of blocking branches of the cervical colli nerves.

Knowing the location of the foramen can help in establishing the infraorbital block. Most often, the foramen is found below the medial quarter of the infraorbital rim rather than at the midway point. The neurovascular bundle can be approached only if the needle enters the upper labial mucosa at a point midway between the vestibule and the vermilion border. The surgeon should retract the lip with the thumb and middle finger and then palpate the foramen through the skin with the index finger of the same hand. The direction of the syringe should be upward and inward toward the area of the foramen through the soft tissues, and the anesthetic should be discharged only when the needle is felt against bone beneath the palpating forefinger. Entering the gingiva as if to infiltrate a canine tooth prevents advancement of the needle to the infraorbital nerve because of the deep concavity of the canine fossa.

The maxillary (second division) block is important in implant surgery. It is established by entering the anterior (greater) palatine foramen, which may be found by piercing the mucosa in the middle of the operative side of the hard palate at the mesial level of the first molar. A few drops are injected, followed by a pause to allow the tissues to become anesthetized. The needle tip then is advanced until it falls into the foramen. It is propelled in an upward and forward direction. A 27-gauge, 1½-inch needle is used if the block is to be effective, because it must pass through the canal to its full length. Injections are made very slowly, because the space is restricted and rapid discharge of the solution causes severe pain. At least two tubes of anesthetic should be used. As a general rule, but particularly with this block, the practitioner never injects the solution while the needle is being advanced; this is extremely painful, it tears the tissues, and it negates the value of a sharply pointed needle.

If the second division block is given correctly, numbness of the ipsilateral upper lip, nasal ala, facial tissues, and lower eyelid result. Intravascular injections should be avoided. In adults, a fully patent canal is encountered approximately 65% of the time. If full needle-length entry cannot be made, the injection still should be given, which at least achieves anesthesia of the hard palate, ridge, and buccoalveolar gingivae up to the second premolar.

The incisive and posterosuperior alveolar blocks also are important, because they allow a longer operating time and provide more profound anesthesia than can be obtained with simple infiltrations.

Sutures and Suturing

Suture Materials

Table 6-4 presents the available types of suture material and their characteristics and possible uses. Complicated implant closures, for example, require a synthetic resorbable suture, such as Vicryl (polylactic acid/polyglycolic acid), Polysorb or Biosyn, because this type of suture allows long, continuous, and complicated closures and eliminates the need to remove all parts of the suture material.

Sutures are available in silk, expanded polytetrafluoroethylene (e-PFTE), nylon, polyglycolic acid (Dexon), Vicryl, plain gut, and chromic gut, all in sizes ranging from 1-0 to 6-0 or even finer. Some are made in braided form (silk Dexon, Vicryl) and others come in monofilament form (e-PTFE, nylon, Biosyn, and gut). The braided types are easier to use because of their softness, compliance, ease of tying, and stability of knots. On the other hand, they serve as wicks (particularly silk) that may cause retrograde infection, which the monofilaments discourage.

Silk, e-PFTE, and nylon are nonresorbable. Some patients may be sensitive or allergic to silk because silk is a foreign protein. The other products are resorbable. Vicryl and Polysorb are synthetic polymers and resorb very slowly (over 30 to 45 days). Most dentists are accustomed to using silk. However, all its remnants must be removed. When a complicated closure (e.g., closure over a subperiosteal implant) is performed with a continuous mattress suture with much pericervical wrapping, removing all remnants of the suture material may be extremely difficult. In these cases, Vicryl or Polysorb is recommended. Once the surgeon becomes comfortable with these two suture types, convenience and ease of management (despite their relative expense) make their use worthwhile. Deeper layers (i.e., periosteum, muscle, subcuticular tissues) may be closed with 3-0 plain gut (which resorbs in about 5 days), chromic gut (which resorbs in about 30 days), or one of the synthetic polymers (30 to 45 days). Nylon usually is reserved for skin, because it is so stiff that the cut edges can be too sharp for the oral tissues, causing lacerations and ulcerations.

Suture Needles

Needles may be tapered (round in cross section) or cutting (either outside or inside), or they can be straight (for skin closure) or curved irregularly or regularly in ⅜, ½, and ⅝ circles of varying sizes. The needle that is preferable for use in intraoral surgery, including implant closure, is a ⅜ circle, inside cutting needle mounted atraumatically to the suture material (an eyeless needle swaged to the suture material). Cutting needles are preferred for intraoral closures, particularly for keratinized tissues, because too much resistance exists for easy passage of a tapered needle. However, 5-0 silk or Vicryl on a tapered needle is indicated for closure of fine, thin, fixed gingiva, such as the type found in the anterior portion of the mouth overlying the alveolar ridge (e.g., for apicoectomies). When a cutting needle is used, it is passed evenly and smoothly, one flap at a time, and is pushed in the direction of its own arc. In this manner, the cutting edge assists the progress of the needle and does not excessively incise the tissues through which it passes.

The needle holder is grasped the way scissors are held, through the loops. Many surgeons hold the needle holder in a palm-thumb grasp, which gives good tactile control. However, when the needle is

Table 6-4 Advantages and Disadvantages of Different Types of Suture

Name	Material	Resorbable	Time to Resorb	Purpose/Size	Advantages	Disadvantages
Silk	Braided, black, natural	No	–	Mucosal closure (3-0), tongue and flap retraction (2-0)	Slides and knots easily, knot does not slip	Acts as a wick, needs to be removed, not very strong
Plain gut	Monofilament, clear, animal	Yes	5-7 days	Subcuticular and mucosal closure (3-0)	Resorbs quickly, good for noncritical wounds	May cause sensitivity, does not hold knots well, unreliable for critical wounds, bothers the tongue intraorally, weak
Chromic gut	Monofilament, gut, beige, natural	Yes	28 days	Deep muscle closure (3-0, 4-0)	Resorbs slowly, dependable	May cause sensitivity, not for intraoral use, holds knots poorly, weak
e-PTFE	Monofilament, white, microporous	No	–	Mucosal closure, securing of e-PTFE membrane (4-0, 5-0)	Soft, strong, no out of package memory, minimal tissue response	Acts as a wick, requires removal
Nylon	Monofilament, blue/black, synthetic	No	–	Skin closure (5-0, 6-0)	Strong, discourages wicking	Holds knots poorly, has plastic memory, requires removal
Tevdek	Braided, green, Teflon-coated Dacron, synthetic	No	–	Skin closure (5-0, 6-0)	Strong, knots well	Acts as wick to some extent, requires removal
Dexon	Braided, white or dyed, polyglycolic acid, synthetic	Yes	28-45 days	Deep suturing, mucosal closure (2-0, 3-0)	Strong, holds knots well, after removal residual deep components may be left behind but eventually will resorb	Causes some wicking, requires removal when used intraorally because 28 days is too long, when wet neither slides nor knots as well as silk
Vicryl	Braided, white or dyed violet, polylactic acid, synthetic	Yes	28 days	Deep suturing, mucosal closure (2-0, 3-0)		

e-PTFE, Expanded polytetrafluoroethylene.

passed halfway through the flap, the needle holder is opened so that the needle can be released. To do this, the fingers are wriggled backward, seeking the instrument's scissors holes or loops, which must be engaged to allow the jaws to snap open. These potentially traumatic machinations often cause the grasped needle to tear the tissues. Some surgeons acquire the skill of releasing the needle holder with the heels of their hands. If this technique cannot be mastered, the fingers should be kept in the scissor holes during all the steps. This allows the surgeon to pass sutures and open and close beaks without disturbing the posture of the needle. An alternative is to use a "loopless" needle holder (e.g., a Crile or Mathieu needle holder), which opens easily when the handles are squeezed together.

Another technique that should not only hasten closures, but also make them more accurate, is to acquire the custom of using a toothed pickup forceps (Adson or Gerald) to hold, position, and stabilize the flaps. This is not an easy technique to master, although few, if any, surgeons who operate in other fields spear the tissues without supporting them. An assistant is needed to retract so that the surgeon's other hand can remain free to stabilize the tissues to be sutured. Once the technique is mastered, however, it becomes an effective method for closing wounds quickly and accurately. A good way to practice the technique is on a towel or bedspread.

Surgical assistants must be reminded not to suction after the first suture throw (two clockwise turns). The first half of the knot is allowed to lie flat and untouched until the second (counterclockwise) throw is completed, which locks and fastens it. Suctioning or wiping disturbs and loosens the knot, slowing progress.

Methods of Closure

Several methods of closure can be performed (Fig. 6-8), each of which offers advantages when used for different types of incisions and at various locations.

Interrupted Sutures

Interrupted sutures are the classic type used by most practitioners for simple closures (Fig. 6-8, *A*). A good alternative to help create firm, accurate knots is to make the first throw singly clockwise (rather than twice as is generally taught). The turn is tightened and laid it flat. This is followed by a second clockwise throw, which creates a granny knot. In most cases (particularly with new silk and nylon), the suture may still be drawn tight, because the granny knot permits some beneficial slipping and tightening. At this stage, the knot remains stable and firm while the final, counterclockwise turn locks it (Fig. 6-9). As braided suture becomes moistened, the granny technique may become more difficult to use.

The problem with interrupted sutures in general is that they bring very thin mucosal edges together, which may not heal primarily. In addition, interrupted sutures create areas of intermittent ischemia, which may further impede healing, collect food and debris, and serve as general sources of annoyance to the tongue and lips.

Simple Continous Suture

The simple continous (running) suture is an uninterrupted series of simple interrupted sutures (Figure 6-8, *B*). The suture is started by placing a simple interrupted stitch, which is tied but not cut. A series of simple sutures are placed in succession without tying or cutting the suture material after each pass. Sutures should be evenly spaced, and tension should be evenly distributed along the suture line. The line of stitches is completed by tying a knot after the last pass at the end of the suture line. The kuot is tied between the tail end of the suture material where it exits the wound and the loop of

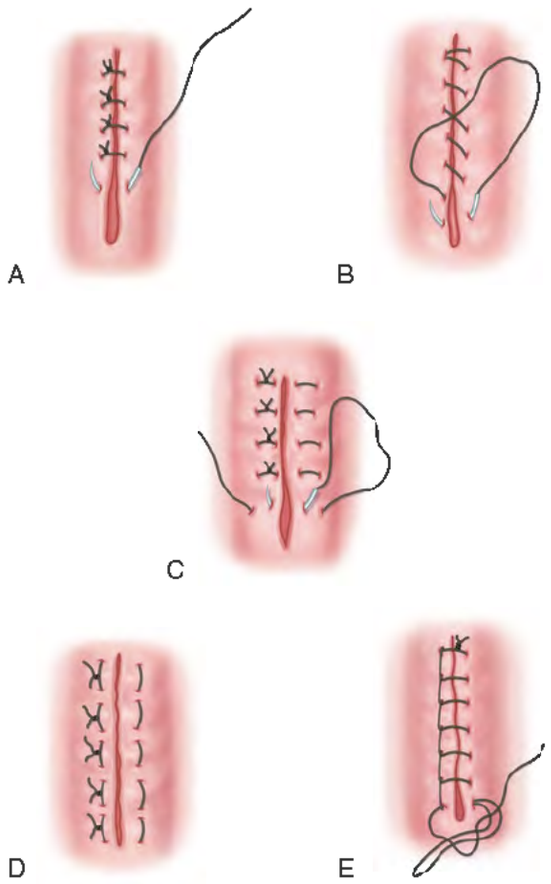
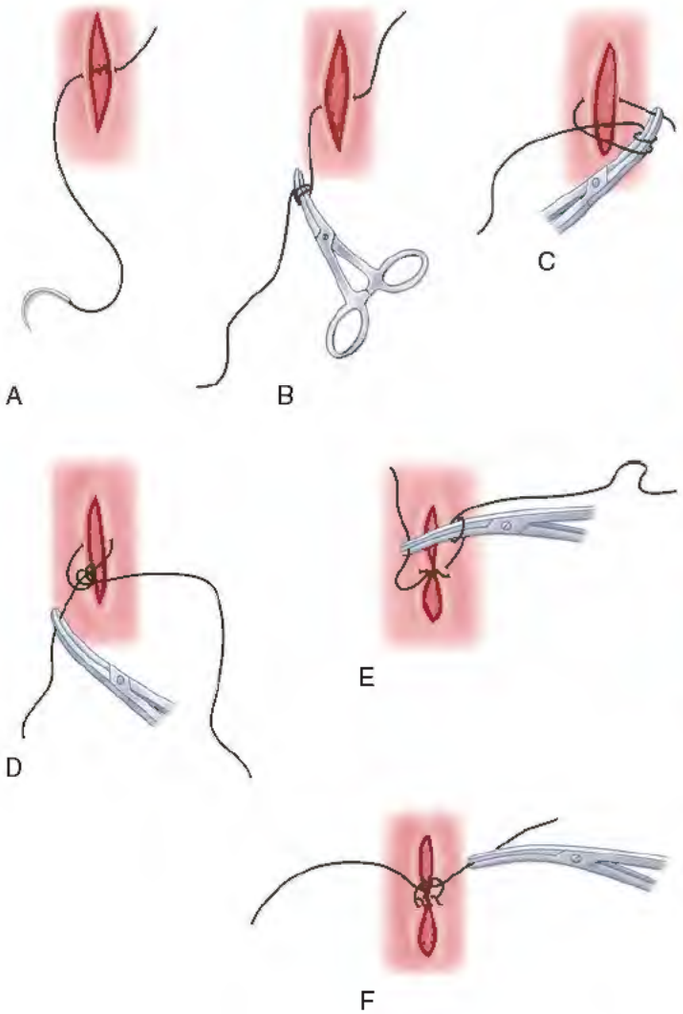


FIGURE 6-8. **A,** Interrupted sutures. **B,** Continuous sutures. **C,** Vertical mattress sutures. The flaps are stabilized, and the needle is passed through each of the flaps 1 mm from the incision. The needle is then reversed and passed in the opposite direction 4 mm from the wound margins. Both the exit and entry points are on the buccal flap. They are tied in a surgical knot. **D,** Interrupted horizontal mattress sutures. **E,** Continuous box-lock sutures. This technique is useful for closing crestal incisions. The needle enters from buccal to lingual each time, as for a continuous suture. Before each pass is tightened, however, the loop is lifted from the tissue and turned once clockwise, and the needle is passed through it. When the suture is tightened, a locked box configuration results.

the last suture placed. Running sutures are useful for long wounds in which wound tension has been minimized with properly placed deep sutures and in which approximation of the wound edges is good. This type of suture may also be used to secure a split- or full-thickuess skin or gingival graft. Theoretically, less scarring occurs with running sutures compared with interrupted sutures because fewer knots are made with simple running sutures; however, the number of needle insertions remains the same. Advantages of the simple continous suture include quicker placement and more rapid reapproximation of wound edges, compared with simple interrupted sutures. Disadvantages include possible crosshatching, the risk of dehiscence if the suture material ruptures, difficulty in making fine adjustments along the suture line, and puckering of the suture line when the stitches are placed in thin skin.

Horizontal Mattress Sutures

The continuous horizontal mattress suture avoids the problems cited previously, apposes zones of bleeding periosteum 1 to 2 mm wide, and presents the greatest opportunities for primary healing (Fig. 6-8, *D*). With a little practice, skill in this technique can be acquired.



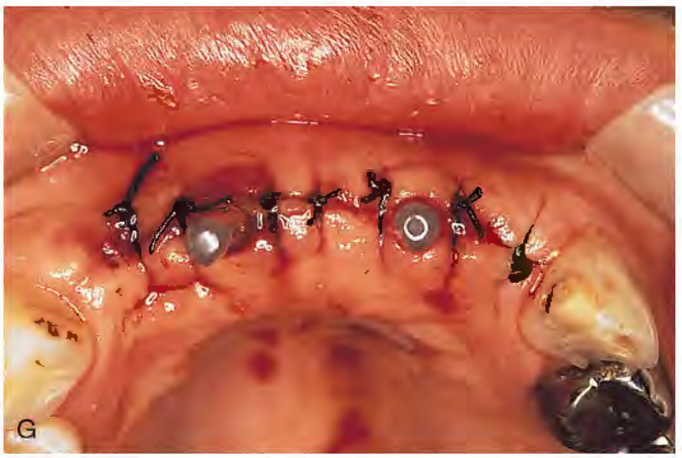


FIGURE 6-9. Simple interrupted suture. **A,** The needle is passed through both flaps. **B,** The needle end of the suture is wrapped twice around the needle holder in a clockwise direction. **C,** The beaks of the needle holder are then opened, and the free end is grasped. **D,** The free end is pulled through the double loop and fastened snugly alongside the incision. **E,** The needle end then is wound counterclockwise one revolution around the needle holder, and the free end is grasped with the beaks. **F,** The free end is pulled through the loop, and when tightened, it creates a stable square knot. The knot should not be allowed to rest directly on the incision but should lie alongside it. The cut ends must be left long enough to allow easy access for removal. **G,** Clinical view of closure with interrupted sutures.

Stringing a series of single horizontal mattress sutures together creates the continuous horizontal mattress. To perform this maneuver, the practitioner uses the mouse tooth pickup forceps to grasp the distal end of the buccal flap and pierces the flap with the needle (Fig. 6-10, *A* and *B*). The same procedure is performed through the inside (or periosteal surface) of the distolingual flap. The needle then is reversed and passed from the mucosal surface of the lingual flap 2 to 3 mm mesially and then from the periosteum of the mucosal surface of the buccal flap in parallel posture, moving anteriorly.

At this juncture, four penetrations have been made, creating a U of suture material (Fig. 6-10, *C*). It starts at the buccal and ends at the buccal, therefore the needle and the trailing end both protrude through the buccal flap, 3 mm apart. This constitutes an interrupted horizontal mattress suture. These ends are tied in a standard surgical knot, described previously. The trailing, or free, end is cut, leaving a 3-mm tail. The needle then is turned on itself to face the mucosal surface of the buccal flap 3 mm mesially. The mouse tooth forceps again is used to stabilize the tissue, and the suture is passed through this flap and then through the lingual flap, as on the previous pass. The pattern is continued at 3-mm intervals, lingual through buccal, followed by buccal through lingual (Fig. 6-10, *D*).

The closure is continued to the anterior end of the incision, and at this point, the practitioner plans for the final knot at the last buccal to lingual pass. This is done by leaving a small loop protruding from the buccal side, which the assistant holds taut to prevent the entire system from loosening (Fig. 6-10, *F*). The needle is then guided through both flaps from lingual to buccal, and the knot is tied using the protruding loop as one end and the needle end as the other. Both ends are cut, and three tails are left at the final suture (Fig. 6-10, *G*).

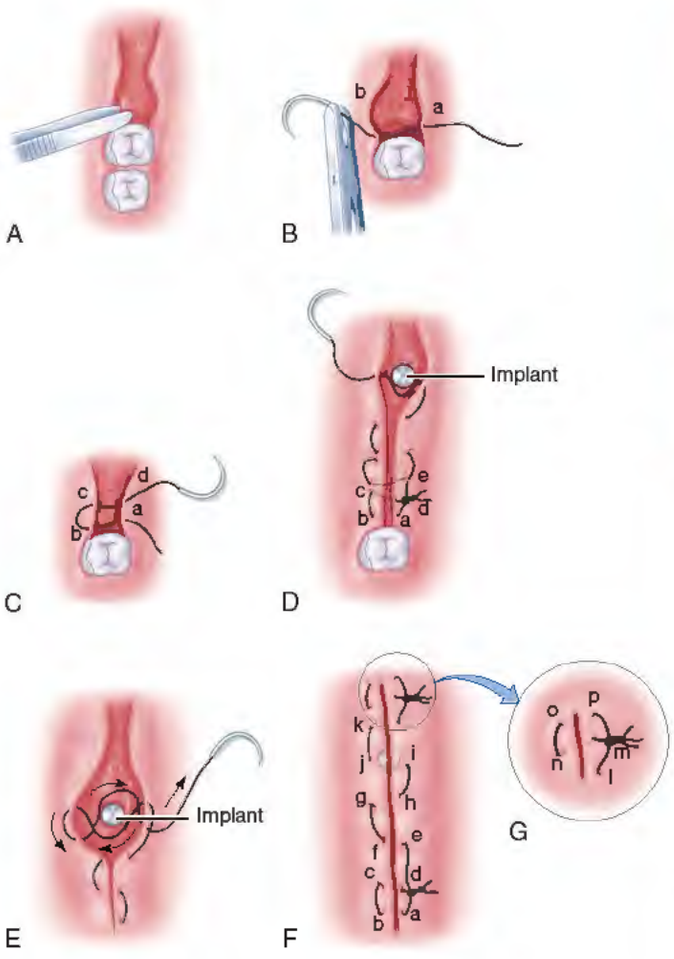
If the system is tightened after each pass by pulling on the suture material, the flaps give the appearance of the welt of a mattress edge (Fig. 6-10, *H*). If the coaptation of the flaps does not appear satisfactory, appropriate supplementary horizontal mattress sutures should be placed to achieve a more reliable closure.

When an implant with a protruding cervix is reached (as in subperiosteal and nonsubmergible implant forms), one pass is made distal to the abutment, and the suture then is carried around the abutment's mesial surface and exits on the lingual side, distal to the cervix. The returning lingual to buccal pass is initiated mesial to the cervix, with the suture passing distal to it and exiting on the mesial side of the buccal flap. This makes a "figure 8" configuration and gathers the tissues around the cervix in the form of a purse string. The continuous closure may then be completed (Fig. 6-10, *E*).

Vertical Mattress Sutures

Vertical mattress sutures have few uses intraorally but are valuable for skin suturing when the possibility for primary closure needs to be enhanced, such as in the case of a transosteal or staple implant (Fig. 6-8, *C*). This technique can be used only with interrupted sutures.

The needle is passed from one flap to the other (a straight needle makes this technique easier), and the entry and exit both are made



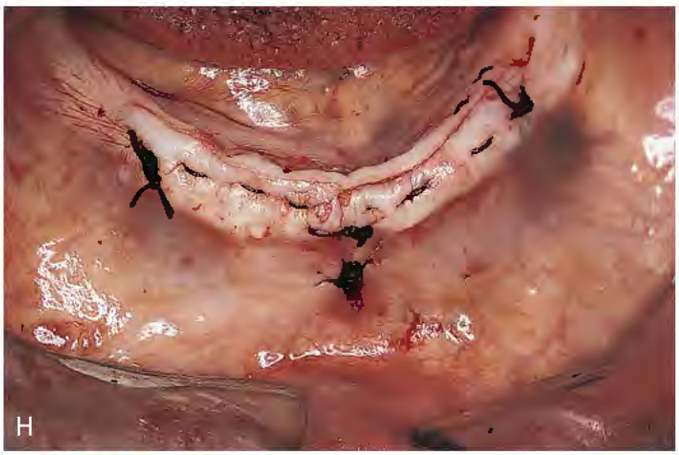


FIGURE 6-10. Continuous horizontal mattress suture. **A,** The flaps are stabilized with mouse tooth forceps. **B,** At the beginning of the incision, the needle is passed through the buccal and lingual flaps (*a* to *b*). **C,** The needle is then reversed and passed from lingual to buccal (*c* to *d*). **D,** A knot is tied between ends *a* and *d,* the loose end is cut, and the needle is passed from buccal to lingual at point *e.* The pattern from lingual to buccal and buccal to lingual is continued until the mesial surface of the single-stage implant is encountered. The needle enters the buccal flap at a point distal to the abutment, wraps to the abutment's mesial surface, and exits distal to the cervix through the lingual flap. **E,** The needle is brought mesially (see *arrow* on lingual) and pierces the lingual flap mesial to the abutment. The arrows indicate that the suture then passes distal to the cervix and exits mesially through the buccal flap; on this fourth pass, when the suture is tightened, it gathers the tissue around the cervix, much like the action of a purse string. **F,** The suture pattern is continued through points *k, l, n, o,* and *p* and suture at point *m*. **G,** The final closure is made by taking end *n* and tying it to loop *pl,* creating knot *m*. **H,** Clinical view of continuous horizontal mattress suture. Rapid, reliable healing is a characteristic of this kind of closure.

1 mm from the incision. Next, the two flaps are elevated by lifting the entering and exiting suture ends, leaving extra suture material protruding at the needle end. With the wound margins lifted, the straight needle is passed back from the second flap to the first in the same vertical plane but 4 mm more removed. As the knot is tied, the two flaps evert, creating the first component of the requisite mattress welt. As additional vertical mattress sutures are placed, the eversion occurs from one end of the incision to the other. Time and physiology offer reliable healing with subsequent flattening of the welt.

Continuous Box-Lock Sutures

The box-lock technique offers a type of nonmattress, continuous closure that is more reliable than a simple continuous suture or a series of interrupted sutures. The box-lock suture may be used after alveoloplasties, multiple extractions, or other procedures that result in linear gingival defects (Fig. 6-8, *E*).

The procedure is initiated with a simple interrupted suture, which should be tied with a surgical knot. The labial flap is lifted with the pickup forceps, and the needle is passed through it and then through the lingual flap but not pulled tight. Instead, a loop is left. One twist is made in the loop, and the needle is passed through it. The suture then is pulled tight, creating a locked box. These steps are repeated, and when papillae are present (as after extractions), they may be interdigitated so that the underlying bone is covered. These locked boxes are continued until the entire closure has been completed. The final box loop should not be drawn tight, because it is used as an end for tying the final knot, along with the other, or protruding, needle end (Fig. 6-11).

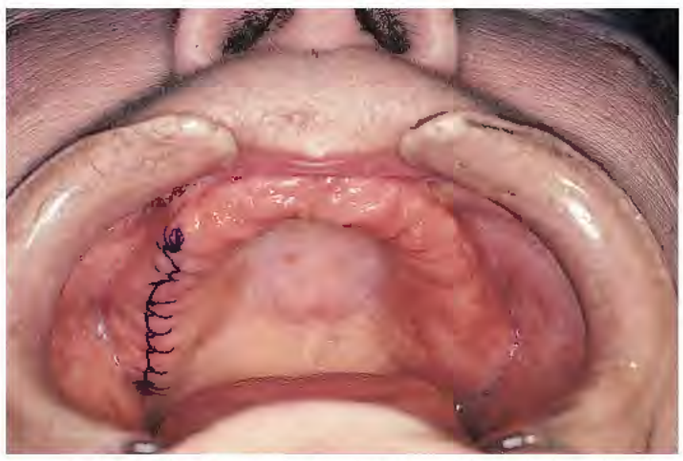


FIGURE 6-11. Continuous box-lock suture. This technique is valuable for closing crestal incisions. The needle enters from buccal to lingual surfaces each time, as for a continuous suture. Before each pass is tightened, however, the loop is lifted from the tissue and turned once clockwise, and the needle is passed through it. When the suture is tightened, a locked-box configuration results (see Fig. 6-8, *E*).

Periodontal Sling Sutures

The continuous sling (periodontal closure) technique is begun by entering a facial papilla at the distal end of the wound and then passing the needle through the lingual papilla. The needle is returned to the facial side by passing it over the two papillae through the greater embrasure, and a square knot is tied. The short end is cut, and the

needle is passed over the papillae through the same greater embrasure to the lingual side. Now the needle is brought mesially around the lingual cervix of tooth no. 1 and passed above the mesial lingual papilla and through the buccal papilla. Next, the needle is returned over the same buccal papilla, back through the embrasure, and passed through the lingual papilla.

The system is tightened, and the needle is returned over both papillae. Next, the suture is wrapped mesially over the buccal papilla of tooth no. 2. The next papilla should not be pierced, but rather passed over through the embrasure so that the lingual papilla can be pierced. Then, the buccal papilla is entered in this fashion, and the flaps are drawn tightly into the dental interspaces, directly (rather than obliquely) and without distortion. Three passes are made between each tooth: the first to catch the buccal papilla, the second to pierce the lingual, and the third to simply return over them to the buccal. With each successive pass, the pattern is reversed; the effect is the same. The suturing is completed in the same manner as for all continuous closures, by leaving a loop to be used for one end of the knot and the needle end for the other.

As an alternative to the technique just described, periodontal sling suturing may engage only the buccal papillae proceeding in the distal direction and the lingual papillae in returning (Fig. 6-12, *A-G*). The final knot is made at the anterior facial papilla by tying the protruding needle end to the original suture end (Fig. 6-12, *H, I*).

LIGATION OF A SPLINT, STENT, OR PROSTHESIS

Circumosseous Ligation

Circumosseous ligatures are useful for securing prostheses to the jaws after preprosthetic procedures (e.g., ridge augmentation, insertion of intramucosal insert prostheses) and in the fixation of stents after vestibuloplasties and other oral plastic operations. To achieve a snug fit of ligature wire against bone, most techniques require that the skin be incised directly down to the bone (mandible or zygoma) or, at the least, that the ligature be forced through the soft tissues using a sawing motion. This procedure is time-consuming, fraught with the danger of injuring a nerve or blood vessel, results in a skin scar, and requires the sterile precautions of a hospital operating room.

The methods described in the following paragraphs are suitable for ligating a splint either to the mandible or the maxilla by using the zygomatic arch or alveolar processes. These methods also are quick, safe, and only one of these does not require incisions. The armamentarium is minimal and readily available in any office or clinic.

A new needle is used for each ligature. The practitioner should hug the bone to avoid garroting soft tissues. The regions of the mental nerve and facial vessels should be avoided, and Wharton's duct and the lingual nerve should be retracted medially so that they are not injured.

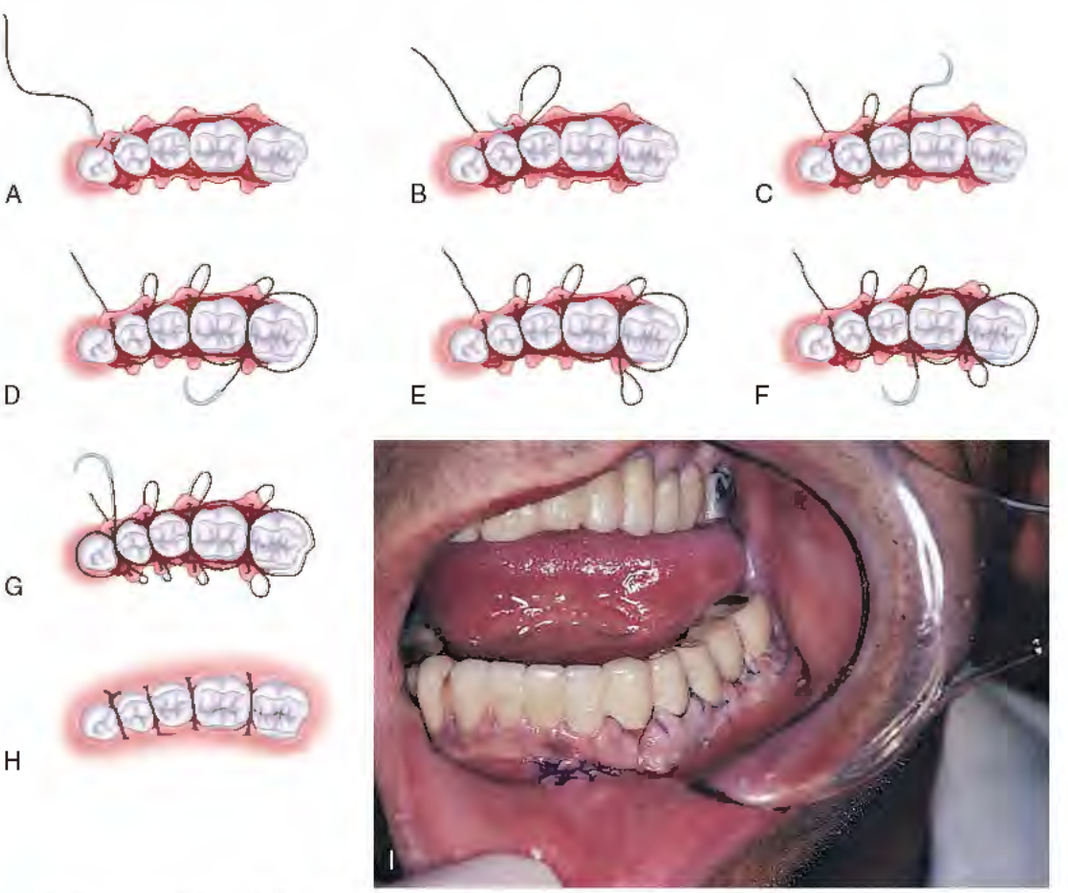


FIGURE 6-12. Periodontal sling suturing. **A,** The needle enters through the first buccal papilla. **B,** The needle is passed to the lingual through the greater embrasure, wrapped around the lingual cervix of the first tooth, and then passed through the second buccal papilla. **C,** The needle is returned over this second papilla through the second embrasure, again to the lingual flap, and wrapped around the second tooth. **D,** In this fashion, the buccal flap is brought firmly into place. At the distal portion of the last tooth, after the suture is passed through the buccal papilla, it is passed to the lingual and enters this papilla. **E** and **F,** In similar fashion, all the papillae of the lingual flap are engaged. **G,** The final pass is made around a tooth anterior to the incision so that the suture travels directly from lingual to buccal at the mesial surface of the first tooth. Before the two ends are tied, the system is tightened by tugging gently at each loop. **H,** The knot is tied at the mesiobuccal papilla of the first tooth. **I,** Clinical view of a properly executed periodontal sling suture.

Circummandibular Ligation

The inferior border of the mandible is palpated, and the regions of the anterior facial artery and vein and the mental foramen are avoided.

The skin is prepared with a chlorhexidine or hexachlorophene soap, followed by saline. It then is dried and painted liberally with povidone-iodine. An 18-gauge, 1½-inch needle is inserted in an upward vertical direction until it contacts the inferior border of the mandible. A sweetheart retractor then is used to compress the tongue and sublingual tissues medially. The needle, which is manipulated with the other hand, is slid off the inferior border medially and directed toward the mucosa. The tip should hug the cortex.

Once the needle has perforated the floor of the mouth (Fig. 6-13, *A*), a piece of No. 2 stainless steel monofilament ligature wire is threaded through its lumen. (Extra wire is needed for this technique, therefore a sufficient length must be passed into the mouth at this initial threading through the lumen.) The end of the wire is grasped with a Kelly hemostat as it emerges through the needle's tip (Fig. 6-13, *B*). The hemostat is held with one hand while the other hand withdraws the needle so that it hugs the bone during retraction. The needle is not withdrawn any farther than the inferior border. At this point, it is swung around to the lateral side of the inferior border and pushed upward toward the buccal vestibule, and a retractor again is used to stretch the tissues laterally (Fig. 6-13, *C*). As the needle is pushed upward, a double thickness of vertically ascending wire is carried with it: one thickness in the needle, the other alongside it. If the wire that protrudes from the submandibular skin is pulled taut, it will bend sharply over the lumen of the needle and fold back parallel to the needle shaft, allowing the point to be the advancing structure. This makes pushing it easier and less traumatic. The wire from the intraoral (hemostat) end must be fed as the needle is advanced.

After the needle has perforated the mucobuccal fold (see Fig. 6-13, *C*), the double-thickness wire protruding from the needle tip is grasped with a second Kelly hemostat. The wire is held while the needle is withdrawn directly downward through the skin at its original and only point of entry. Now, a thin instrument is inserted through the protruding loop and used to pull up that portion of the wire into the mouth through the fold (Fig. 6-13, *D*).

An end of the wire extends from both the buccal and the lingual vestibule. These ends are twisted over the prosthesis; they are then cut, tucked in, and covered with a bit of self-curing acrylic (Fig. 6-13, *E*). There may be reason to cut a receptacle for the twisted wire ends before they are covered. As many circummandibular ligatures as needed may be placed to stabilize the prosthesis (Fig. 6-13, *F*), but three such anchors usually suffice.

Circumzygomatic Ligation

Circumzygomatic wiring is initiated by palpating the superior surface of the zygomatic arch. After the skin has been prepared with a chlorhexidine gluconate and povidone-iodine scrub, an 18-gauge, 3½-inch spinal needle with stylet is inserted until it contacts the superior bony surface of the arch. Next, the needle is directed medially to the arch; the forefinger of the practitioner's opposite hand is inserted into the mucobuccal fold as far superoposteriorly as possible, and the needle is aimed toward the finger. The tissues are compressed laterally, and the needle should be made to hug the maxilla so that it is not pushed through the mandibular sigmoid notch (Fig. 6-14, *A*). This can be assisted by having the patient partly close the jaw.

When the needle has perforated the maxillary mucobuccal fold, a length of No. 2 wire is passed through its lumen, pulled down at least 30 cm, and grasped with a Kelly forceps (Fig. 6-14, *B*). The needle is then withdrawn along its path of insertion only as far as the superior surface of the zygomatic arch while the intraoral wire end is stabilized. The needle tip is passed, and its wire is wrapped around and over the zygomatic arch and forced downward around its lateral side as the wire is fed from its intraoral source. Again, the needle is directed toward the same spot: an intraorally placed finger (Fig. 6-14, *C*). An effort is made to have the wire emerge from or near the first point of perforation. The doubled end of the wire that protrudes from the needle tip is grasped with a second hemostat and held in place while the needle is withdrawn (Fig. 6-14, *D*).

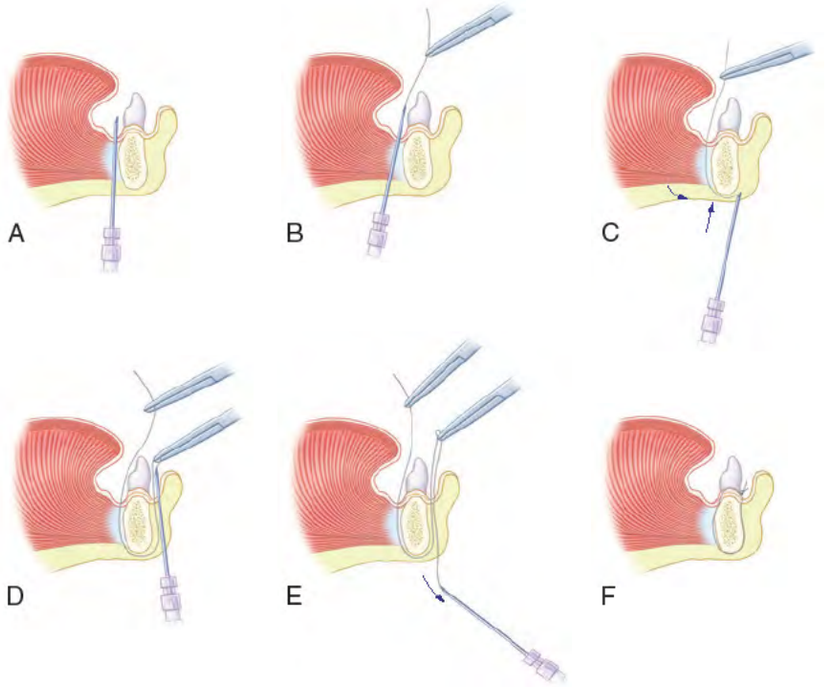


FIGURE 6-13. Circummandibular ligation. **A,** Dentures, stents, splints, and other prostheses often must be fastened to the mandible. This can be done without making an incision by using a disposable 18-gauge needle and No. 2 stainless steel ligature wire. Local anesthesia can be used for this procedure. The needle is passed through the submandibular skin and exits through the lingual vestibule. **B,** The wire is passed through the lumen and grasped intraorally with a hemostatic forceps. The needle is withdrawn, but only to the level of the inferior mandibular border. At this point, the needle (with the wire in its lumen) is redirected around the border and pushed through the buccal vestibule, hugging the bone. The mental bundle must be avoided. **C,** The wire loop protruding from the needle is grasped and held with a hemostat while the needle is withdrawn. **D,** The looped end is pulled up through the floor of the mouth. **E,** The buccal and lingual ends are twisted to lock the prosthesis into place. **F,** The procedure is repeated contralaterally.

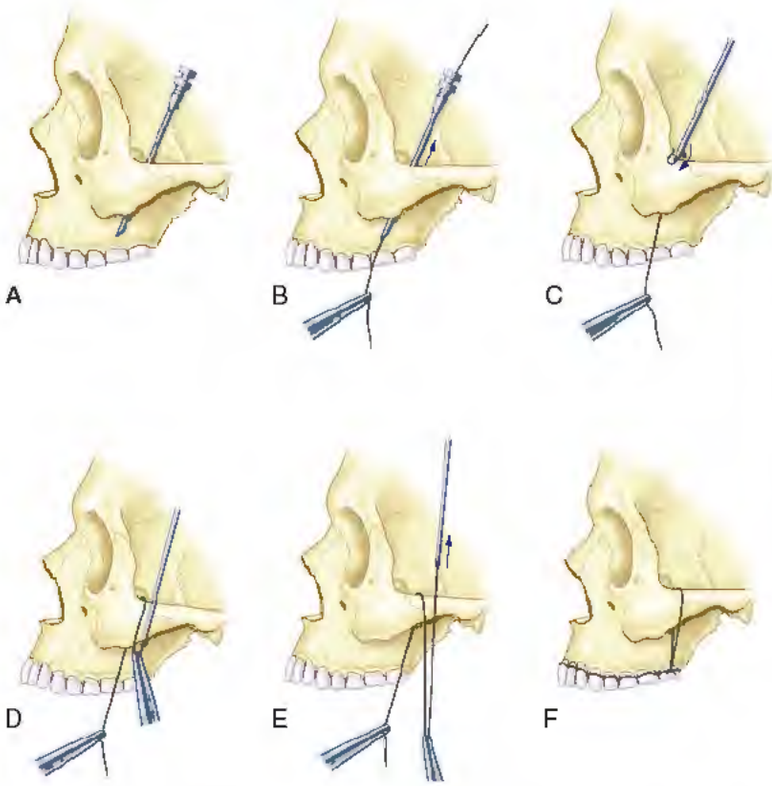


FIGURE 6-14. **A,** Ligatures can be passed around the zygomatic arch to stabilize maxillary prostheses. Local anesthesia can be used. The procedure requires an 18-gauge, 3½-inch long spinal needle. The first entry is made through the skin above the arch. **B,** The needle point contacts the superior surface and then is directed medially to enter the buccal vestibule in the tuberosity area. **C,** The forefinger of the other hand is used to retract the buccal tissues and to serve as a directional guide. **D,** When the needle pierces the mucosa, the wire protruding from its lumen is grasped and stabilized with a hemostat. The needle is withdrawn and passed subcutaneously over the arch to its lateral side and used to carry the wire back to the same vestibular site. A second hemostat is used to grasp the protruding double end of the ligature, and the needle is withdrawn. The free end of the wire is drawn down into the mouth. **E** and **F,** The two ends are twisted around an intermaxillary hook processed into the flange of the prosthesis.

Finally, the double-looped end is pulled into the mouth. The ligation is made through a hole in the denture flange or around a buccally placed lug, intermaxillary hook arch bar, or mucosal insert on the flange of the prosthesis (Fig. 6-14, *E* and *F*).

For ligation of a full splint or denture, the procedure is repeated on the contralateral side, and a third wire is passed over or through the anterior nasal spine. This is done by making an incision, reflecting the tissues, exposing the spine, and threading the wire over it or into a drill hole made through it. One flange hole on either side of the frenular notch serves for anterior splint retention. These ligatures, too, should be covered with self-curing acrylic.

Transalveolar Ligation

Transalveolar ligation is a simpler method of ligating a prosthesis or splint to the maxilla for the period when root form implants are becoming integrated or for other purposes requiring stabilization of a stent or splint. This can be done in most (but not all) cases simply by selecting a site in the buccal mucosa above the apical level of the teeth or implants and placing a disposable, 18-gauge hypodermic needle through the soft tissues and against bone. The needle is aimed in a direction that allows it to emerge through the opposing palatal tissues when tapped with a surgical mallet (Fig. 6-15, *A*). After the needle has emerged from the palatal side, a 20-cm length of No. 2 stainless steel wire (Fig. 6-15, *B*) is passed through its lumen. The protruding end is grasped, and the needle is withdrawn.

The two ends are twisted tightly over a prosthesis (Fig. 6-15, *C*), denture, or splint; this ligature (single or more than one) serves as an anchor for periods of up to 6 months. Antibiotic therapy may be required if incipient symptoms of retrograde infection are noted.

When a patient is missing most or all of the teeth in the maxilla and cannot or will not wear a removable prosthesis during the period of osseointegration, a temporary fixed prosthesis may be fabricated and fixed to the maxilla using transalveolar ligatures, sometimes with the addition of a distal end one-piece implant (i.e., Straumann) or a two-stage implant with abutment attached. These can be included or removed at the time of implant exposure when healing collars or abutments are placed. They can be put into service immediately as abutments for transitional fixed or fixed-detachable prostheses if they have osseointegrated (Fig. 6-16).

Ligature Removal

Before intraoral portions of ligatures are removed, they must be disinfected, cleaned, and made aseptic with povidone-iodine. The mucosa then should be pushed apically, exposing a portion of the buried wire. The wire is snipped at this point, and a needle holder is used to pull it out from the other end. Removal is rapid, painless, and clean if performed in this fashion. Local anesthesia is not required. If the intraoral portions of the wire are not sterilized, contaminants will inoculate the soft tissues as the wire is withdrawn, and serious infection may result.

PREPROSTHETIC SURGERY

Every implant surgeon should become comfortable with a number of procedures, mostly preparatory in nature. Nonneoplastic structures (e.g., ridge undercuts, tori, and tuberosities) should be removed or reduced, and soft tissue aberrations or malformations (e.g., high frenular or muscle attachments, absence of fixed gingivae, and epulides fissurata) should be recontoured before placement of implants.

Tori Removal

Tori may be found in the palatal midline and attached to the mandible, lingual to the premolars. They may appear to be sessile but are always pedunculated and are found in single or multiple

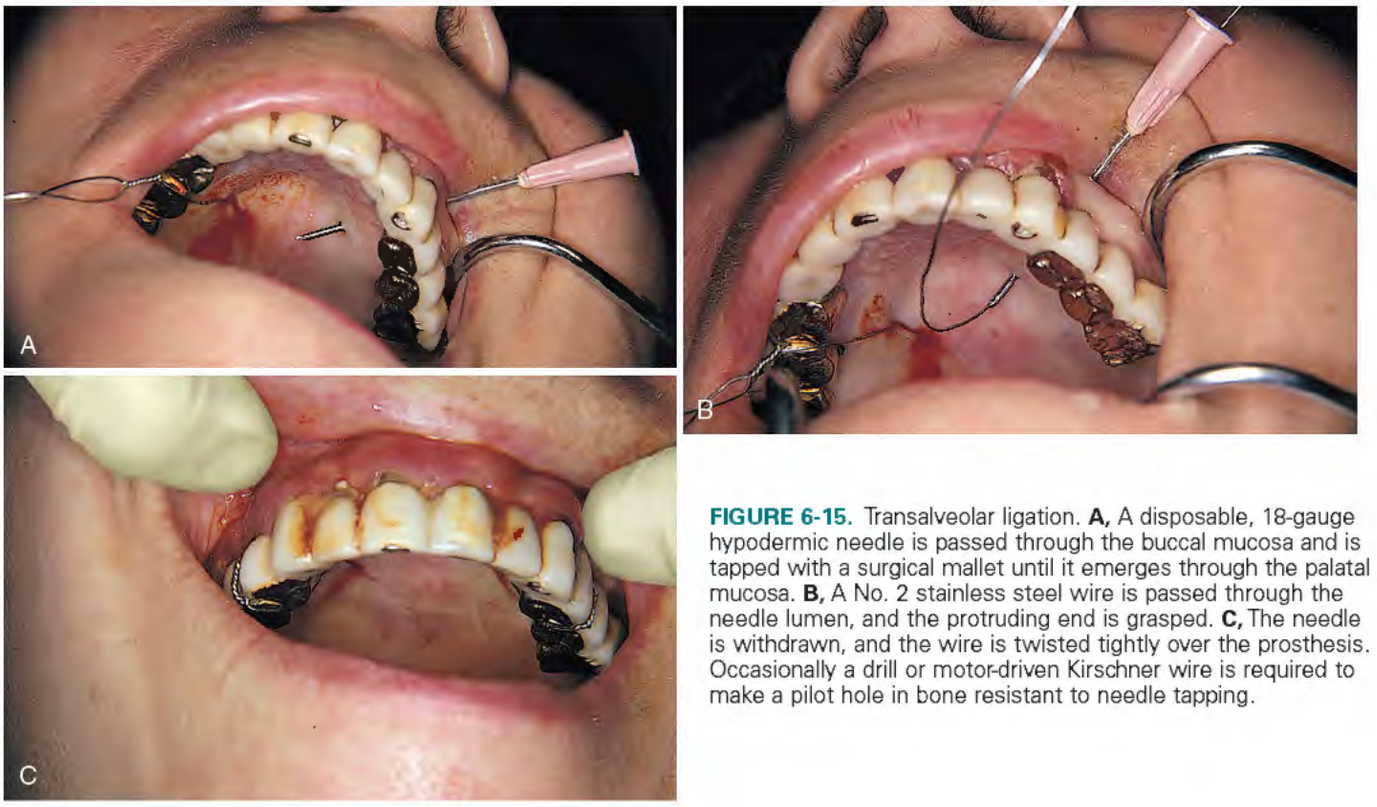


FIGURE 6-15. Transalveolar ligation. **A,** A disposable, 18-gauge hypodermic needle is passed through the buccal mucosa and is tapped with a surgical mallet until it emerges through the palatal mucosa. **B,** A No. 2 stainless steel wire is passed through the needle lumen, and the protruding end is grasped. **C,** The needle is withdrawn, and the wire is twisted tightly over the prosthesis. Occasionally a drill or motor-driven Kirschner wire is required to make a pilot hole in bone resistant to needle tapping.

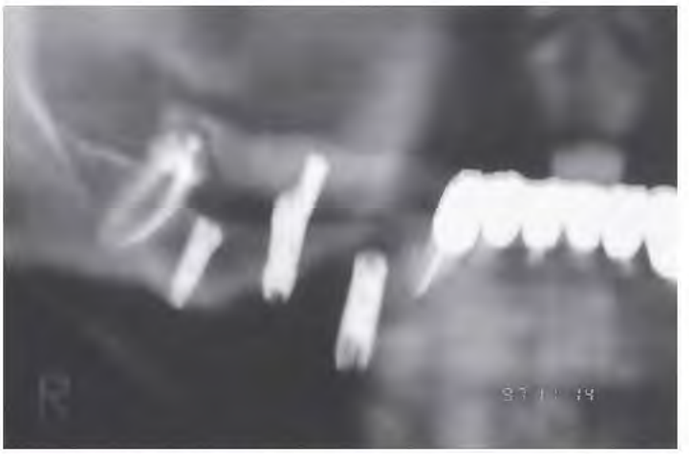


FIGURE 6-16. Radiograph showing the use of a pier implant abutment, with immediate placement of the transepithelial abutment (TEA) to support an all-acrylic interim prosthesis (see Chapter 20).

configurations. They are covered by normal-appearing epithelium except for an occasional superficial traumatic ulcer. Removal requires flawless incision, flap and osteotomy planning, and careful hard and soft tissue management.

Palatal Tori

The incision is made directly over the middle of the bony growth extending from the soft palate anteriorly almost to the incisive papilla (Fig. 6-17, *A*). A sharp periosteal elevator is used, because the tissues are resistant to reflection, particularly at the base of the tori (which are undercut). The reflection is started at the anterior end and continued posteriorly until the superficial portion of the torus is uncovered. The reflection then proceeds down to the hyperostotic base. If the tissues do not come away without the threat of tearing, a No. 12 blade is substituted for the elevator, and the mucosa is carefully detached with gentle strokes of the blade point. The No. 12 blade is used with great care to avoid perforation. The exposure is completed by uncovering the base fully around the periphery. A zone of normal hard palate is established, 5 mm in all directions, (Fig. 6-17, *B*). When the torus is fully visible, a No. 1 L round bur in the high-speed Impactair or a Hall drill is used, with copious irrigation, to make perforations 2 to 3 mm apart completely around the base of the torus. The bur is directed through the cortex and parallel to the palatal vault.

A 701 L fissure bur is used to cut the torus into quarters from its top directly down to the levels of the expected palatal contour. Throat packs or curtains must be used to protect the patient from aspiration of bone fragments.

A curved osteotome of appropriate width is placed at the points of perforation in the base of the torus with its curvature following the contour of the palatal vault. Firm tapping with a mallet causes the torus to cleave from its base, in most cases, at the correct level. When this step is completed at several locations, the osteotome is inserted into one groove of the cruciform osteotomy and turned. The four quarters fall away, one by one. The contouring and smoothing of the base bone is completed using a large, round, water-cooled vulcanite bur.

Perforation of the bony palate is a rare but dangerous complication. If this occurs, careful handling of the soft tissues during their reflection is a valuable asset, because primary closure over the defect using a continuous horizontal mattress suture of 4-0 dyed Vicryl is required to help prevent an oronasal fistula (Fig. 6-17, *C*).

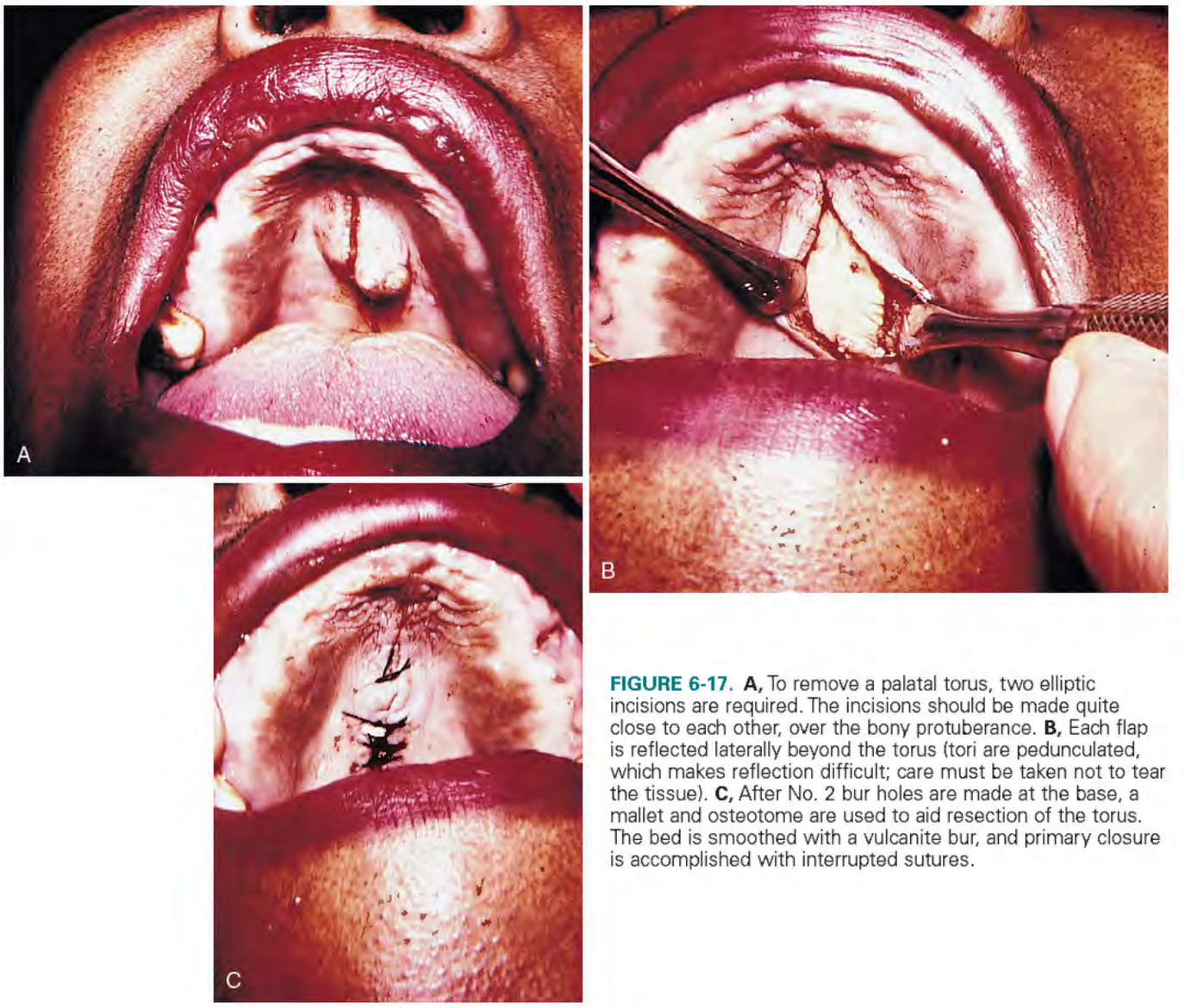


FIGURE 6-17. **A,** To remove a palatal torus, two elliptic incisions are required. The incisions should be made quite close to each other, over the bony protuberance. **B,** Each flap is reflected laterally beyond the torus (tori are pedunculated, which makes reflection difficult; care must be taken not to tear the tissue). **C,** After No. 2 bur holes are made at the base, a mallet and osteotome are used to aid resection of the torus. The bed is smoothed with a vulcanite bur, and primary closure is accomplished with interrupted sutures.

Mandibular Tori

The management of mandibular tori is not dissimilar from that of palatal tori. The incision is made at the lingual marginal gingiva from molar to midline. The curvature of the arch permits the reflection to be completed inferiorly without the benefit of inferiorly vertical relieving incisions (Fig. 6-18, *A*). Again, because mandibular tori are pedunculated, detachment of the gingiva at their bases must be done with great care. Once the entire bony mass has been fully exposed, a No. 1 L round bur is used to perforate the tori bases at 2- and 3-mm intervals parallel to the lingual cortex. Simple tapping with a sharp, curved osteotome placed in the perforations allows them to cleave from the mandible, usually in a satisfactory plane (Fig. 6-18, *B* and *C*). Bone files or egg-shaped vulcanite burs are used to smooth the bone, and an anatomic closure is made with a periodontal sling suture.

Tuberosity Reduction

Tuberosities in need of reduction should present few problems. First, using panoramic or periapical radiographs and probing, the practitioner must determine whether these enlargements are bony or fibrous (Fig. 6-19, *A*). If they are composed of soft tissue, a crest of the ridge incision is made over the tuberosity directly to bone (Fig. 6-19, *B*). The incision is started at the distal end and advanced anteriorly to the first premolar area. Reflections are made buccally and palatally (Fig. 6-19, *C* and *D*) with the flaps supported with a toothed Gerald forceps; each one is filleted (thinned) by removing 50% or more of its internal layers from the periosteum outward. The cuts are tapered so that as the scalpel advances buccally and palatally away from the incisions to the bases of the flaps, the layers to be removed are thinned to a fine edge (Fig. 6-19, *E*). When the newly reduced flaps are brought together, there is an excess of tissue, and the flaps must be trimmed so that their margins meet comfortably in the midline without redundancy at the suture line (Fig. 6-19, *F*).

If the tuberosity is bony, the same incisions and reflections are made, but the ridge requires trimming with a side-cutting rongeur forceps or a saline-cooled, slow-turning large ovoid surgical bur (Fig. 6-19, *G*). This is followed by use of a bone file, and the flaps are tailored to fit the excess soft tissues at the wound margins. The procedure may be completed successfully by suturing with a continuous box-lock mattress closure (Fig. 6-19, *H*).

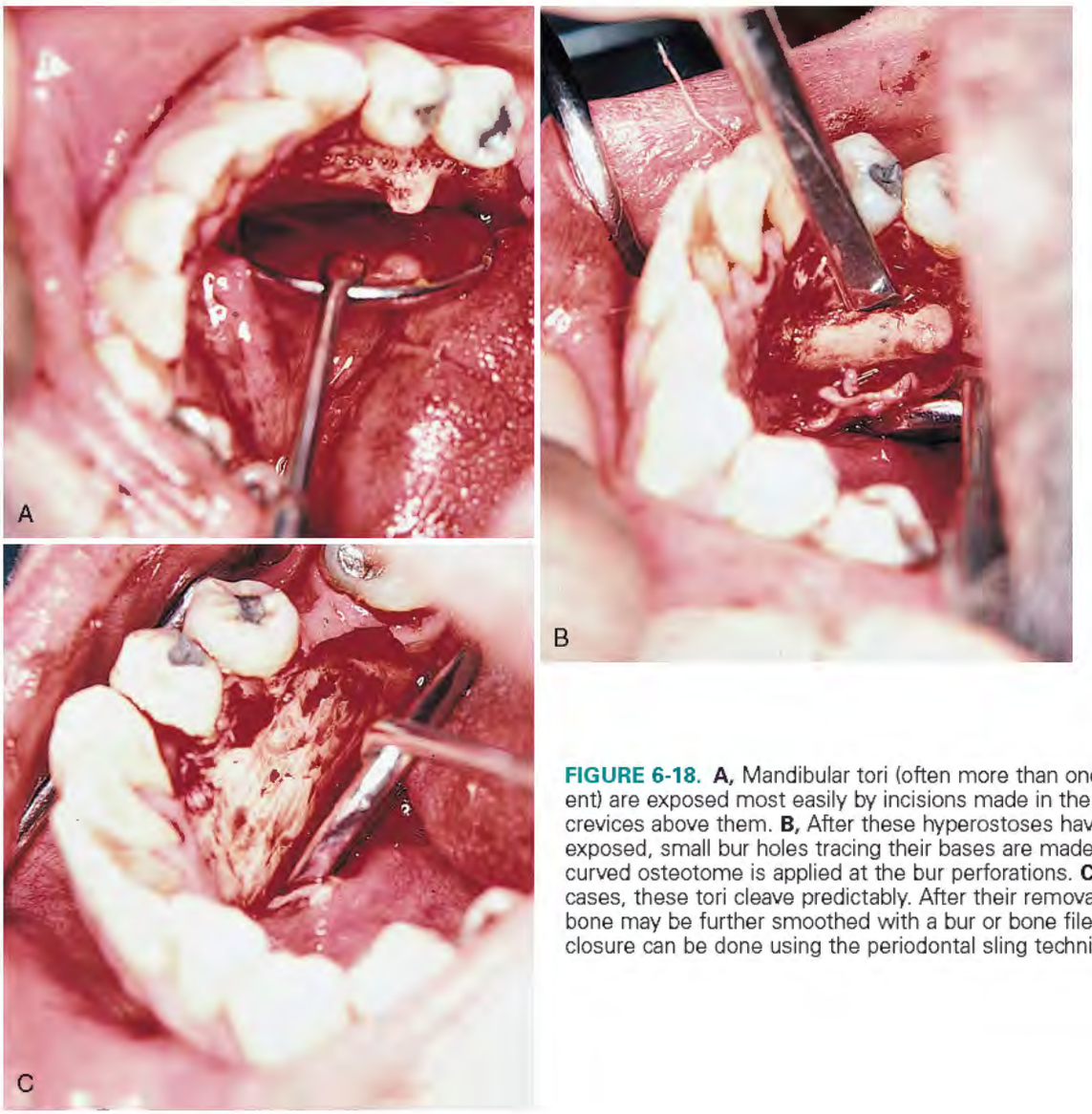


FIGURE 6-18. **A,** Mandibular tori (often more than one is present) are exposed most easily by incisions made in the gingival crevices above them. **B,** After these hyperostoses have been exposed, small bur holes tracing their bases are made. Then, a curved osteotome is applied at the bur perforations. **C,** In most cases, these tori cleave predictably. After their removal, the bone may be further smoothed with a bur or bone file, and closure can be done using the periodontal sling technique.

Alveoplasty

All surgical practitioners must become competent in alveoplasty. Knife-edged ridges may require planing, undercut reduction, or removal of sharp, spinous processes before implant osteotomies are made. Incisions are made at the ridge crests, and soft tissues are reflected with care to preserve the mucoperiosteal flaps (Fig. 6-20, *A*). With rosette and flame-shaped burs (always saline cooled), rongeurs, and bone files (Fig. 6-20, *B* and *C*), the reduction, contouring, and smoothing of the bone can be performed with precision. The results can be tested by running a piece of gauze over the bone; the gauze should pass easily over the ridge without shredding or pulling of any threads (Fig. 6-20, *D*). When the alveolus passes this test, closure can be achieved with either a box-lock or a continuous horizontal mattress suture (Fig. 6-20, *E*).

Correction of High or Hypertrophic Muscle Attachments

Some simple soft tissue manipulations should be mastered by the practitioner. Frenula and other high muscle attachments often require elimination (Fig. 6-21, *A*). With a high buccinator attachment in the mandibular region, the mental nerve must be avoided. After infiltration anesthesia has been achieved, incisions are made through the soft tissues and down to bone on either side of the frenulum or muscle attachment, starting at its apex and widening elliptically until the vestibule is reached. Having the assistant pull the cheek or lip taut facilitates these incisions. When cutting through fixed gingivae, the knife must stay against bone. As the scalpel passes into mucosa, the depth of the incisions is controlled to the muscle level. The widest point between the two incisions should be at the depth of the vestibule. The incisions then curve toward one another through the labial mucosa, on either side of the muscle attachment, until they touch at the point where the frenulum or muscle attachment ends, creating an ellipse. A thin, sharp periosteal elevator is used to lift the alveolar end of the frenulum from the bone. The liberated segment is grasped with an Allison forceps, and as it is pulled gently forward (Fig. 6-21, *B* and *C*), it is snipped neatly from the orbicularis oris or buccinator muscle with the tips of a baby Metzenbaum scissors.

Each soft tissue flap is lifted with the toothed Adson or Gerald forceps and undermined laterally for about 5 mm, until the flaps may be drawn together easily and closed with interrupted, dyed, or

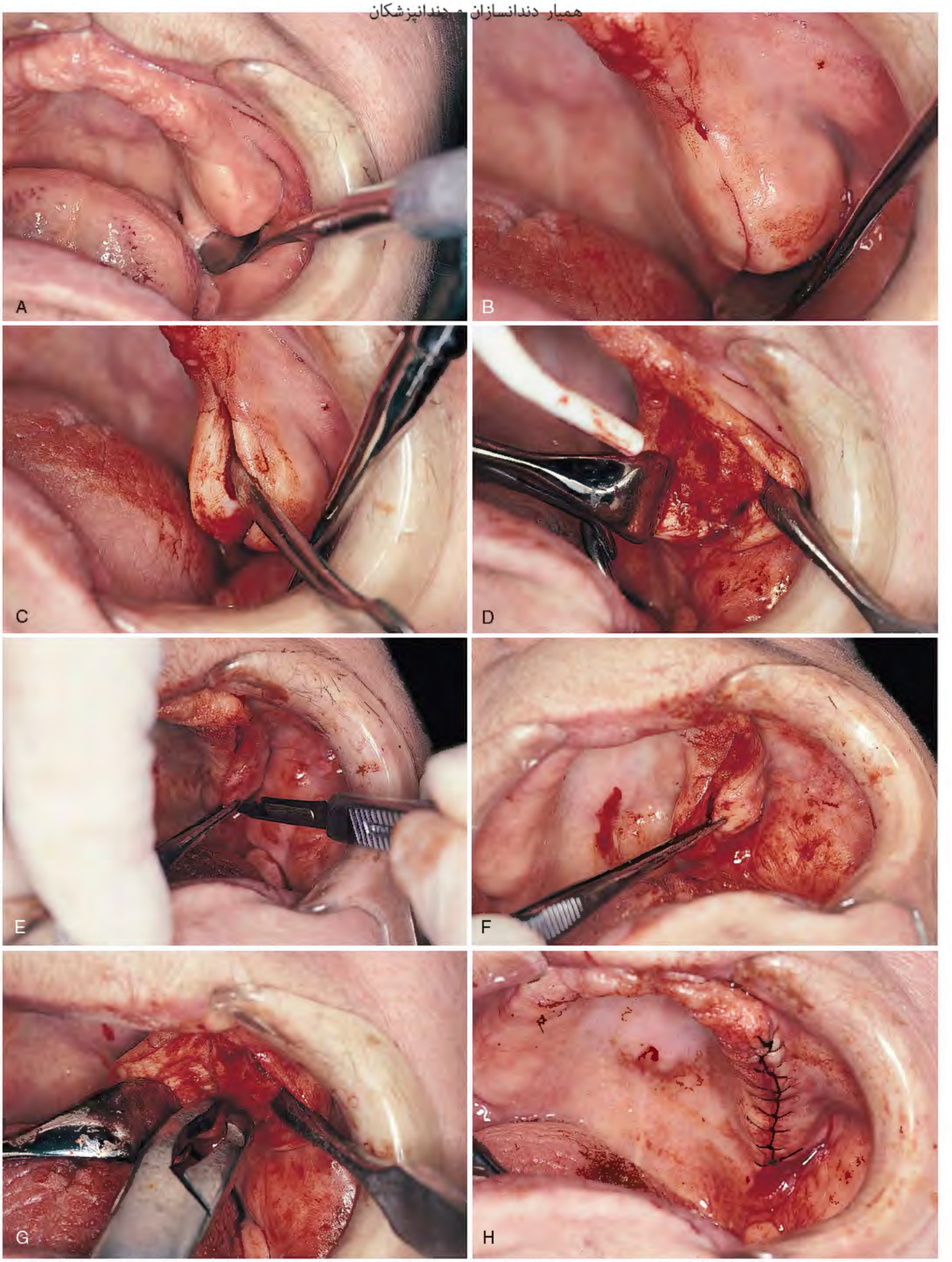


FIGURE 6-19. **A,** Large tuberosities may be composed of bone, connective tissue, or both. **B,** The initial incision should start from behind the tuberosity at the pterygomandibular raphe attachment and come forward over the crest of the ridge to the premolar area. **C,** Periosteal elevators reflect the flaps. **D,** Exposure extends to the base of the tuberosity. **E,** To reduce the thickness, hypertrophic soft tissues are stabilized and filleted with a No. 15 blade. Each flap is thinned in this manner. **F,** After thinning, the flaps are drawn together and tailored to fit snugly against each other, allowing primary closure. **G,** Excessive bone is trimmed with rongeurs and bone files. **H,** The tissues are brought together, and a continuous box-lock closure may be done.

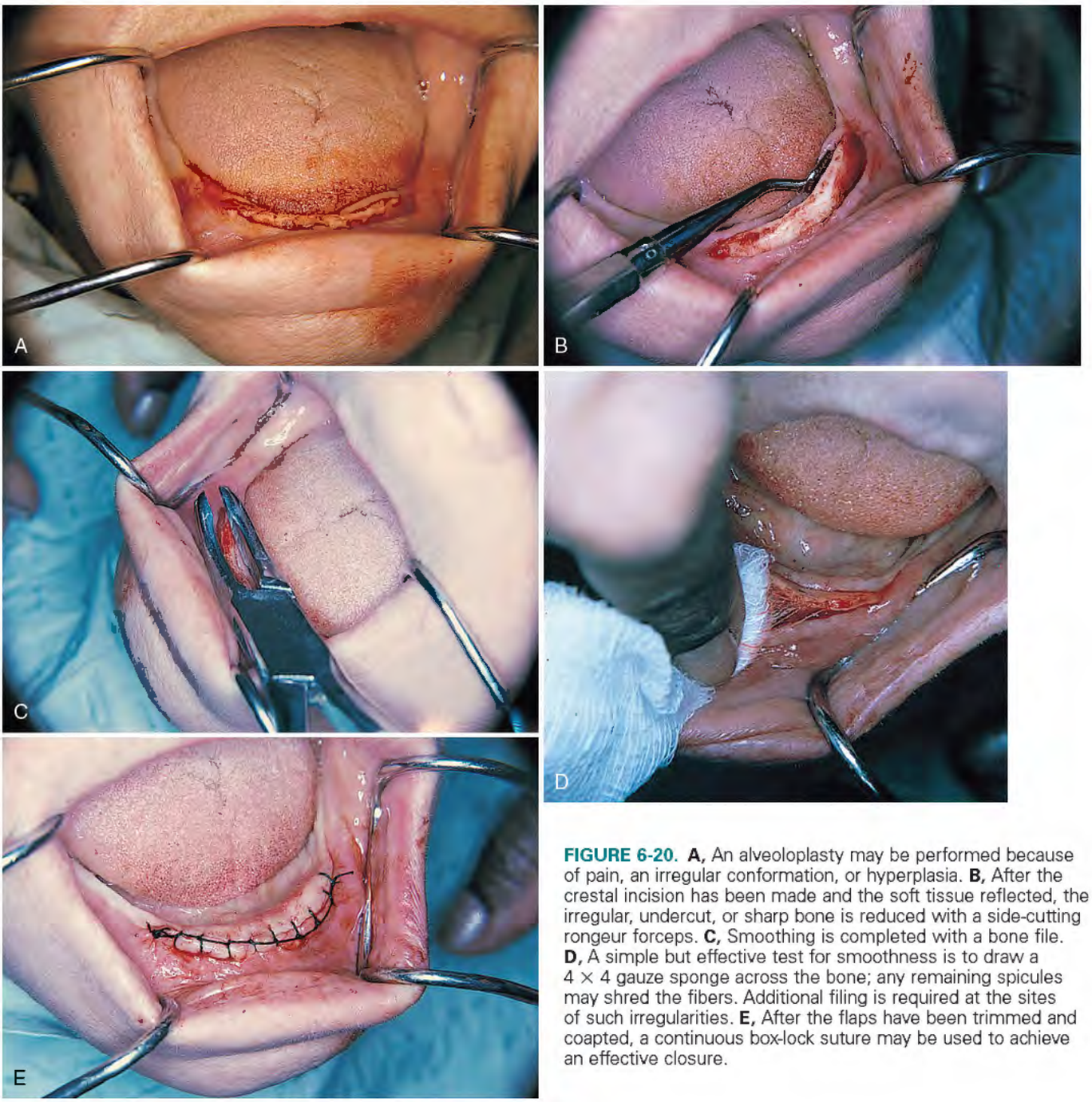


FIGURE 6-20. **A,** An alveoloplasty may be performed because of pain, an irregular conformation, or hyperplasia. **B,** After the crestal incision has been made and the soft tissue reflected, the irregular, undercut, or sharp bone is reduced with a side-cutting rongeur forceps. **C,** Smoothing is completed with a bone file. **D,** A simple but effective test for smoothness is to draw a 4 × 4 gauze sponge across the bone; any remaining spicules may shred the fibers. Additional filing is required at the sites of such irregularities. **E,** After the flaps have been trimmed and coapted, a continuous box-lock suture may be used to achieve an effective closure.

continuous horizontal Vicryl sutures (Fig. 6-21, *D*). Obviously, the tissues overlying the alveolar bone cannot be drawn together because they are fixed, but this portion of the wound should be sutured across despite the lack of primary closure. If more than 1.5 mm of bone is exposed, Coe-Pak or some other the periodontal dressing should be placed beneath the sutures. This protects the bone during healing by secondary intention (Fig. 6-21, *E*).

Epulides Fissuratum and Other Hyperplasias

Excessive growths such as epulides fissurata and other hyperplasias are best trimmed and contoured with an electrosurgical loop (5-mm diameter) set on "cutting" current (Fig. 6-22, *A*). The loop is moved smoothly and rapidly, encouraging bleeding and minimizing necrosis of the tissues. If metal restorations or implants are adjacent to the operative field, care must be taken not to touch them. If proximity is a problem, the metal is insulated with a square of rubber dam. As an alternative, a scalpel blade may be used (Fig. 6-22, *B*).

After the resection has been completed, the patient's own denture is used as a stent and lined with a non-eugenol-containing periodontal dressing, such as Coe-Pak (Fig. 6-22, *C*). The stent may be ligated to the jaw (as described in the section on ligating in this chapter) or sutured with 2-0 nylon through submandibular buttons placed against the submandibular skin (Fig. 6-22, *D*) (see Chapter 7). After removal of the stent, acceptable postoperative healing with good fixed tissue control should be expected (Fig. 6-22, *E*).

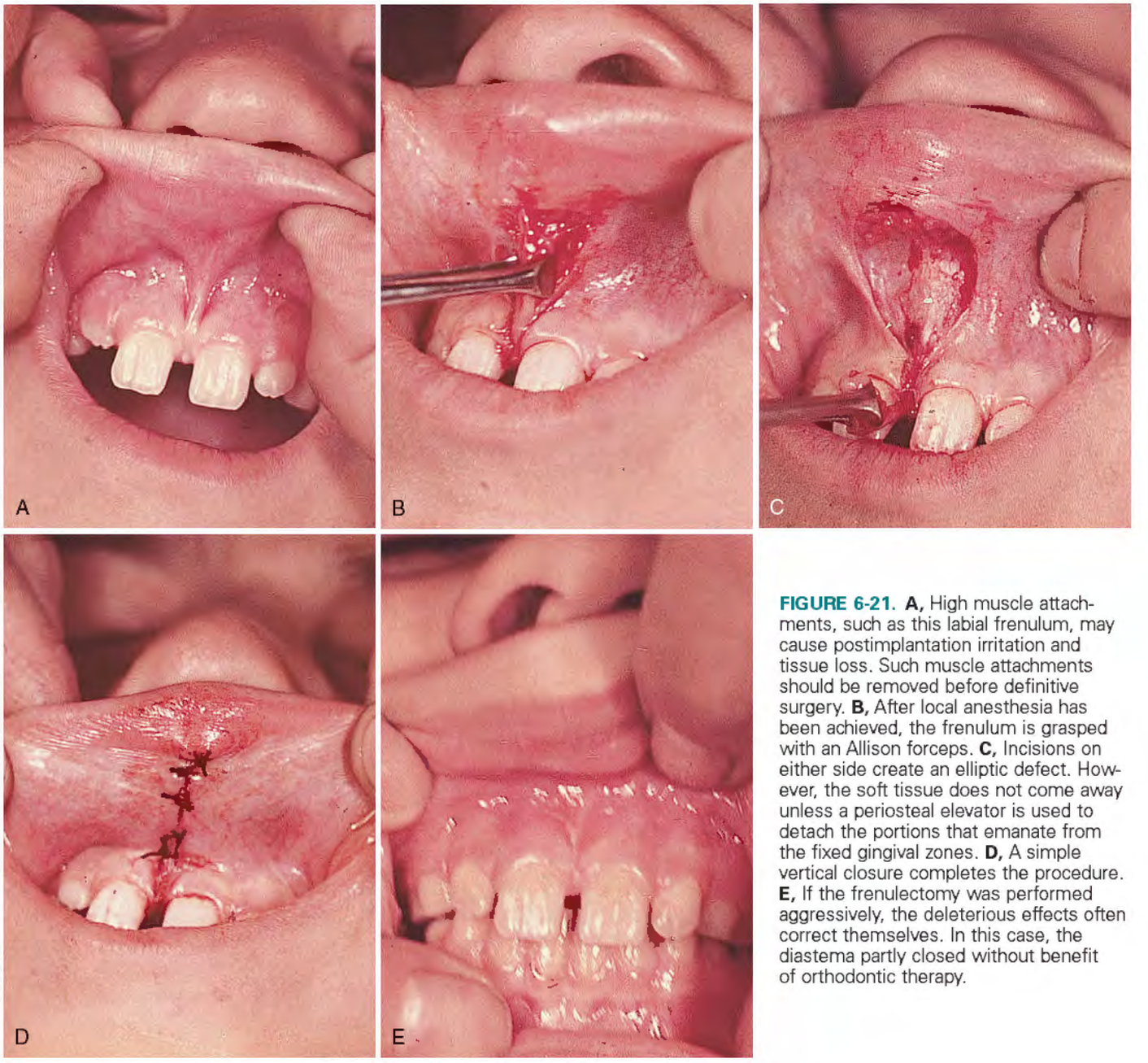


FIGURE 6-21. **A,** High muscle attachments, such as this labial frenulum, may cause postimplantation irritation and tissue loss. Such muscle attachments should be removed before definitive surgery. **B,** After local anesthesia has been achieved, the frenulum is grasped with an Allison forceps. **C,** Incisions on either side create an elliptic defect. However, the soft tissue does not come away unless a periosteal elevator is used to detach the portions that emanate from the fixed gingival zones. **D,** A simple vertical closure completes the procedure. **E,** If the frenulectomy was performed aggressively, the deleterious effects often correct themselves. In this case, the diastema partly closed without benefit of orthodontic therapy.

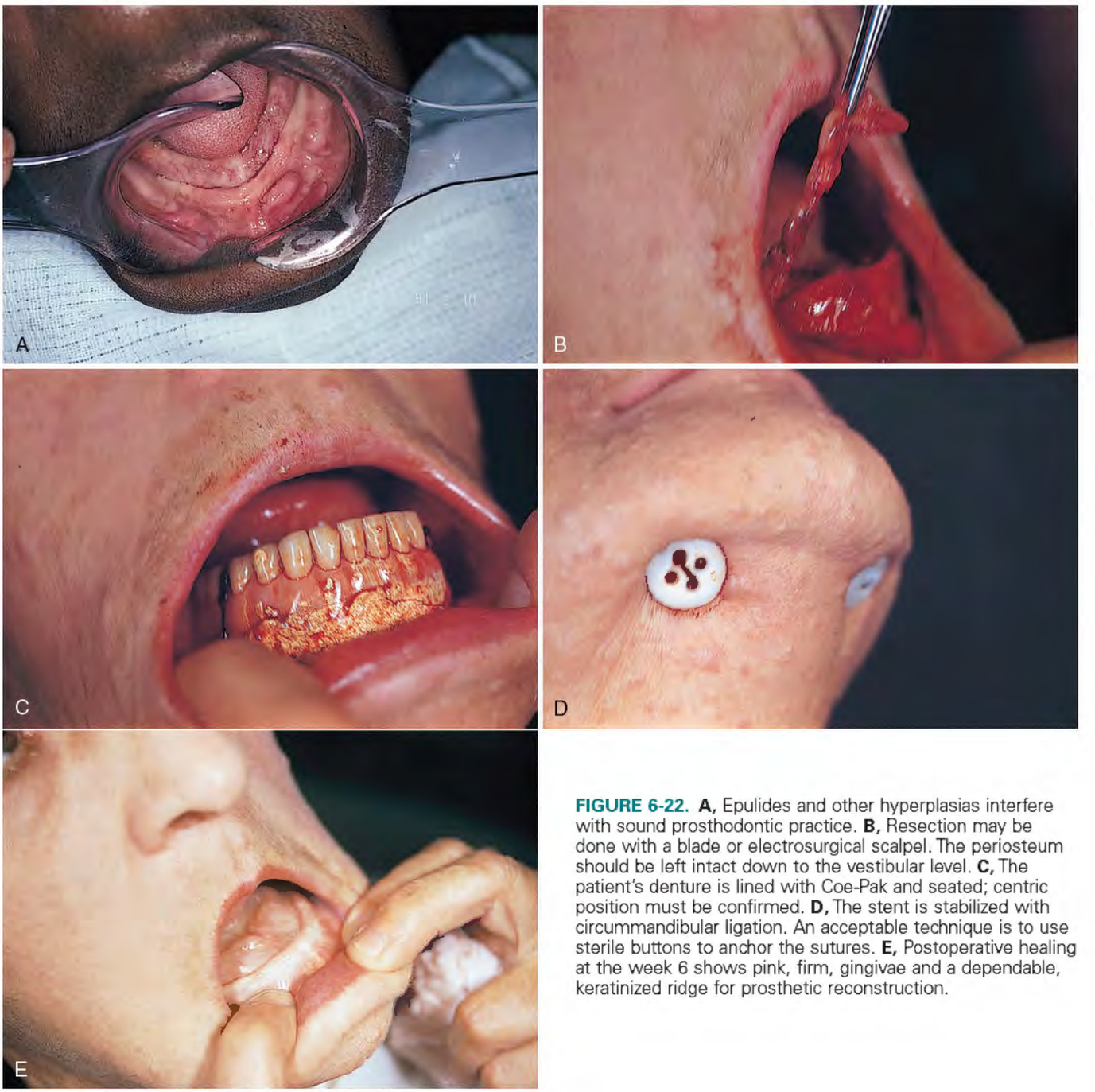


FIGURE 6-22. **A,** Epulides and other hyperplasias interfere with sound prosthodontic practice. **B,** Resection may be done with a blade or electrosurgical scalpel. The periosteum should be left intact down to the vestibular level. **C,** The patient's denture is lined with Coe-Pak and seated; centric position must be confirmed. **D,** The stent is stabilized with circummandibular ligation. An acceptable technique is to use sterile buttons to anchor the sutures. **E,** Postoperative healing at the week 6 shows pink, firm, gingivae and a dependable, keratinized ridge for prosthetic reconstruction.

Soft Tissue Management and Grafting

CHAPTER 7

ARMAMENTARIUM

Bougies: whalebone, olive tipped
Buttons: sterile
Forceps: Adson and Gerald (toothed and nontoothed)
Forceps: hemostatic, mosquito
Needle holders
Retractors: Blunt Mathieu, beaver tails, sweetheart
Scalpel blades: Bard-Parker (BP) No. 15, No. 12
Scalpel handles: BP No. 3
Scissors: Baby Metzenbaum
Scissors: Goldman-Fox
Sutures: Biosyn 3-0, 4-0 on C13, C14 on F1, F2 cutting needles
Sutures: Polysorb or Vicryl 3-0, 4-0 on C13, C14 cutting needles 5-0, 6-0 on CV 23 tapered needles
P10 cutting needles

CAVEATS

When scant mucosa is available, a variety of soft tissue grafting strategies may be undertaken. In the planning of pedicle grafts, certain guidelines must be meticulously observed:

1. The pedicle cannot be more than two and a half times longer than it is wide.
2. The flap must be well vascularized.
3. Suturing must be tension free.

Impeccable tissue handling ensures that the highest levels of functional and cosmetic success result.

Pedicles must be created with care. The mucosa must not be thinned too much, or devascularization may result. If excessive connective tissue is allowed to remain, the graft may be bulky, unsuitable, and esthetically displeasing.

The sharpest instruments and the finest sutures that will serve satisfactorily should be used, and tissue forceps should be used as gently as possible.

Regional block anesthesia is preferable to infiltration, because the tissues requiring plastic surgery respond best if they are not bloated with anesthetic solution (which causes distortion) and ischemia from the vasoconstrictor.

Perforation can be prevented by careful dissection for undermining; this demands attention to the surface of the mucosa as the scissors dissect beneath the flap.

Soft tissues are required to cover bone, transport vascular channels, enclose implant host sites, and bring functional and esthetic contour to critical anatomic areas. Defatted and split-thickness skin and mucosa from the patient make the best free grafts. These grafts may be taken by dermatome from the lateral thigh, the skin behind the ear and the overlying the mastoid process, and the palate. Mucosa for pedicle grafts is taken primarily from the superior and inferior vestibular areas. To a lesser extent, mucosa for closing oroantral fistulae is taken from the palate. Gingival defects may be repaired reliably with palatal split-thickness, connective tissue, or free grafts covered by gingivomucosal pedicles.

Plastic surgical manipulation of oral tissues plays an integral role in implant-borne oral habilitation and should become an essential skill of all implant surgeons.

INCISIONS

Incisions made properly result in rapid, consistent primary wound healing because they cause fewer postoperative sequelae (e.g., edema, pain, and bleeding), and they create a surgical environment that preserves and protects the implants that have been placed.

Surgical assistants should be taught that suctioning, particularly when powerful, can do harm. It can tear tissues, injure small blood vessels, encourage bleeding to continue and, as the tip sweeps back and forth, disturb the alignment of flaps. Suctioning also aspirates the organisms floating in the aerosol above the wound directly into it, inviting infection. Suction should be used only to enable the surgeon to see the operative field and to evacuate the pharynx. If neither of these needs exists, the suction tip should be kept away from the operative site, and the surgical assistant should be instructed to use sponges first. The following rules are crucial to an optimal outcome.

1. Only sharp scalpels should be used. Blades should be changed frequently.
2. For dentoalveolar surgery, incisions should be made at the crest of the ridge. The preferred scalpel blade is the Bard-Parker (BP) No. 15 blade. On each edentulous ridge, a linea alba is centered directly on the superior surface; this is an avascular scar that resulted from the trauma of extractions and pressure from denture saddles. Recent research has indicated that no blood flow occurs from the buccal to lingual sides of each ridge because of a lack of capillary anastomoses across this whitish line (Fig. 7-1). Unique, innovative, or unconventional incisions (e.g., the S type or the labial vestibular visor) present risks of retarded healing, implant dehiscence, and ischemia or necrosis of the part of the flap between the incision site and the linea alba.
3. The scalpel should be pressed firmly to the bone to avoid retracing incisions. If the incision is not made cleanly, periosteal reflection is resistant, the danger of tearing tissue is significant, and postoperative pain and swelling increase. Incisions should be made once and made correctly. Multiple slices in the periosteum reduce vascularity and retard healing. If the ridge is sharp or knife edged, care must be taken to prevent the blade from slipping off to the side.
4. Incisions must be extended adequately; that is, anteriorly by at least one tooth and posteriorly over the tuberosity or through and beyond the retromolar pad. This may eliminate the need for vertical or releasing incisions, which can cause pain and swelling and also may retard healing. When releasing incisions are required to obtain further exposure of an operative site, they should be oblique with broader bases, and they must always include full papillae. Hemisectioned papillae are difficult to suture and are poor prospects for predictable healing.

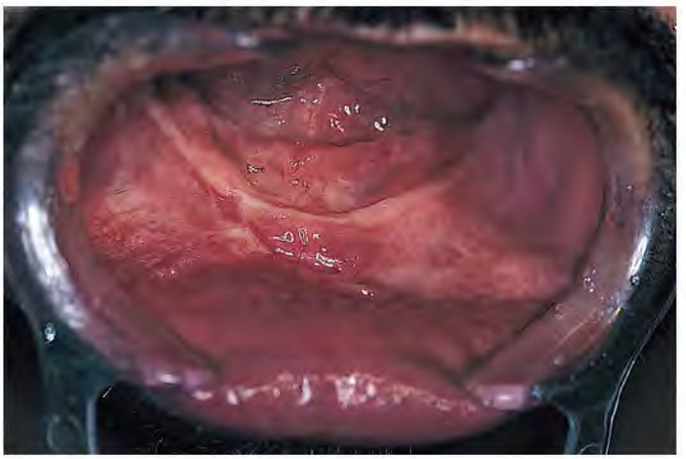


FIGURE 7-1. The linea alba, a fine, white crestal line found on edentulous ridges, is avascular and does not allow cross-ridge capillary anastomoses. If novel incisions are made (e.g., S-shaped or visor type), the site may break down or heal slowly, resulting in bone loss around implant cervices.

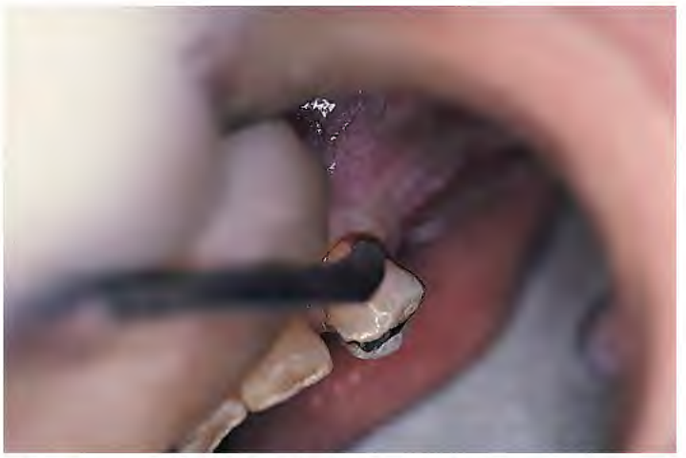


FIGURE 7-2. A No. 12 Bard-Parker scalpel blade enables the surgeon to make sharp incisions in inaccessible places.

5. Use of a BP No. 12 blade is important. Because of its curvature, this blade allows incisions to be extended through the gingival crevice of the most distal tooth present, and it makes surgical separations accurately and cleanly in all the crevices (Fig. 7-2).
6. Before the first incision is made, the procedure should be planned on a study cast. Small or inadequate incisions may be a major reason for surgical failure. Larger, rather than smaller, incisions should be made; they heal just as rapidly. Improved access to the operative site contributes to more precise surgery. In addition, retraction is gentler, causing the tissues to respond more kindly to the trauma of surgery.

FLAP DESIGN, ELEVATION, AND RETRACTION

Careful, thorough, and complete flap design, and elevation without tearing or injuring the periosteum, is necessary for a smooth operative and postoperative course. For this purpose, the surgeon must have new or freshly sharpened periosteal elevators available (Fig. 7-3). The fibers must not be ripped or torn. Instead, they should be sharply incised at the level of the cortical

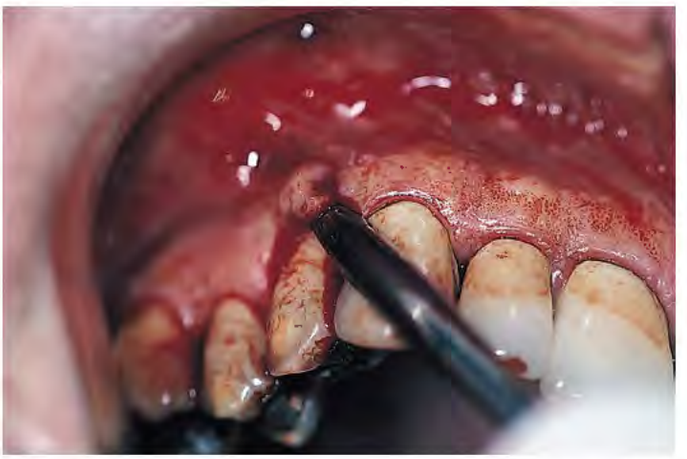


FIGURE 7-3. Periosteal elevators should incise, not tear, tissues. To perform their function, they must be kept sharp.

bone; this requires a keen-edged elevator. Before each operation, the auxiliary staff should make sure that the elevators are as flawless and as sharp as new ones.

Flaps with releasing incisions should have bases that are wider than their alveolar margins, essentially trapezoidal (Fig. 7-4). If tooth areas are to be included in the surgical exposure, the gingival papillae should never be split, but rather should be included totally in the flap. Such gingival tissues must be elevated gently with a fine-pointed elevator only after thorough incision.

In areas where previous surgery or trauma has occurred or where evident scarring is present, or in other cases in which the investing tissues are resistant to easy, complete reflection, the procedure can be expedited using a technique that accomplishes this challenging task easily and consistently. The technique requires a small-toothed pickup forceps (Adson or Gerald) and a scalpel armed with a new BP No. 12 blade (Fig. 7-5). The practitioner lifts an edge of the flap with forceps so that the tip of the blade can gently stroke the scarred, adherent fibers in the fashion of a periosteal elevator. The practitioner proceeds a bit at a time, carefully elevating the flap until a zone is reached that allows conventional periosteal separation. This technique should not be attempted for the first time on a patient. Implantologists should practice on a cow mandible (which can be obtained from a butcher) until they achieve a high level of confidence in their ability to perform full-thickness reflection without perforating the mucoperiosteum

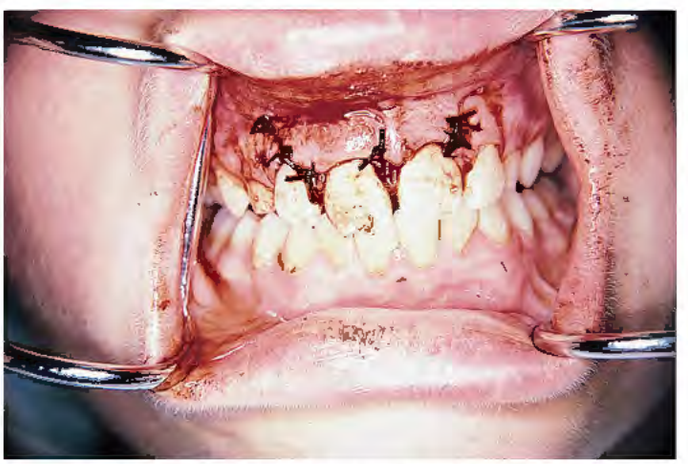


FIGURE 7-4. Flaps heal fastest when their bases are wide. Wide bases ensure the greatest amount of vascularity.

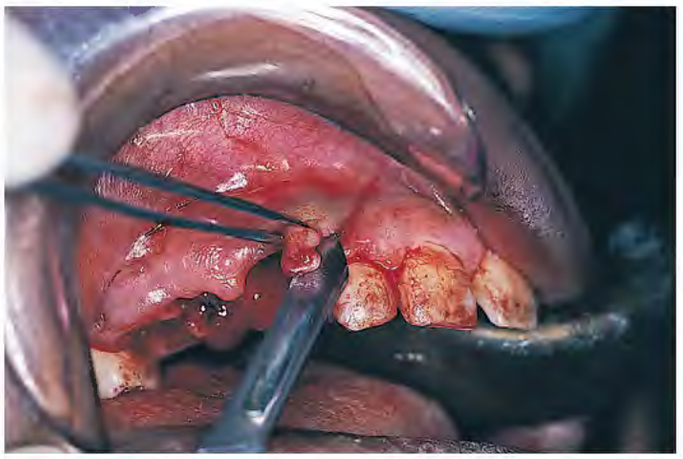


FIGURE 7-5. Adherent or scarred tissue often resists elevation. To resolve this, the practitioner can grasp an end of the mucoperiosteum with an Adson or Gerald forceps and stroke beneath the flap gently with a No. 12 scalpel blade. This allows the flap to be lifted effortlessly and atraumatically.

(a serious but not always irrevocable occurrence). If the blade tip is kept against the bone and the strokes are made in a short, gentle fashion, the technique can be mastered readily. If the overlying mucosa is perforated, the laceration must be kept to a minimal length, the reflection is continued, and the subsequent surgery is completed. After suturing and closure, the iatrogenic laceration is closed with 6-0 Vicryl or Polysorb continuous horizontal mattress sutures using a fine, tapered, small half-circle (SH) needle (see the sutures and suturing section in Chapter 6).

In two areas, the palatal and the mandibular facial, special care must be taken in the reflection of mucosal flaps so that the greater palatine and mental neurovascular bundles are protected. Such efforts are abetted if a 2 × 2 gauze sponge is inserted beneath the flap. By pushing the sponge with a periosteal elevator, the surgeon can enlarge the separation safely and accurately (Fig. 7-6). In this fashion, as a foramen is approached, it comes into view in a trauma-free fashion, sparing injury to its neurovascular bundle.

Once the flaps have been reflected, they must be managed gently. They should be kept well hydrated with saline-moistened sponges. The manner in which they are kept retracted also plays a role in subsequent healing. Retractors should be smooth surfaced; these include the Henahan, Seldin, beaver tail, and blunt-toothed rake (Mathieu) (Fig. 7-7). The staff should make sure that these instruments are not nicked or scratched. All rakes in the armamentarium should have blunt, not sharp, tips.

A suitable, convenient alternative to manual reflection is autoretraction using sutures. Buccal flaps may be sutured to the buccal mucosa. Palatal flaps may be sutured into a midline bundle, which keeps these tissues out of the operative field. Unilateral palatal flaps may be sutured to the teeth on the contralateral side, which keeps the surgical site well exposed without the need for retractors. Bilateral mandibular lingual flaps may be sutured to each other across the dorsum of the tongue; this configuration serves not only as an excellent means of retraction, but also as a competent tongue depressor (Fig. 7-8). Unilateral mandibular flaps may be kept retracted by suturing them across the dorsum of the tongue to teeth on the unoperated side.

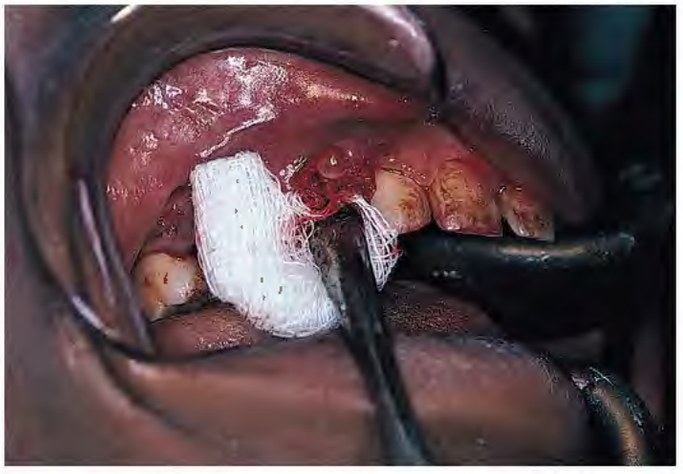


FIGURE 7-6. Flaps can be elevated in mucosal areas with minimal trauma by teasing them away from the bone; this is done by pushing a 2 × 2 sponge ahead of the periosteal elevator. The neurovascular bundle, when reached, is clearly visible, and the gentle progress of the sponge protects it from damage (see Figs. 7-8 and 7-9).

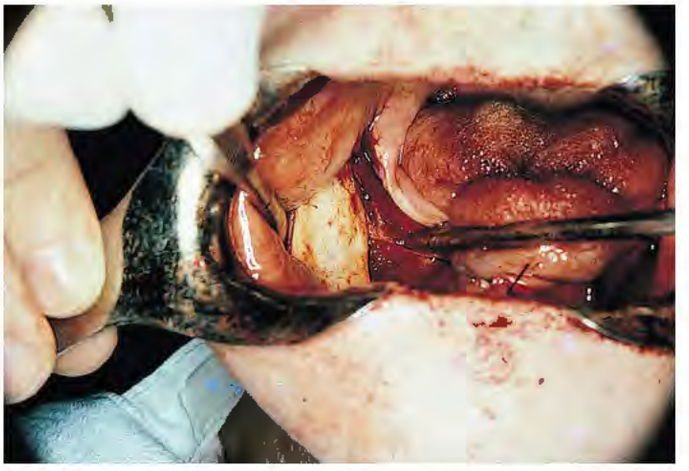


FIGURE 7-7. Polished edges on retractors prevent tissue injury. Blunt rakes, smooth Henahans, beaver tails, and Seldins should be used. Retractors cause the least damage when they are allowed to rest against bone.

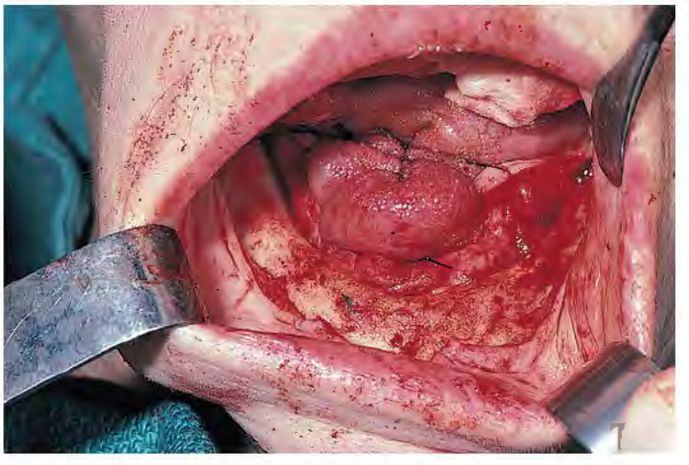


FIGURE 7-8. Sutures can serve as excellent retractors. In surgery of the mandible that involves both sides, the two lingual flaps can be tied together across the dorsum of the tongue in a shoelace configuration. This not only keeps the lingual flaps out of the field, it also stabilizes the sublingual adnexa and immobilizes the tongue. In unilateral procedures, the contralateral teeth may be used as anchorage for the retracting sutures.

In planning and designing flaps, the dental surgeon must not split papillae, frenula, or muscle attachments; rather, they should be included totally within the flap design. When palatal flaps are planned, all incisions should be made in the gingival crevices or at the ridge crest and never across the palatal mucoperiosteum. In this way, only full-thickness, total palatal mucosa is reflected (Fig. 7-9). If, as a worst case scenario, palatal tissues are segmented, the risk arises that the palatine artery will be cut; at best, such incisions retard healing and cause considerable pain. To elevate a full palatal flap, the incisive neurovascular bundle can be cut while the reflection is performed. Surprisingly, little or no bleeding results, and no significant dysesthesia or retardation of healing is noted postoperatively.

Soft tissue flaps should be filleted (i.e., thinned) with great care. After incision and reflection, the flap to be thinned is lifted with an Adson (short) or Gerald (long) forceps, and the deep layers are excised at a depth that allows the required thickness of mucosa to remain (Fig. 7-10). Care must be taken with dissection in a plane parallel to the mucosa, so that the mucosa is not perforated or overly thinned. The technique of filleting allows the implantologist to thin and streamline many types of tissues, such as those covering the ridges or tuberosities. In addition, sheets of such salvaged, uninjured connective tissue can be used as substitutes for synthetic membranes, either with a poncho design or over synthetic grafting materials placed to cover a perforation of the cortical plate. (See Chapter 8, the sections on periodontal defect correction and the use of guided tissue regeneration membranes.)

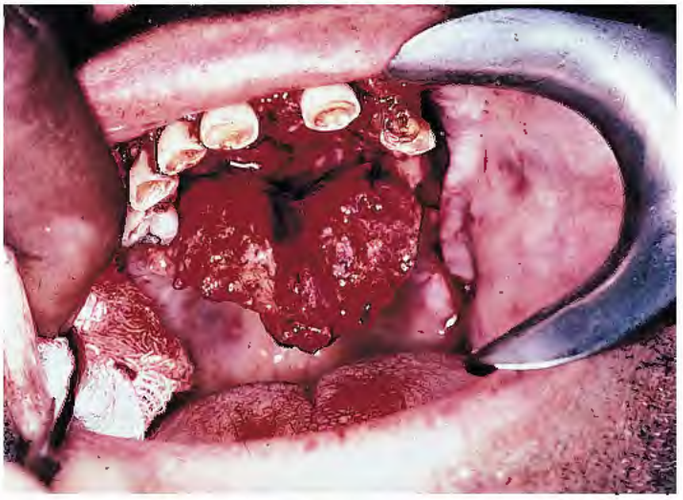


FIGURE 7-9. Only crevicular incisions should be used in surgery on the palate. The resulting full-thickness, complete palatal reflections remain well vascularized and offer the greatest chance of primary healing.

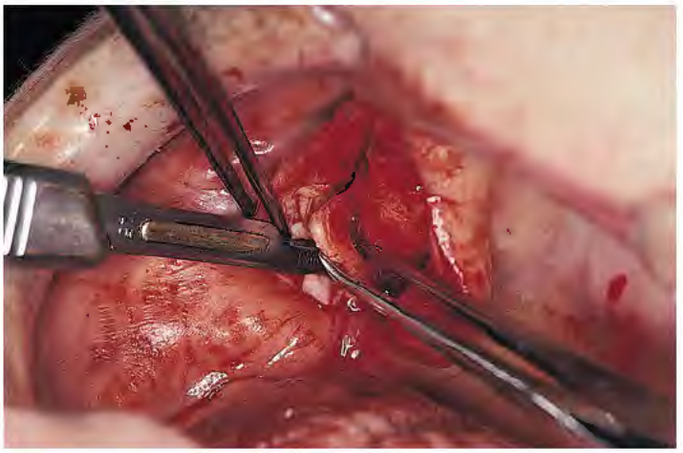


FIGURE 7-10. Flaps often require thinning. For this process, they are stabilized with toothed forceps so that a sharp scalpel blade can be used to fillet the deeper layers. Although the tissue reduction is performed beneath the flap, the surgeon's eyes should be focused on the mucosal surface to guard against flap perforation.

SOFT TISSUE GRAFTING, VESTIBULOPLASTY, AND PEDICLE GRAFTING

In some cases, not enough tissue is available to create a *primary closure* (i.e., to bring the margins of the wound together firmly so that the underlying bone and implants are covered). Neither primary healing nor osseointegration can be assured if the flaps are sutured under tension. This is particularly important in the use of guided tissue regenerative membranes (GTRMs). Flaps cannot be pulled, stretched, caused to blanch, or allowed to become ischemic. Unfortunately, a quiescent, tension-free closure is not always possible. The key to surgical success is mastering the technique of *undermining*, which allows creation of an easy closure (Fig. 7-11). Undermining is a simple technique, but many practitioners may be unfamiliar with the method and unaware of its inestimable value.

Undermining is performed as follows: A toothed Adson or Gerald forceps is used to pick up a buccal or labial flap (the procedure cannot be done on the palatal or lingual sides). Muscle fibers (buccinator or orbicularis oris) are attached to the underside of the flap. These fibers are stretchable and compliant. However, they have isometric memory; if they are pulled or drawn excessively to allow closure of a flap across a wound, they immediately begin to retract the tissues to their original position, causing wound dehiscence. To prevent this, baby Metzenbaum scissors (which are curved and blunted) are used to snip the muscle fibers carefully from the overlying flap. This allows the flap to cover the bony operative site without tension (Fig. 7-12, *A* to *C*).

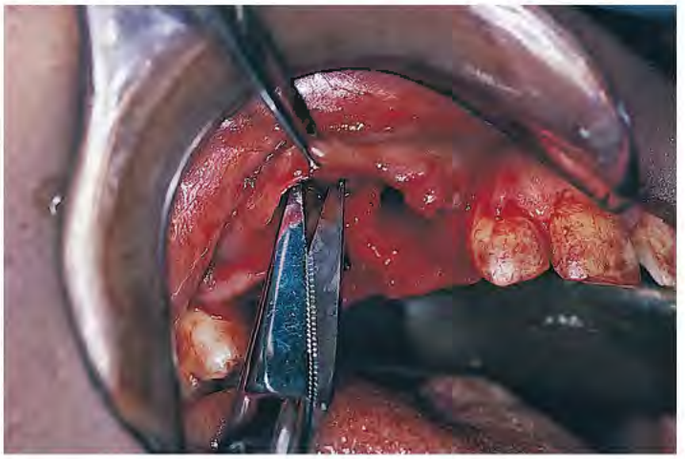


FIGURE 7-11. If not enough tissue is available to cover the bone, more tissue can be made available by undermining mucosa from the buccinator or orbicularis oris muscles. This is done by lifting the edge of the mucosa and detaching it from its muscular bed with baby Metzenbaum or other curved scissors. The surgeon's eyes should remain on the mucosal surface, even though the dissection is carried out beneath it. When the newly made flap is drawn across the denuded bone, it should show neither tension nor blanching.

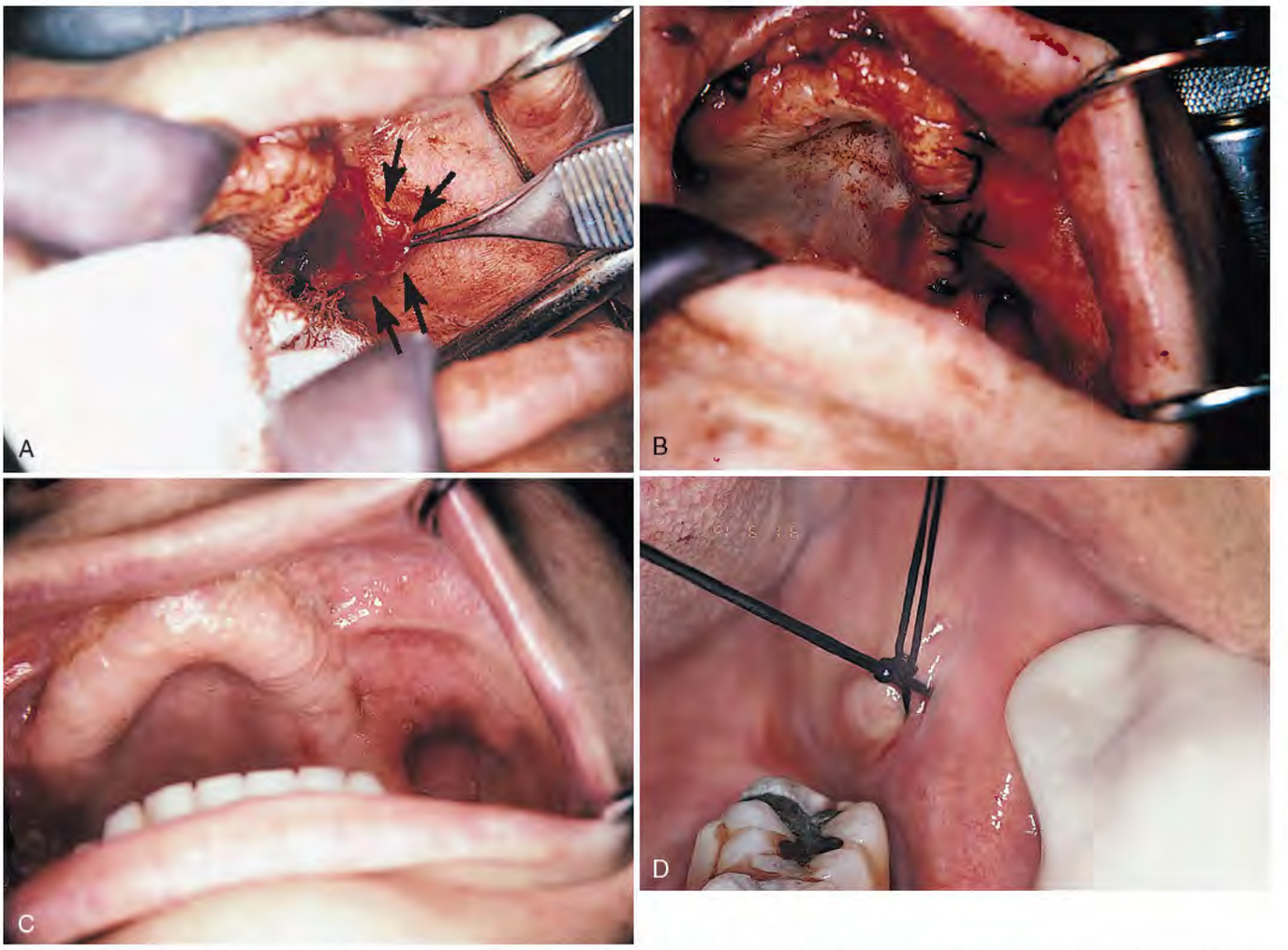


FIGURE 7-12. **A,** The buccal mucosa is a generous donor site for creating pedicle grafts. During undermining, the flap *(arrows)* is held with a toothed forceps (Adson), and Metzenbaum scissors are used to detach it from the musculature. **B,** A tension-free closure is required, to allow primary healing. **C,** Two weeks after surgery, good tissue tone and color indicate a successful graft. **D,** If Stensen's duct is close, it can be avoided by suturing a whalebone bougie or lacrimal probe into it.

The surgeon must take special care when undermining in the vicinity of the mental nerve. Also, Stensen's duct may present a potential hazard in surgery performed in the maxillary first molar area. If the location of the duct is questionable, the surgeon should dry the tiny caruncula that indicates its presence in the midbuccal mucosa and then milk the gland with one hand while retracting and pulling forward the cheek with the other hand to straighten the premasseteric kink. When a drop of saliva is secreted, a fine, olive-tipped bougie or lacrimal probe is inserted into the orifice. The assistant then stabilizes the probe while the surgeon passes a circumferential suture of 3-0 black silk through the tissues and ties it around the probe to anchor it in place. Subsequent undermining is simple, because the indicates the exact position of the duct in relation to the dissection (Fig. 7-12, *D*).

Early undermining efforts may result in mucosal perforation, but these defects can be repaired. To prevent such accidents, surgeons should not look at the tissues being cut away from the undersurface of the flap; rather, they should watch the dissection and the snipping of the scissors from the intact mucosal surface above.

After the flap has been mobilized so that it can be drawn over the wound easily, it is sutured into its new position. It is vital that implant surgeons become comfortable with the undermining technique.

Split-thickness grafting offers additional benefits (Fig. 7-13, *A*). To prevent loss of vestibular depth, which occurs with a tension-free, undermined pedicle flap, the newly liberated tissue, the mucosa, should be separated from the periosteum (Fig. 7-13, *B* and *C*). The deeper layer is used to cover the implants and ridge; the superficial layer can be used to maintain vestibular depth by closing it short of the crest and tacking it to the periosteum with several 5-0 Vicryl or Polysorb sutures (Fig. 7-13, *D*). The denuded crestal periosteum, which is closed with a periodontal dressing, is covered within 5 days by secondary-intention epithelium (Fig. 7-13, *E* and *F*). Within 3 weeks, a stable zone of fixed gingiva becomes established (Fig. 7-13, *G*).

Pedicle (attached base) grafting also can be useful. However, three cardinal rules must be carefully followed with these flaps:

1. The dimension of the flap should be more generous than the surgeon would deem adequate.
2. When possible, the flap should be elevated from the donor site with the neurovascular bundle included. This allows primary coverage of fistulous sites, antral communications, dehiscent implants, or ridge augmentation devices (Fig. 7-14, *A*).
3. A well-vascularized, bleeding, muscular bed must be present to receive the graft when it is sutured to the adjacent host site mucosa.

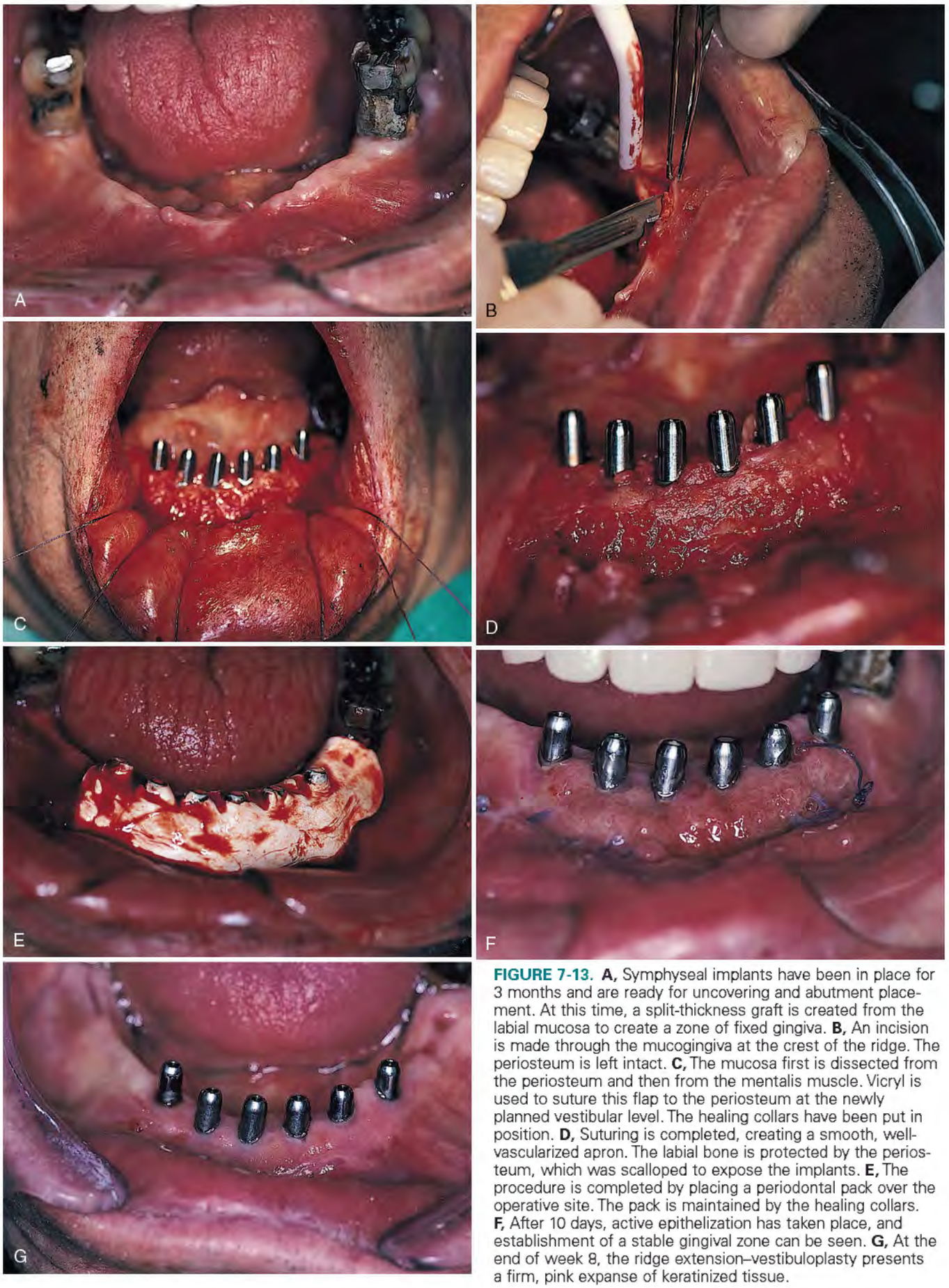


FIGURE 7-13. **A,** Symphyseal implants have been in place for 3 months and are ready for uncovering and abutment placement. At this time, a split-thickness graft is created from the labial mucosa to create a zone of fixed gingiva. **B,** An incision is made through the mucogingiva at the crest of the ridge. The periosteum is left intact. **C,** The mucosa first is dissected from the periosteum and then from the mentalis muscle. Vicryl is used to suture this flap to the periosteum at the newly planned vestibular level. The healing collars have been put in position. **D,** Suturing is completed, creating a smooth, well-vascularized apron. The labial bone is protected by the periosteum, which was scalloped to expose the implants. **E,** The procedure is completed by placing a periodontal pack over the operative site. The pack is maintained by the healing collars. **F,** After 10 days, active epithelization has taken place, and establishment of a stable gingival zone can be seen. **G,** At the end of week 8, the ridge extension–vestibuloplasty presents a firm, pink expanse of keratinized tissue.

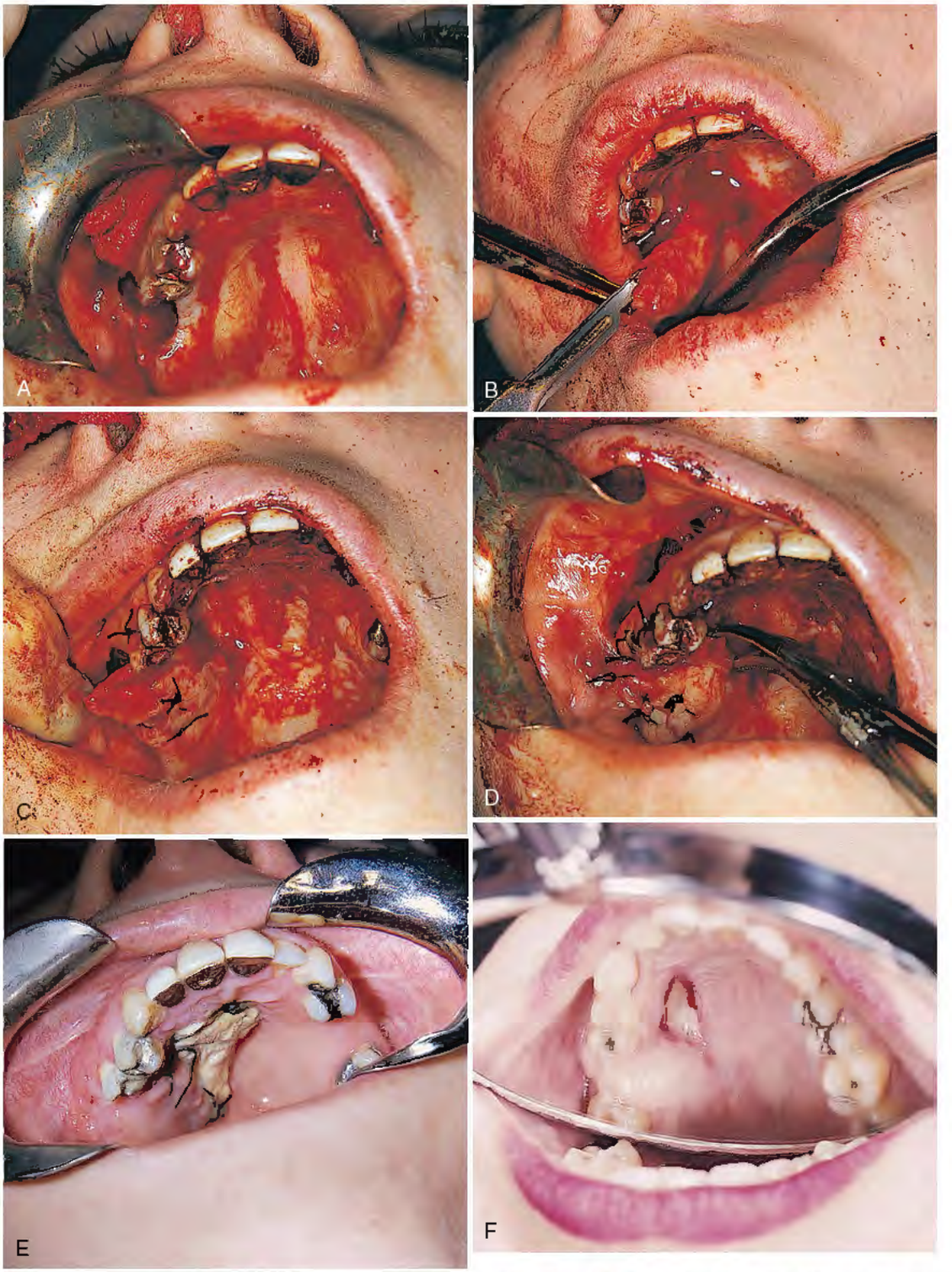


FIGURE 7-14. **A,** Extraction of maxillary molars sometimes creates antral communications. Occasionally, an oroantral fistula results. **B,** Fistulae may be closed by excising the epithelized tract and making a buccal incision designed to receive a rotated palatal pedicle flap. Such a flap must be made to include the greater palatine neurovascular bundle. It also should be full thickness and not be more than two and a half times longer than it is wide. After the flap has been elevated and rotated laterally to cover the bony defect, it should rest at its new site in a tension-free environment. **C,** The flap is tacked to the surrounding buccal and gingival tissues with interrupted sutures. **D,** After the tip of the pedicle is denuded, it is snuggled beneath the buccal mucosa into a prepared pocket; this offers double assurance of primary healing. **E,** The donor site is allowed to heal by secondary intention. During this period, it is protected with iodoform packing stabilized by crisscross silk sutures. **F,** The well-vascularized flap indicates good healing at week 4. The palate has yet to epithelize. **G,** By week 8, the palate has filled in fully with keratinized tissue, the rugae have recurred, and the pedicle's rugae are present and will remain so for the remainder of the patient's life.

When pedicles are created, an exposed donor site of either bone or muscle should be left behind. These donor sites are dressed with iodoform or Xeroform gauze or a periodontal pack, and splints, stents, or sutures are used to hold them in place. Palatal, labial, and buccal mucosal pedicles are created by dissecting the mucosa from its bony or muscular bed through elevating or undermining. Flaps generated from buccal and labial areas should be mobilized and brought over the area to be covered only after a bleeding host site has been created to receive them on the lingual or palatal surfaces over healthy bone.

In similar fashion, palatal flaps with neurovascular bundles can be developed, elevated, and rotated 90 degrees across the ridge, where they can be sutured into newly made, bleeding, buccal pockets (Fig. 7-14, *B* and *C*). To do this, a horizontal incision is made in the buccal margin of the wound, separating the mucosa from the muscle. Dissection should extend 1 cm into the buccinator muscle. A scalpel blade or sterile, abrasive, heatless wheel is used to denude the transported palatal flap of epithelium from its tip for a distance of 1 cm. The tip then is slipped into the buccal pocket, and several deep 4-0 Vicryl sutures are used to tack it in place. The double layer created in this manner offers additional assurance of a primary closure (Fig. 7-14, *D*).

After healing, the primary defect is covered by the transported mucosa, and the donor (palatal) site, which had been protected by a pack, is filled in with secondary-intention epithelium (Fig. 7-14, *E* and *F*). In most cases, the patient's vestibule has been sacrificed (Fig. 7-14, *G*), and a subsequent vestibuloplasty may be required.

A more predictable procedure is the vestibuloplasty made with a pedicle graft (Fig. 7-15, *A*). Three sides of the graft must be outlined on the labial mucosa with a BP No. 15 blade. Its two sides should extend from the vestibule to a length equal to the height of the planned zone of fixed gingiva. The lateral incision is connected across the mucosa parallel to the vermilion border, leaving an intact base at the vestibule (Fig. 7-15, *B*). The flap is lifted and undermined as described earlier, and the three cardinal rules for pedicle flaps must be followed. When the mucosa has been dissected from the orbicularis oris muscle to its full extent, it is lifted with two Adson forceps, revealing the periosteum against the anterior mandible (Fig. 7-15, *C*). A periosteal elevator is used to push the attached muscle fibers apically to the depth of the anticipated correction that is equal to the length of the flap. The periosteum must be allowed to remain in place; the elevated pedicle flap is pressed against it, extending it apically and expressing entrapped blood and air. A tapered needle and 5-0 dyed Polysorb are used to tack the flap to the periosteum at its corners. Additional sutures are used, as needed, to keep the flap securely in place.

If teeth are present, brass ligature wires are placed between them, and extended, twisted loops are left to act as retentive devices for a protective Coe-Pak dressing (Fig. 7-15, *D*). The pack serves as a stabilizer and keeps the opposing labial donor site more comfortable as it heals by secondary intention (Fig. 7-15, *E*). As an alternative, this process can be simplified by use of an appropriately sized piece of AlloDerm (discussed later in the chapter).

Free Grafting Mucosa and Connective Tissue

Free grafting has its place in implant surgery, particularly during the preparatory phases when areas of implantation need to be altered so that zones of fixed gingiva can be created (Fig. 7-16, *A*). This can occur with vestibuloplasty, which is done either with free dermal or mucosal grafting.

Mucosal Grafting

When a free graft is planned, it should not be taken until the host site has been prepared; this keeps donor tissues most viable. First, a vestibular incision is made at the base of the fixed gingiva, if any exists. If none is available, the incision is made at the gingival margins of the teeth. The mucosa is pushed apically to the planned depth of the zone of fixed gingiva, but the periosteum is left intact against the bone, creating a split-thickness flap. A small, saline-soaked sponge is placed in the wound, and a free split-thickness graft is taken from the palate with BP No. 15 and No. 12 blades (Fig. 7-16, *B*). The lateral portion of the palatal vault is the best donor site. It is important to perform the dissection superficially, harvesting only mucosa and taking care not to injure the greater palatine artery. The graft should be 2 mm larger in each dimension than the host site requires, and the corners should be rounded.

The graft is placed over the exposed host-site periosteum immediately after harvesting and pressed into place with a saline-moistened surgical sponge. Then, a tapered (not a cutting) needle and interrupted sutures of 5-0 dyed Vicryl are used to tack it down in strategic locations on all four sides. The closure is completed with interrupted sutures 2 mm apart. At this point, the graft is blanched (Fig. 7-16, *C*). The palate and graft areas are dressed and then protected with previously prepared acrylic stents, each lined with periodontal pack.

Within 1 week of removal of the pack, evidence of success is seen on inspection. The graft appears pink and well attached to host tissues (Fig. 7-16, *D* and *E*). If AlloDerm is used, similar success can be achieved without the need for harvesting.

Free grafting also is effective for creating vestibules in edentulous jaws. This procedure is performed before implants are placed (Fig. 7-17).

AlloDerm

Allogenic Mucosal Grafting

AlloDerm is a homologous material, an acellular dermal matrix that was introduced in 1994. It is processed from human skin and is reported to have an intact basement membrane, retained collagen, and absence of epidermal and fibroblast cells. It is treated so that it is immunologically inert, and it is packaged in a dehydrated state.

Unlike the other membranes described previously, this allogeneic material is not used as a GTRM. It is used only as a substitute for gingiva or mucosa, because AlloDerm serves as a scaffold for epithelial cell migration, which allows pigmentation and contour to emulate the surrounding tissues. AlloDerm GBR (guided bone regeneration) is used specifically as a resorbable barrier while it simultaneously converts into a zone of keratinized tissue. It has a smooth side, which is placed against the underlying bone or connective tissue, and a roughened side, which faces outward. In addition, to prevent the significant error of the improper side being placed down, each specimen has an orientation slit, which must be horizontal on the surgeon's upper left or lower right corner. This type of surface graft should be used when not enough soft tissue is available to create a primary closure and undermining is not an acceptable alternative; when the potential overlying flap has been torn, damaged, or devascularized; or when the ridge has been enlarged significantly by spreading, splitting, or grafting. Taking palatal tissue is time-consuming and painful, and this graft material serves as a satisfactory substitute.

AlloDerm requires rehydration with two saline baths, each lasting 5 minutes. After rehydration, it becomes soft, compliant, and amazingly strong. If the graft is not large enough (the largest size commercially available is 2 × 4 cm), two or more pieces may be sutured or microstapled together (Fig. 7-18).

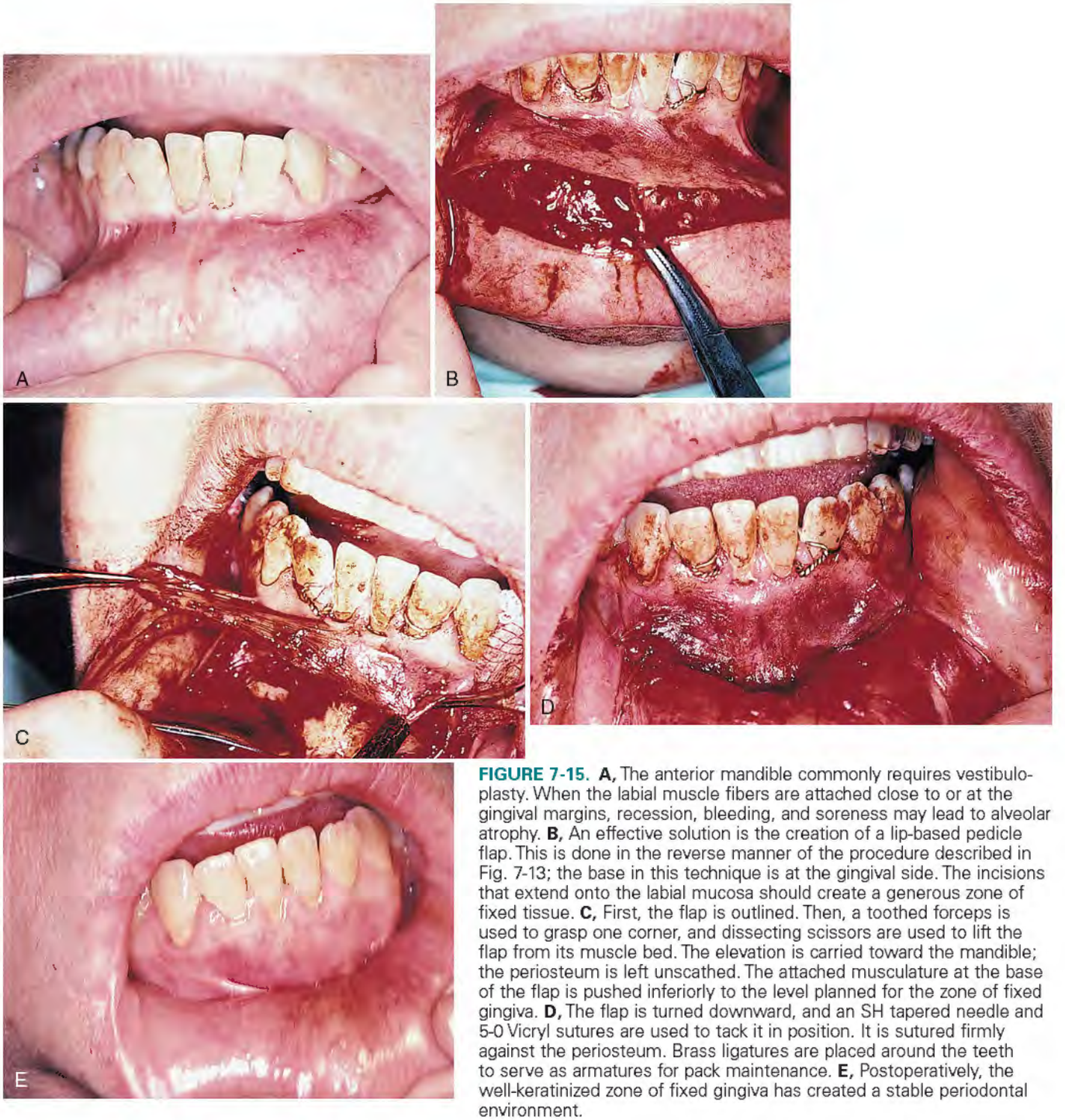


FIGURE 7-15. **A,** The anterior mandible commonly requires vestibuloplasty. When the labial muscle fibers are attached close to or at the gingival margins, recession, bleeding, and soreness may lead to alveolar atrophy. **B,** An effective solution is the creation of a lip-based pedicle flap. This is done in the reverse manner of the procedure described in Fig. 7-13; the base in this technique is at the gingival side. The incisions that extend onto the labial mucosa should create a generous zone of fixed tissue. **C,** First, the flap is outlined. Then, a toothed forceps is used to grasp one corner, and dissecting scissors are used to lift the flap from its muscle bed. The elevation is carried toward the mandible; the periosteum is left unscathed. The attached musculature at the base of the flap is pushed inferiorly to the level planned for the zone of fixed gingiva. **D,** The flap is turned downward, and an SH tapered needle and 5-0 Vicryl sutures are used to tack it in position. It is sutured firmly against the periosteum. Brass ligatures are placed around the teeth to serve as armatures for pack maintenance. **E,** Postoperatively, the well-keratinized zone of fixed gingiva has created a stable periodontal environment.

After cutting, tucking, and contouring, the graft should be large enough to extend peripherally to healthy cortex. It is stabilized with membrane tacks or sutured to the adjacent periosteum with Polysorb, Vicryl, or Biosyn. To retain the graft's morphology, a perio pak (Coe-Pak) stent is placed over it for 7 to 10 days. If the graft remains undisturbed, it becomes vascularized within 1 week.

Protection of the site becomes less important after 3 weeks, when the originally pallid AlloDerm becomes pinker; under the best conditions, it becomes keratinized at the end of 6 weeks. Simple precautions should be recommended, such as no tooth brushing, a pureed or liquid diet, and gentle management postoperatively for 3 weeks (Fig. 7-19).

Connective Tissue Grafting

Autogenous connective tissue is an excellent substitute in grafting. It provides the overlying epithelium with a vascular bed and some requisite bulk. It accepts sutures well and resists tearing. It is particularly valuable for reconstructing cervical dental and implant areas denuded by gingival atrophy (Fig. 7-20, *A*).

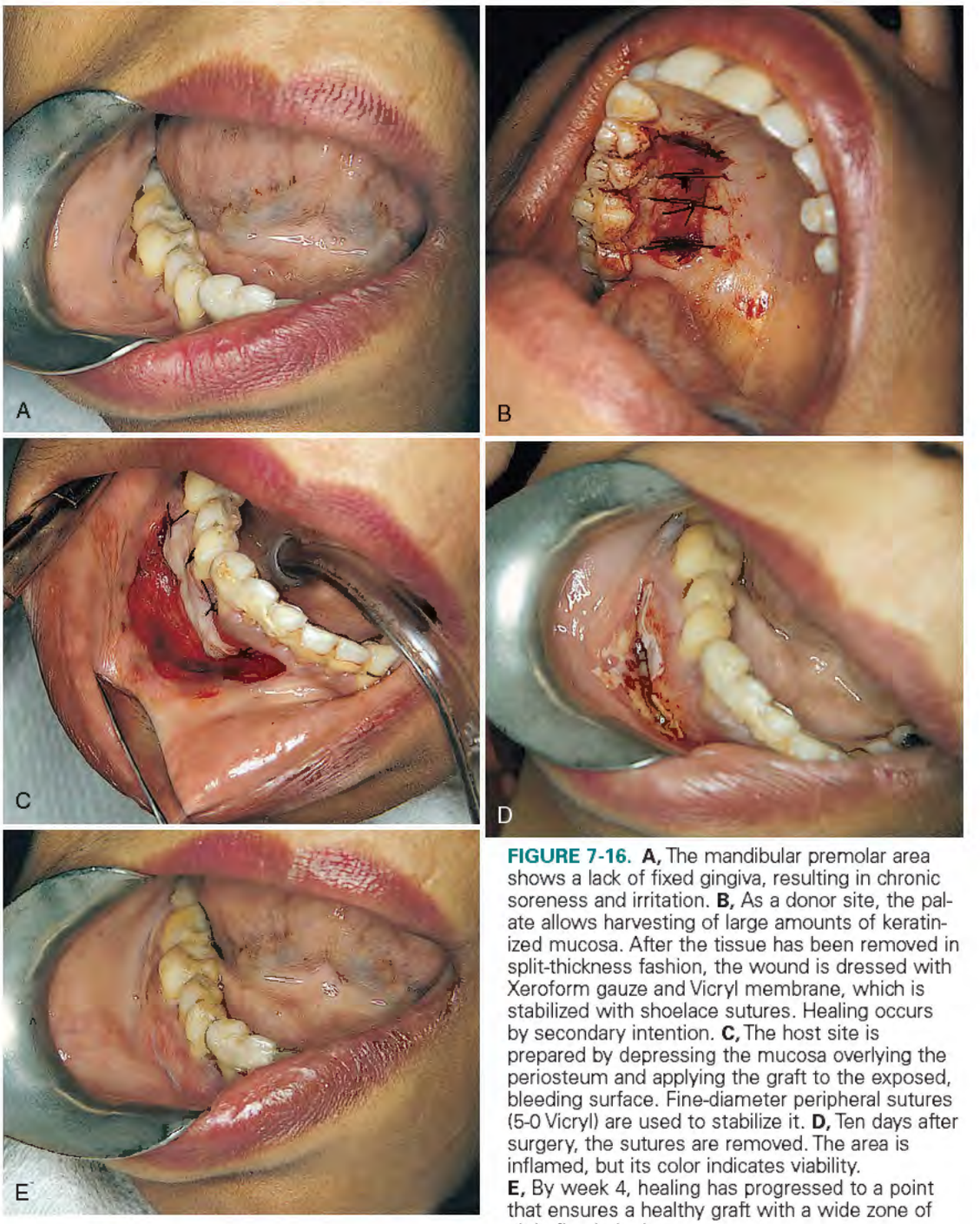


FIGURE 7-16. **A,** The mandibular premolar area shows a lack of fixed gingiva, resulting in chronic soreness and irritation. **B,** As a donor site, the palate allows harvesting of large amounts of keratinized mucosa. After the tissue has been removed in split-thickness fashion, the wound is dressed with Xeroform gauze and Vicryl membrane, which is stabilized with shoelace sutures. Healing occurs by secondary intention. **C,** The host site is prepared by depressing the mucosa overlying the periosteum and applying the graft to the exposed, bleeding surface. Fine-diameter peripheral sutures (5-0 Vicryl) are used to stabilize it. **D,** Ten days after surgery, the sutures are removed. The area is inflamed, but its color indicates viability. **E,** By week 4, healing has progressed to a point that ensures a healthy graft with a wide zone of pink, fixed gingiva.

In such cases, the gingival margin is isolated with two parallel vertical incisions that include the papillae (Fig 7-20, *B*). After reflection and development of this pedicle flap by undermining (Fig. 7-20, *C*), the exposed root or implant is curetted and conditioned with citric acid, and the flap is brought up to the level of the cemento-enamel junction or cervix to verify that it can cover the area without tension (Fig. 7-20, *D*). To cover the exposed root surface, a connective tissue specimen of the appropriate size is retrieved from the palate by means of a crevicular incision, reflection of the full-thickness flaps, removal of the connective tissue by filleting, and primary closure by periodontal sling suture (Fig. 7-20, *E*). On the fourth postoperative day, the gingival pedicle is sectioned free at the vestibular level to convert it to a free graft, which eliminates muscular tension.

The free graft is placed over the root defect, tailored to fit the available area, and sutured peripherally with 6-0 Vicryl suture (Fig. 7-20, *F* and *G*). The gingival pedicle then is brought coronally to cover the connective tissue and sutured peripherally and to the lingual papillae interproximally (Fig. 7-20, *H*). The result 6 months later reflects a high level of home care and gives the appearance of a keratinized repair (Fig. 7-20, *I*).

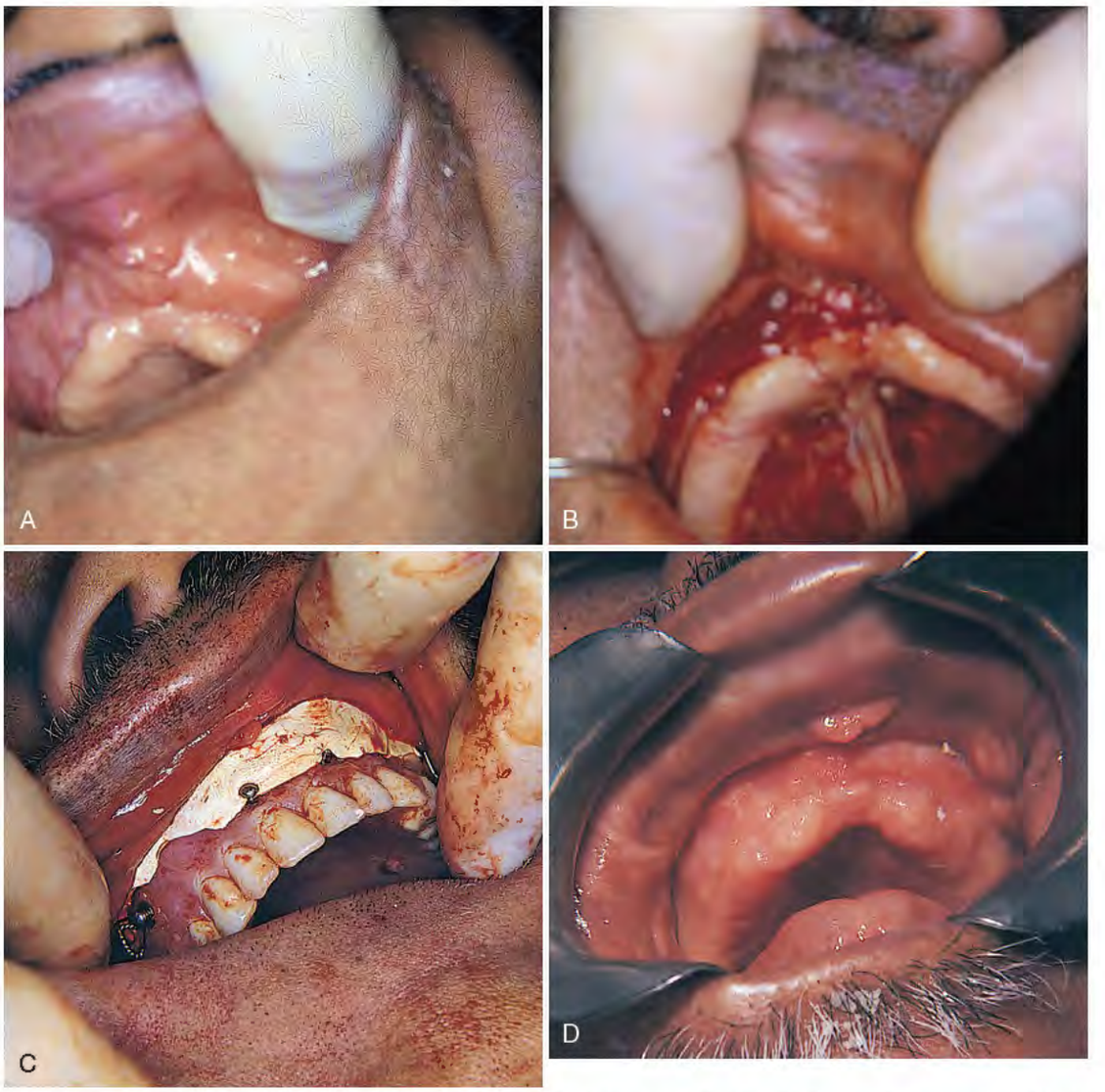


FIGURE 7-17. **A,** For consideration as a candidate for implants, an edentulous maxilla should demonstrate zones of fixed gingiva. **B,** Incisions are made in the labial mucosa down to, but not including, the periosteum. The mucosa is elevated superiorly, leaving well-vascularized host sites against the labial surface of the bone. This step is followed by split-thickness dissection of the palatal mucosa, which will serve as the graft material. Each palatal half is taken to serve as the ipsilateral graft. Only the avascular palatal midline is left intact. **C,** Each graft is trimmed and then placed and tacked in position with fine sutures. Then, a stent prepared before surgery and lined with Coe-Pak is ligated to the zygomatic arches. **D,** Four weeks after surgery, after removal of the stent, the grafts have been accepted, and a significant zone of fixed gingiva is present. The patient now may undergo implant placement through crestal incisions.

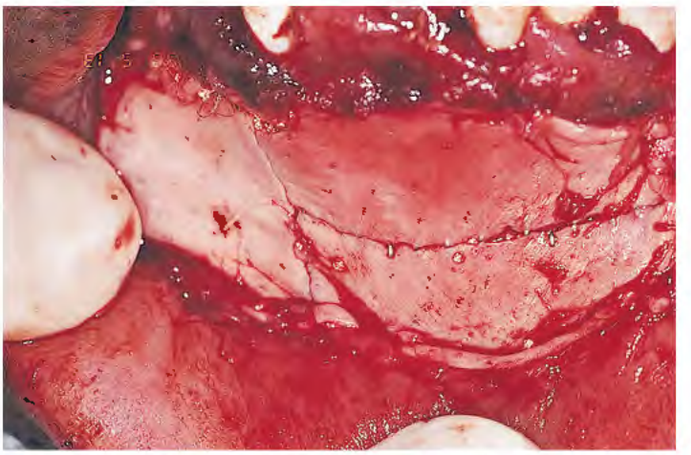


FIGURE 7-18. Pieces of AlloDerm can be patched together with ministaples to satisfy the requirements of a large or irregular host site.

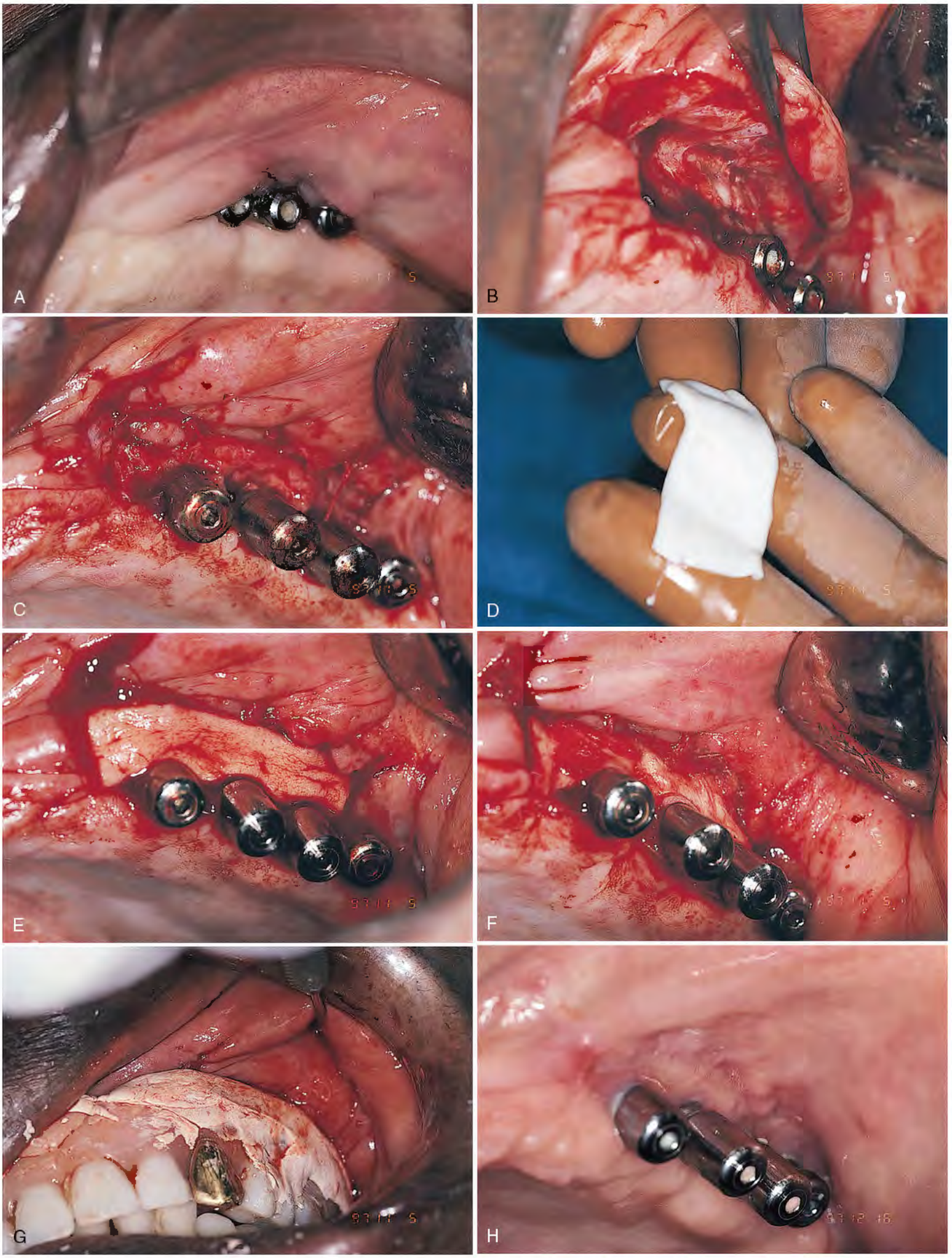


FIGURE 7-19. **A,** An overgrowth of buccal tissue occurred adjacent to these three root form implants. **B,** After an incision is made at the crest of the ridge, the buccal flap is elevated, although the periosteum is allowed to remain in place. **C,** The flap is filleted to thin it, and its lower edge is sutured to the periosteum at the planned new height. **D,** The AlloDerm is hydrated, which makes it more compliant. **E,** The AlloDerm is contoured to the exposed periosteum and compressed with a saline-moistened sponge. **F** and **G,** The material, which is very resistant to tearing, is sutured peripherally and then covered with an obtundent periodontal dressing that is stabilized by the patient's overdenture. **H,** The postoperative view 3 weeks later shows a satisfactory zone of fixed gingiva.

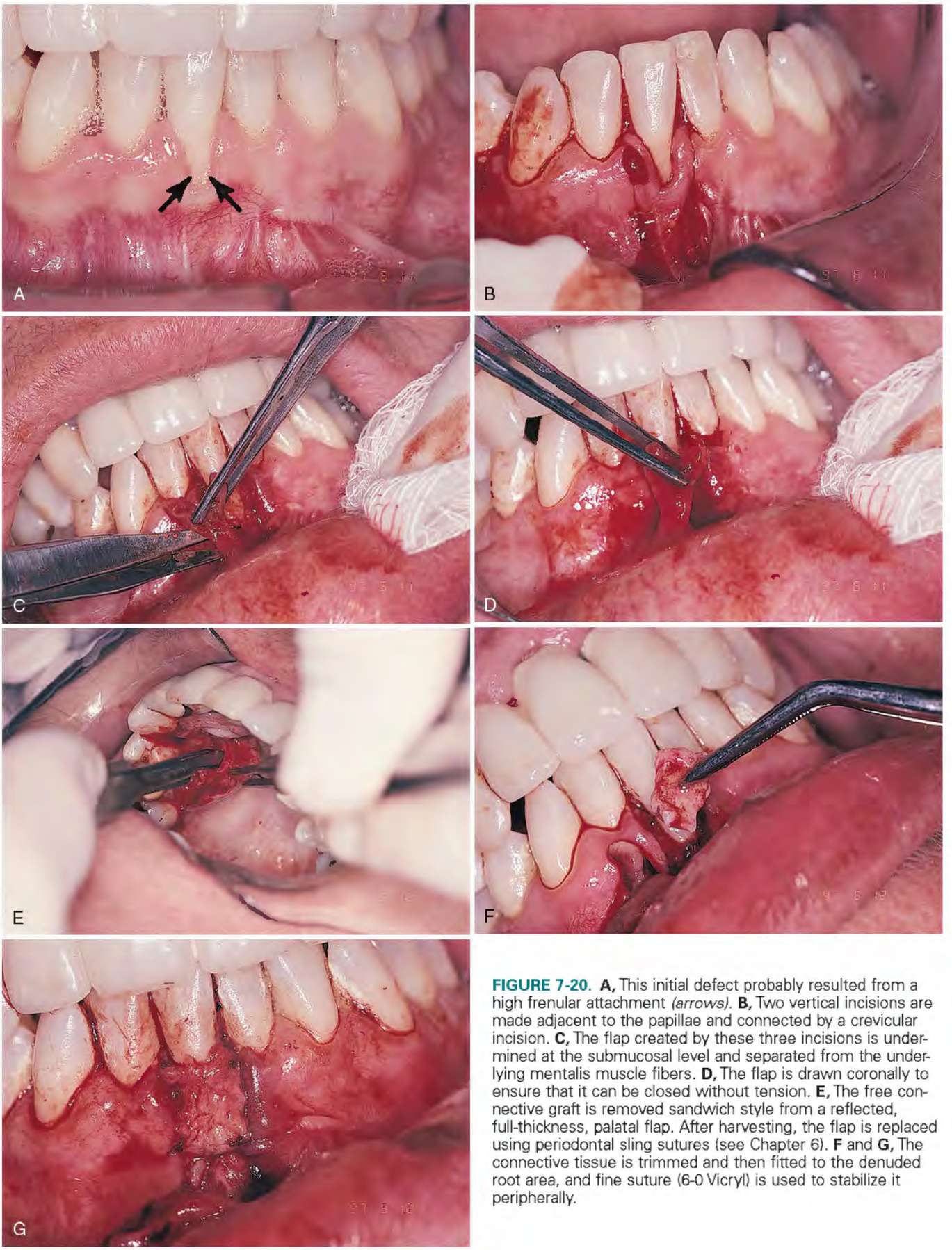


FIGURE 7-20. **A,** This initial defect probably resulted from a high frenular attachment *(arrows)*. **B,** Two vertical incisions are made adjacent to the papillae and connected by a crevicular incision. **C,** The flap created by these three incisions is undermined at the submucosal level and separated from the underlying mentalis muscle fibers. **D,** The flap is drawn coronally to ensure that it can be closed without tension. **E,** The free connective graft is removed sandwich style from a reflected, full-thickness, palatal flap. After harvesting, the flap is replaced using periodontal sling sutures (see Chapter 6). **F** and **G,** The connective tissue is trimmed and then fitted to the denuded root area, and fine suture (6-0 Vicryl) is used to stabilize it peripherally.

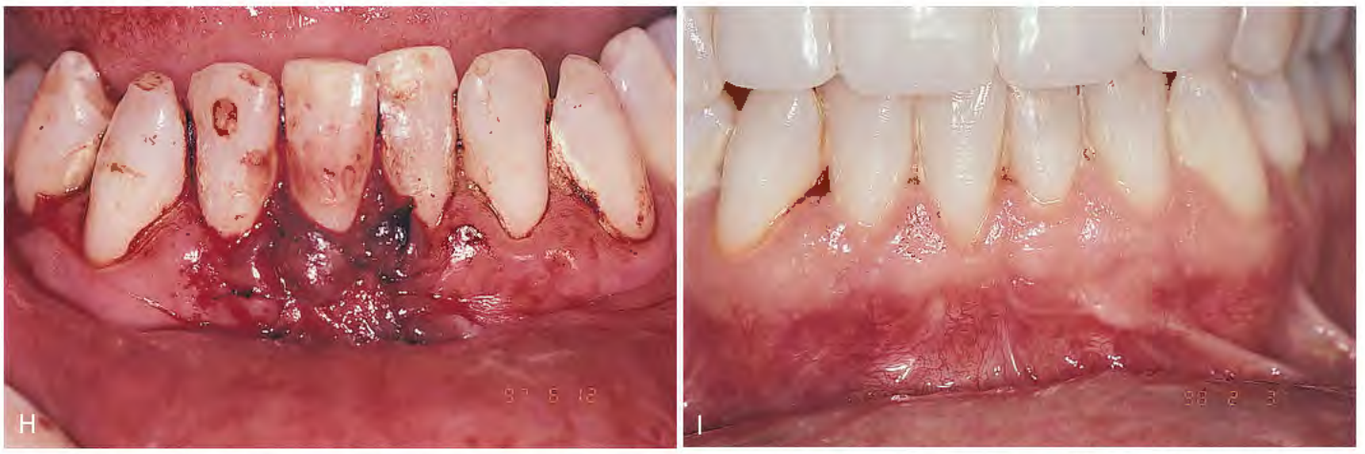


FIGURE 7-20, cont'd. **H,** The mucosal pedicle is brought to its final position of repair and sutured with 6-0 Vicryl. **I,** A 6-month postoperative view of the site reveals a satisfactory result.

Hard Tissue Surgery and Bone Grafting

8
CHAPTER

ARMAMENTARIUM

Antibiotics (tetracycline, gentamicin)
Antral membrane elevators (Tatum)
Atwood, 347 diamond drill
Autopolymerizing resin
Autostaple skin closures
Blades: Bard-Parker (BP) No. 11, 12, and 15
Bone files
Bone marrow gouges
Bone wax
Bougies: whalebone, olive-tipped, or lacrimal probes
Burs: 699L, 700L, 701L, 2L, 4L, 6L friction-grip
Curettes: antrum
Curettes: surgical and periodontal
Electrosurgical unit
Forceps: curved mosquito and baby right angle, Kelly, and tonsil forceps
Forceps: rongeur and Kerrison
Forceps: (Adson and Gerald) toothed and nontoothed pickup
Graft material: particulate (20 and 40 mesh) and block forms, solid and porous hydroxyapatite (HA), tricalcium phosphate (TCP), demineralized freeze-dried bone (DFDB), bioglasses, hard tissue replacement (HTR), xenografts (Bio-Oss, OsteoGraf/N), irradiated bone, bioreactive glass, collagen sheets, plugs, and microfibrillar form
Guided tissue regeneration membranes (GTRMs): Gore-Tex (4 and 6), Vicryl mesh, other resorbable polymers, Lambone, Resolute, TefGen, Bio-Mend, Regentex, GBR-2000, and other polytetrafluoroethylene (PTFE) products
Handles: BP No. 3
Handpieces: high and low speed, straight and angled
Handpiece: Impactair, high speed
Hemostats: mosquito, Kelly, tonsil, Carmalt
Implant osteotomies: Steri-Oss, Brookdale angmented set
Implant osteotomes (Summers)
Ligature wire: No. 2 and 3 stainless steel
Local anesthetic syringes, needles, and solutions
Mallet (plastic covered)
Mandibular mortise form: (titanium mesh), titanium, contouring pliers
Membrane tack or fixation set: IMZ/Steri-Oss, Imtec, Straumann, 3i, OsseoFix
Mortar and pestle
Needle holder
Needles: 18 gauge, disposable, 1½-inch hypodermic
Nerve hooks
Nylon-tipped amalgam carrier
Orangewood or cottonwood sticks
Osseous coagulum trap suction tip
Osteotomes: curved and straight, spatula, regular
Penrose drains: ¼, ½, 1 inch
Periosteal elevators, double ended
Retractors: baby Parker, blunt Mathieu (rake), beaver tail (Henahan), sweetheart (tongue)
Rongeur forceps: side cutting and end cutting
Sable paint brushes: 0 and 0-0
Scissors: Metzenbaum, sharp, and suture scissors
Sheers: wire cutting
Staples for skin closure
Sterile cotton-tipped applicators
Sterile dappen dishes
Sterile saline
Sutures: 3-0 black silk; 4-0 dyed polyglactic acid (Vicryl, Polysorb), Biosyn; 3-0 plain gut on tapered and cutting needles
Syringes (for delivery of particulate graft material)
Titanium miniplate set with taps, screws, and screwdrivers
Tourniquet
Towel clamps
Wire, monofilament: No. 2 and 3 stainless steel
Wire cutters

CAVEATS

Graft materials must be implanted directly against bone. All interposed connective tissue must be removed, or integration will fail.

The guidelines for preimplantation tunneling must be followed with great care to facilitate ridge augmentation; otherwise, permanent injury to the mandibular or mental nerves may result. Augmentation should not be undertaken it if the canal is dehiscent. Overaggressive tunneling can pierce the vestibular attachment and allow ectopic migration of graft material particles.

If infection exists near or within the proposed operative site, grafting materials should not be used.

Periodontal and other defects must have at least two remaining bony walls before grafting can be performed.

The dental surgeon must guard against expecting more of the grafting materials than they can do. Most of these materials *conduct* bone (i.e., they facilitate bone growth in areas where bone ordinarily would regenerate). Their presence merely makes osseous repair more efficient, better contoured, more rapid, and stronger. The only osteogenic material is autogenous bone; it is recommended for the repair of all but three walled defects for which mixtures of osteoconductive materials (hydroxyapatite [HA], tricalcium phosphate [TCP]) and osteoinductive materials (demineralized freeze-dried bone [DFDB]) may be used. For lesions requiring more substantive grafting assistance, autogenous bone should be added to other substitute graft materials or used alone.

GENERAL GUIDELINES

Bone Management

The best protection for bone is an uninjured periosteal envelope. The dangers of overheating bone should also be recognized. Temperatures above 47° C (116.6° F) for only 30 seconds can cause serious, irreparable damage. Staff members must make sure that burs, twist and spade drills, trephines, and bone taps are sharp and are replaced frequently (i.e., depending on bone hardness, after every sixth to tenth implant). After every use, a notch should be made on the shank to keep an accurate count of the number of uses. Replacement drills should always be kept at hand.

Both internal and external irrigation should be used when possible (this feature is not available on all systems), and hollowed drills should be cleaned immediately after each use to ensure future patency (Fig. 8-1). The dental surgeon need not always use the drilling systems supplied by implant manufacturers. Generic consoles,

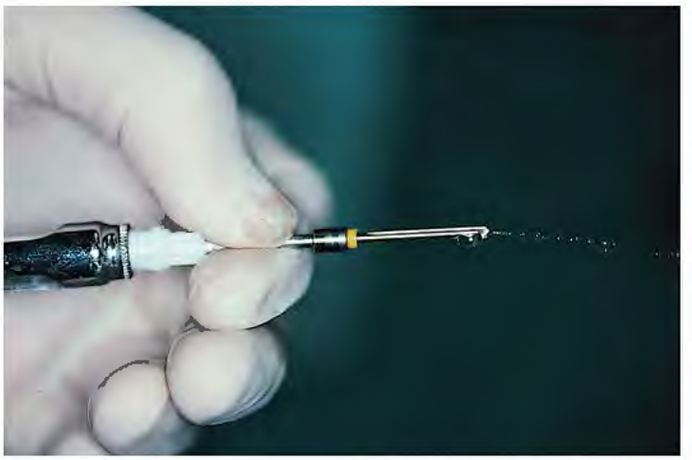


FIGURE 8-1. An anesthetic syringe with a 27-gauge, 1½-inch needle fits comfortably into a hollow drill lumen. When a tube of solution is forced through it, bone fragments and debris are expressed.

motors, handpieces, and drills are available that offer irrigation systems (which keep endosteal sites cool) and assist the final steps in making osteotomies (see chapters 9 and 10 for specifics). Using drills with 0.5-mm diameter increments results in minimal bone injury and allows the drill to be used a greater number of times.

When performing alveoloplasties, osteoplasties, sinus floor elevations, and bone-tapping procedures, the surgeon must keep a steady, copious source of irrigation on the bone and on all cutting instruments. If the surgeon's attention must be diverted from the operative site, the site must be kept dressed with saline-soaked sponges at all times to prevent dehydration.

The greatest care must be taken when electrosurgical units are used for implant surgery. Vascularity must be encouraged to ensure the best prognosis for healing. If an electrode tip touches any part of an implant, the current is conducted throughout the entire implant body (although at a dissipated intensity), creating the possibility of widespread bone injury.

Bone grindings should be preserved, when possible, by placement of a filter in the suction system (Fig. 8-2). The recovered osseous coagulum (mixed with a synthetic particulate grafting material, if necessary) can be used for bone repair, after implant placement, or in the floor of the maxillary sinus after an elevation procedure.

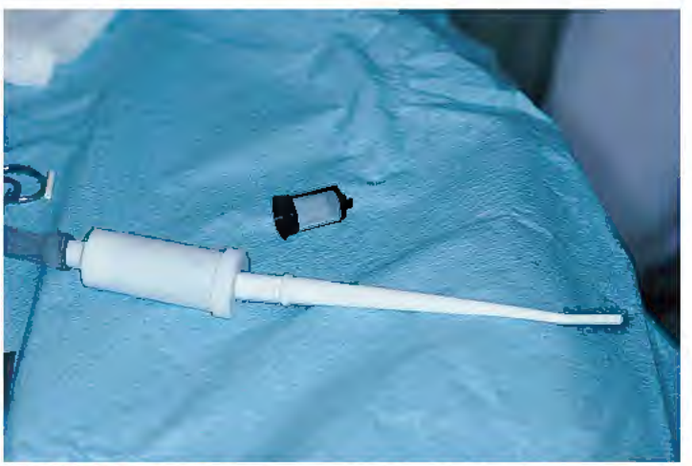


FIGURE 8-2. This filter (Autografter™), which is attached to the suction tubing, is available from Ace Surgical. It collects bone grindings produced during osteotomies. The retrieval material, osseous coagulum, can be used for grafting.

Every implantologist should become competent in the use of synthetic bone grafting materials (Table 8-1). These materials offer a number of benefits and may be needed unexpectedly.

Grafting for repair, augmentation, osteosynthesis, or morphologic maintenance may be performed with autogenous or allogeneic bone, xenografts, or synthetic versions (particulate or porous solid block forms) of both resorbable and nonresorbable osteoconductive biomaterials. Table 8-2 presents the names and other significant characteristics of these grafting materials. The techniques for their use are essentially the same for all, except that some have different handling characteristics. Indications differ for the use of some of the synthetic bone materials (i.e., TCP and other resorbable substances). The clinician may be able to change both the quantity and quality of a patient's bone by using bone-replacement materials.

An essential aspect of the application of grafting materials is the use of resorbable and nonresorbable guided tissue regenerative membranes (GTRMs). A small but stalwart contingent of practitioners remains loyal to the traditional nonresorbable designs, but those materials offer no advantages over the resorbable type, and they require a second operation for removal.

The first part of this chapter presents the more basic procedures of bone grafting, such as ridge maintenance, ridge augmentation, and the general application of membranes and techniques for their fixation. This background serves as a guide for the second part of the chapter, which describes bone alteration and grafting techniques designed for ridges with dimensional deficiencies that prevent routine implant procedures. The methods of selecting donor sites and obtaining grafts also are discussed.

Basic Grafting Procedures

Periodontal Defect Correction

Only teeth that are or can be made clinically firm should be included in the treatment plan. If the teeth are mobile, they must be bonded with stainless steel wire or acrylic intracoronal splints or in some other fashion completely immobilized. If periodontal-endodontic involvement is a possibility, presurgical pulp canal therapy must be performed (Figs. 8-3 and 8-4).

Flaps should be planned carefully, and incisions should be made at least one tooth anterior and one tooth posterior to the anticipated surgical site. Crevicular incisions should be made with a No. 12 blade using the inverted bevel design, so that involved epithelium and granulomas are left in situ, which facilitates excision. The crevicular incisions are connected with those that are vertical and/or oblique. The flaps should be widest at their vestibular bases. Papillae should never be split; rather, they should be included entirely within the flap (Fig. 8-5).

Flaps are reflected with great care so that they are not torn. A sharp, fine periosteal elevator or sharpened No. 7 wax spatula is useful. The alveolar bone need not be exposed any more than 1 to 2 mm apically beyond the periodontal defect. Serious postoperative sequelae occur (e.g., pain and swelling) when reflections extend apically beyond the attached gingival level. Of course, depending on anatomic factors and pocket depth, reflection may need to extend beyond the vestibular attachments.

After facial and lingual flaps have been reflected, impeccable care must be taken to curette and plane all exposed root surfaces. The bone should not be blunted, ramped, or altered in any way. The higher the residual walls, the better the prognosis for osseous repair with graft materials. Cortical perforations can be made with a No. ½ round bur for additional sites for retention.

Table 8-1 Categories of Grafting Materials

	Advantages	Shortcomings
Autografts		
(Bone self-donated by the patient)		
Iliac crest	Patient's own bone Osteogenic Readily available	Second site morbidity Requires general anesthesia Prolonged postoperative recovery
Ascending ramus or symphysis of mandible	Patient's own bone Osteogenic Readily available	Second site morbidity Prolonged postoperative recovery
Torus	Patient's own bone Osteoconductive	Host site availability Second site morbidity Cortical bone only
Rib or tibial plateau	Patient's own bone Osteogenic Readily available	Second site morbidity Requires general anesthesia Prolonged postoperative recovery
Calvarium	Patient's own bone Osteogenic Readily available	Second site morbidity Requires general anesthesia Prolonged postoperative recovery
rhPDGF-BB		
(Highly purified additives derived from recombinant human platelet-derived growth factors [rhPDGF-BB]; used with allografts, xenografts, or alloplasts or alone in a resorbable carrier matrix (Infuse only); used in an infrabony defect or an area where natural host bone is absent but required. *Types:* OP-1/BMP-7, GEM-21S, INFUSE)	Bioactive protein Accelerated growth and bone maturation, more predictable and shows greater bone fill than without Readily available	Very costly May not be acceptable to patient
Homografts/Allografts		
(Bone donated from a human source other than the patient; obtained from bone banks)		
Demineralized freeze-dried bone (DFDB)*	Readily available Osteoinductive/conductive Biologic acceptability Replaced by patient's own bone	Cost May not be acceptable to patient
Freeze-dried bone matrix	Readily available Osteoconductive Biologic acceptability Replaced by patient's own bone	Cost May not be acceptable to patient
Irradiated bone	Readily available Osteoconductive Biologic acceptability Replaced by patient's own bone	Cost Increased concern about disease transmission as a result of decreased processing
Fresh-frozen bone	Readily available Osteoconductive Replaced by patient's own bone	Cost Significant risk of disease transmission and graft-host reaction
Human bone ash (Osteomin)	Readily available (Pacific Coast Tissue Bank) Osteoconductive (human hydroxyapatite [HA]) Resorbable No risk of disease transmission	Cost An HA based on human bone
Xenografts		
(Mineralized bone matrix from a species other than humans; bovine source)		
Bio-Oss	Readily available Osteoconductive Patient acceptance Biologic acceptability	Cost Similar to HA
Alloplasts		
(Synthetic bone materials available from a variety of manufacturers)		
Nonresorbable polymer (hard tissue replacement [HTR])	Readily available Osteoconductive Hydrophilic Patient acceptance Biologic acceptability	Cost Nonresorbable
Ceramic HA (i.e. Calcitite, Osteograf D, Interpore)	Readily available Osteoconductive Patient acceptance Biologic acceptability	Cost Nonresorbable (HA component)
Ceramic HA (35%) in a resorbable medium $CaSO_4$ (65%) (Hapset)	Readily available Osteoconductive Patient acceptance	Cost Nonresorbable (HA component)
Resorbable ceramic (B-TCP) (i.e., Augmen, Synthograf)	Readily available Osteoconductive Acceptable to patient Biologic acceptability	Cost Absorbability Predictability
Ceramic (HA) (i.e., Osteogen, OsteoGraf LD, OsteoGraf/N)	Readily available Osteoconductive Acceptable to patient Biologic acceptability	Cost Absorbability
Bioactive glass (i.e., BioGran, PerioGlas)	Readily available Osteoconductive Acceptable to patient Biologic acceptability	Cost Absorbability
Bone banks (See Appendix L for members of the American Association of Tissue Banks.)		

*Available in various forms: cortical or cancellous powder, cortical chips, monocortical or bicortical blocks, as a gel in combination with glycerol (Grafton/Osteotech), or in thin cortical sheets to be used as a membrane (Lambone/Pacific Coast Tissue Bank).

Table 8-2 Guided Tissue Regenerative Membranes (GTRMs)

Name	Material	Resorbable or Nonresorbable	Manufacturer	Advantages	Shortcomings
Gore-Tex	Expanded polytetrafluoroethylene (e-PTFE)	Nonresorbable	W.L. Gore & Associates	Proven track record Established good standard Available with titanium reinforcement variations	Nonresorbable, requires removal surgery Exposure results in inflammation possibly less favorable results
TefGen-FD	Nonexpanded PTFE	Nonresorbable	Lifecore Biomedical	Some clinical studies suggest primary closure not 100% necessary Nonporous surface inhibits bacterial colonization	Nonporous structure may result in increased exposure Nonresorbable
Regentex TXT-200/GBR-200	Nonexpanded PFTE	Nonresorbable	Osteogenics Biomedical	Some clinical studies suggest primary closure not 100% necessary Nonporous surface inhibits bacterial colonization	Nonporous structure may result in increased exposure Nonresorbable
Cytoplast Ti-250	Titanium reinforced				
Biobarrier	PFTE	Nonresorbable	Imtec	Resorbable	Somewhat technique sensitive
AlloDerm GBR	Acellular dermal matrix	Resorbable	Biohorizons	Primary closure not 100% necessary Enhanced soft tissue quality and esthetics	
Bio-Mend	Bovine type I collagen	Resorbable	Sulzer Calcitek	Resorbable	Difficult to manipulate when wet
Bio-Mend–Extend					
BioGwide	Porcine type I and type III collagen	Resorbable	Osteohealth (Approved by the FDA for use around implants)	Resorbable	Short track record
Vicryl mesh	Polyglactin 910 (9:1 ratio of polylactic acid to polyglycolic acid)	Resorbable	Ethicon	Resorbable Easy to position and place	Easily collapsible into defect
Resolute XT	Polyglycolide and Polylactide polymers	Resorbable	W.L. Gore & Associates	Resorbable Retains form once shaped	Stiff, difficult to bend and adapt
Ossix Plus	Porcine collagen	Resorbable	Orapharma	Resorbable Easy to position and place	Must be rehydrated in saline for 5-15 min
Atrisorb	Poly DL–lactide in N-methyl-2-pyrolidone	Resorbable	Block	Chairside fabrication Resorbable Mildly adherent to tooth	Short track record Learning curve Can be difficult to adapt
Lambone	Freeze-dried demineralized allogenic laminar bone sheets	Replaced by bone	Pacific Coast Tissue Bank	Replaced by bone Available in variable thickness	Must be rehydrated in saline for 5-30 min Thicker pieces more difficult to adapt May not be acceptable to patient
Capset	Calcium sulphate	Resorbable	LifeCore	Resorbable Custom adapted at time of placement Does not require bone tacks or suturing	Somewhat technique sensitive

GBR, Guided bone regeneration; *FDA*, U.S. Food and Drug Administration.

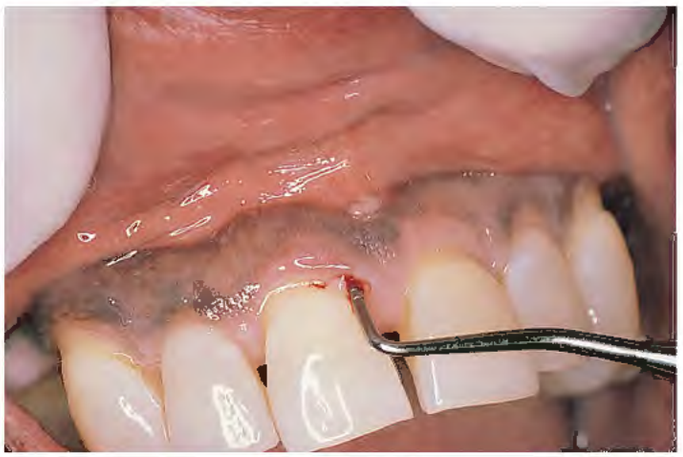


FIGURE 8-3. A thorough examination, including periodontal probing, is essential before surgical intervention.

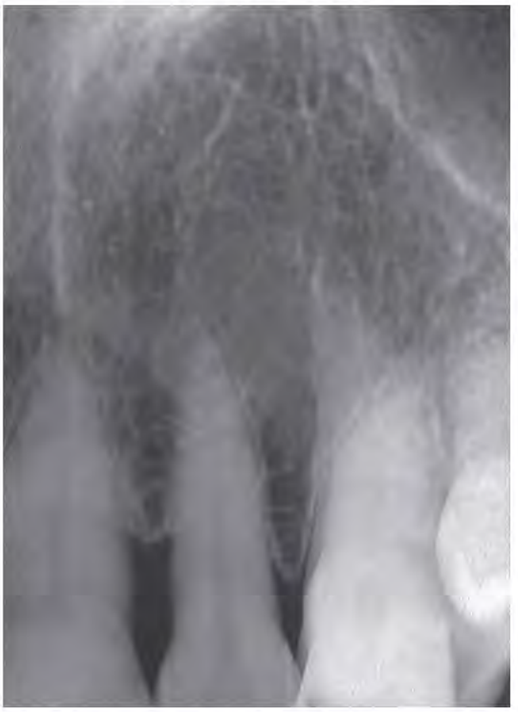


FIGURE 8-4. A radiographic survey should be done to further clarify the prognosis of the involved teeth.

Hemostasis must be achieved to ensure particle stabilization; however, slight bleeding is important, because blood is necessary for particulate incorporation and to encourage osseous repair. Active bleeding, on the other hand, often washes the new graft material away. Periodontal particulate graft material should be a fine grain size (40 mesh or 250 to 350 μm in diameter). When mixed with the patient's blood and allowed to remain in a dappen dish for 15 minutes, the material should take on a texture that allows easy handling. It clumps quite naturally and reliably remains in position. Of course, improper condensing, poor suturing, brisk bleeding, or incorrect operative design (e.g., defects without walls) may be responsible for a less-than-perfect result.

When the operative site is absolutely free of granulomas, plaque, and calculus, the graft material can be placed in the defect. It can be delivered with a nylon-tipped amalgam carrier; the old-fashioned, all-plastic, back-end plunger type, kept sterile and reserved for grafting use, is preferable.

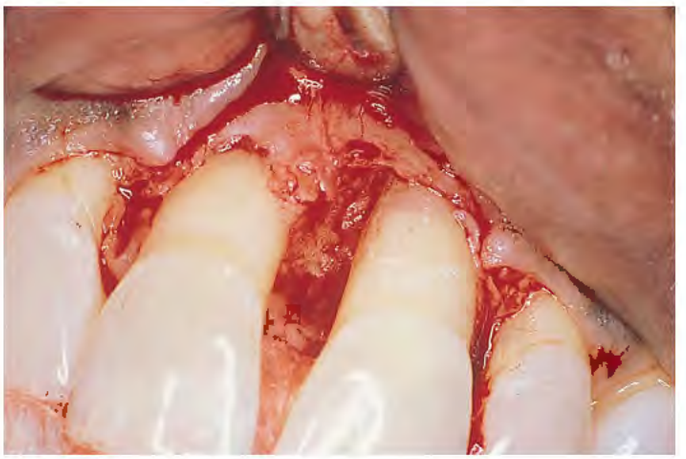


FIGURE 8-5. A full-thickness periodontal flap is planned so that at least one tooth anterior to the defect and one posterior to it are included. The base of the flap must be wider to establish an adequate vascular supply. A sharp, fine periosteal elevator allows careful flap management without tissue perforation.

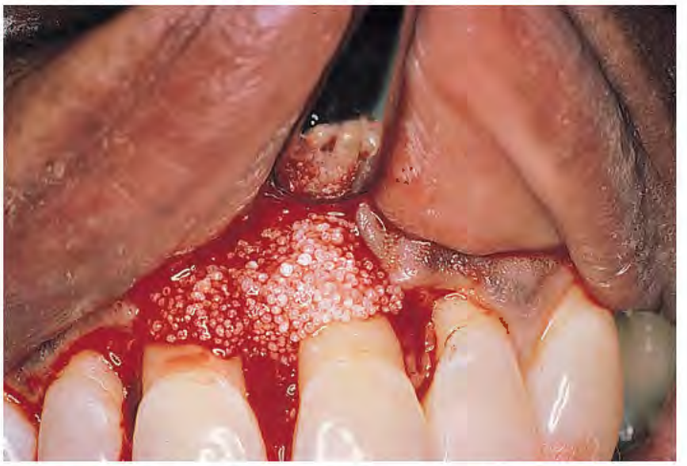


FIGURE 8-6. Before the graft material is placed, all granulomatous tissue is thoroughly debrided. The graft material then is placed so as to restore ideal anatomic contours. Proper condensation must be carried out to prevent particulate loss and soft tissue ingrowth.

After the graft material has been placed in the furcation or against one of several (at least two) remaining bony walls and tamped with a moistened cotton applicator, firm pressure is applied until fibrin becomes incorporated into and stabilizes the particles (Fig. 8-6). Suturing should follow, using 4-0 violet-dyed polyglactic acid or glycomer on a cutting needle (see Chapter 6). Watertight closures that replace each papilla accurately are mandatory to ensure particle fixation (Figs. 8-7 and 8-8).

When a bony peri-implant defect is adjacent to an edentulous area, classic wedging is performed. After a full-thickness flap has been reflected, the pocket and opposing implant surface are treated as described in the section on failing implants in Chapter 28. Then, a spatula osteotome, placed at the ridge crest and 3 to 4 mm from the lesion, is tapped gently with a mallet to a depth equal to that of the pocket. The osteotome is directed inferobliquely toward the failing implant. When the osteotome reaches the depth of the defect, it is used as a lever to mobilize the new triangle of bone. The wedge is pushed against the denuded implant surface and maintained in this position by pressing some nonresorbable, 40-mesh HA particles into the donor site that supplied the triangular graft.

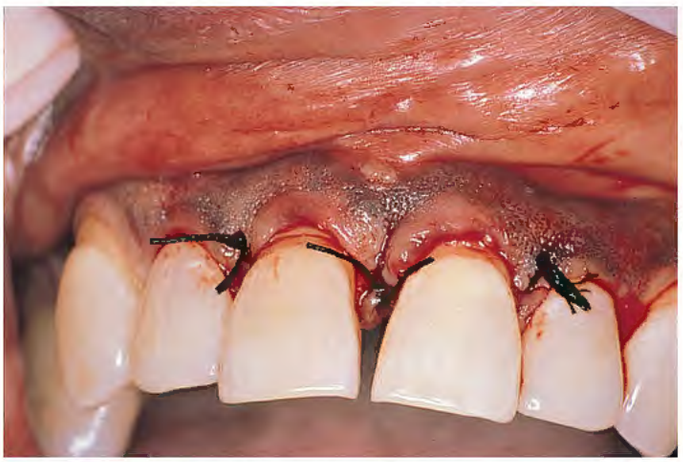


FIGURE 8-7. Primary closure is imperative for successful grafting results. A variety of suturing techniques may be needed to achieve this outcome.

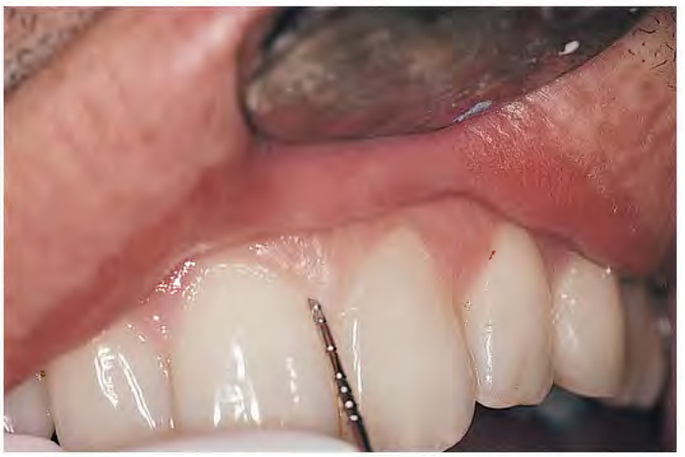


FIGURE 8-9. Periodontal probing can be done 3 months after surgery. These measurements are performed gently so that the newly formed attachment is not compromised.

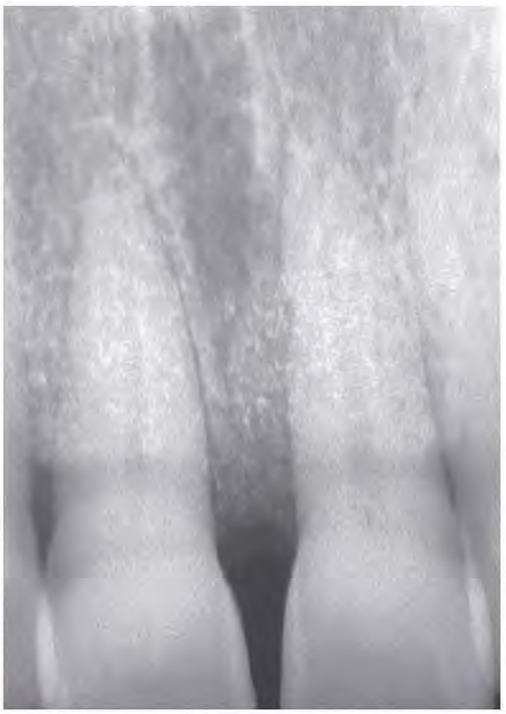


FIGURE 8-8. Immediate postoperative periapical radiographs should be taken using a standardized technique so that future assessments for comparison can be made.

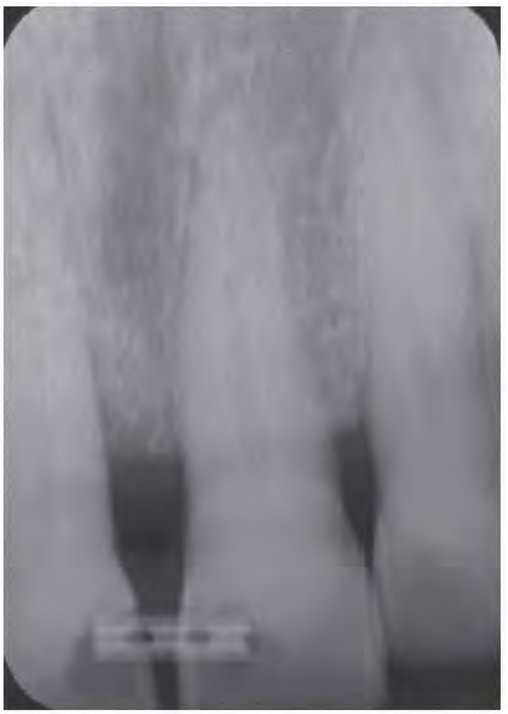


FIGURE 8-10. The radiographic examination is repeated at semi-annual recall visits. Changes in bone morphology should be noted and the exam results should be used in conjunction with other diagnostic tools to formulate long-term prognoses.

Simple closure completes the procedure. Pocket measurements should not be attempted for at least 3 months, and even after that, they should be attempted only with great care (Fig. 8-9).

If the patient's and practitioner's expectations are realistic, and the home and office care regimens meet the stringent requirements of most periodontal systems, the results can be quite pleasing (Fig. 8-10). If GTRMs are used, the grafting of peri-implant and other defects mentioned in this and other chapters becomes simpler and is more successful (see Table 8-2).

Use of Resorbable and Nonresorbable Guided Tissue Regeneration Membranes

The use of membranes to cover osseous repairs does not automatically ensure an improved prognosis. In fact, improper use may result in delayed healing, breakdown of the suture line, and a compromised operative site. A wide variety of membranes is available. Before selecting one, the surgeon must decide whether a particular choice would be beneficial.

Essentially, membranes are used in the following situations:

- Primary soft tissue closure is questionable.
- A void exists in the osseous operative site.
- A mucosal pedicle is required.
- The graft material is physically unstable.
- Additional bone height or width is required.

If the operated area presents no irregularities and closure can be accomplished without tension, membranes should not be used.

GTRMs may be applied with or without bone-grafting materials for perforations of the cortical plates, saucerization phenomena (Figs. 8-11 through 8-18), thin ridges, exposed implant cervical

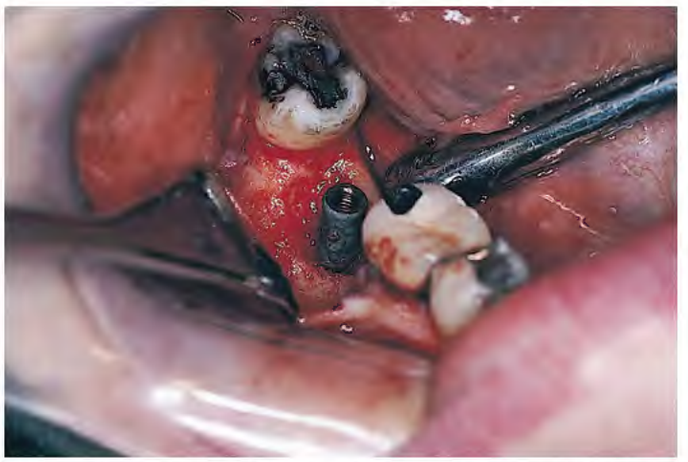


FIGURE 8-11. Guided tissue regenerative membranes (GTRMs) are valuable adjuncts to the correction of bony defects associated with the saucerization phenomena. Before the GTRM is placed, all soft tissue must be thoroughly curetted from the defect.

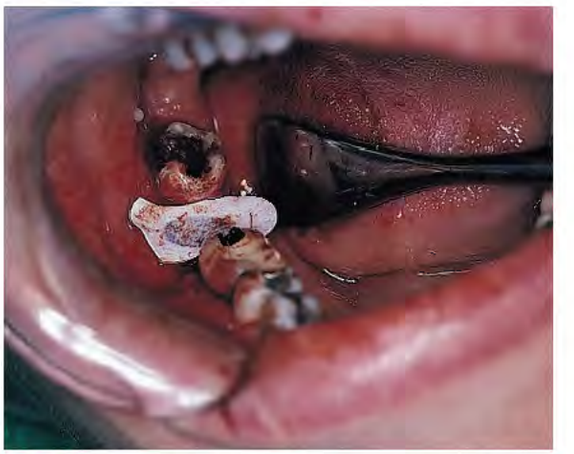


FIGURE 8-14. The GTRM is placed meticulously, and its periapical margins are fixed below the periosteum. If possible, the surgical healing screw of the implant should be used to stabilize the GTRM.

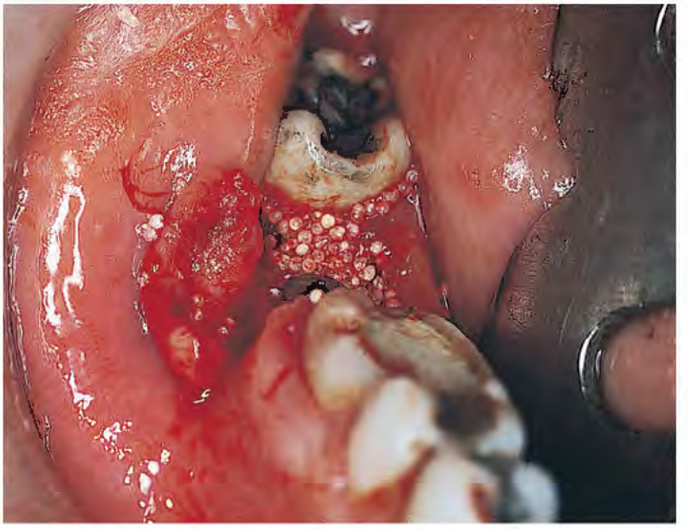


FIGURE 8-12. Before the membrane is placed, the selected bone grafting material is condensed firmly into the defect.

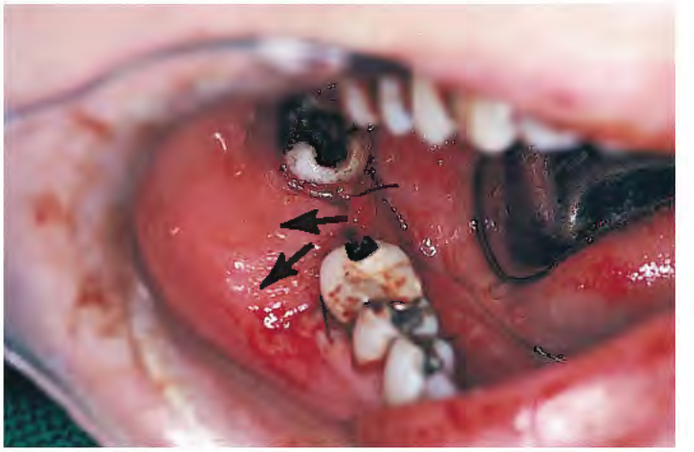


FIGURE 8-15. Primary closure is mandatory for the success of this procedure. If the GTRM is not covered completely, the consequences are exposure and a less positive prognosis. To achieve this closure, a buccal pedicle *(arrows)* had to be undermined from its buccinator bed to allow tension-free suturing.

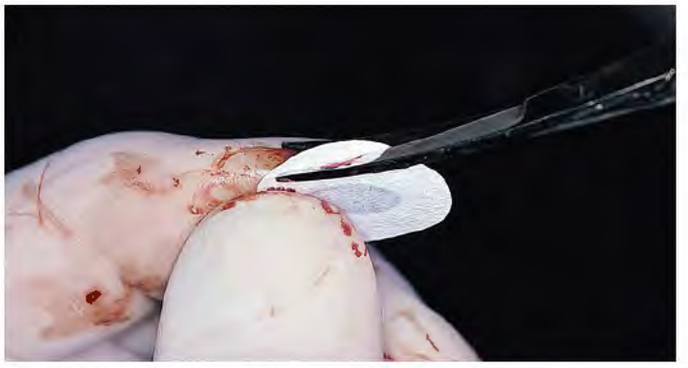


FIGURE 8-13. The membrane is tailored precisely to cover the osseous void fully and overlap the peripheral cortex by 3 mm.

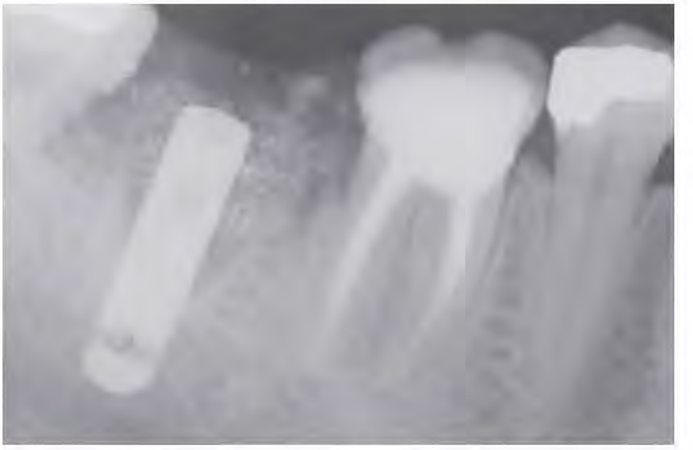


FIGURE 8-16. Although the GTRM is not radiopaque, a periapical radiograph should be taken to confirm the graft's position and stability.

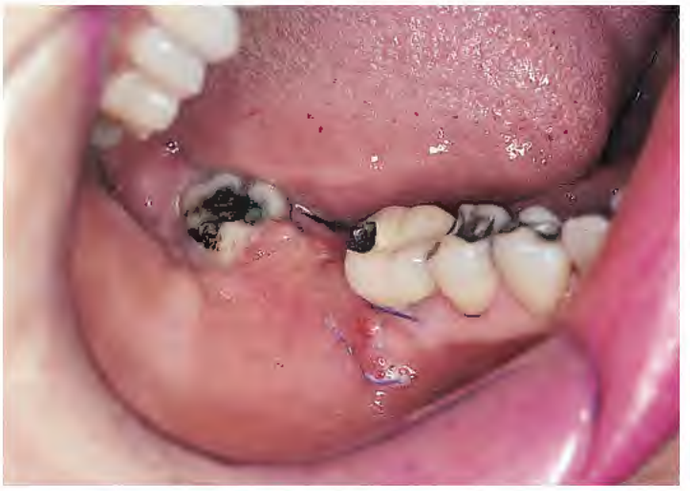


FIGURE 8-17. Evaluation at the 2-week postoperative visit shows that healing is proceeding by primary intention. The area is checked bimonthly until the membrane is removed.

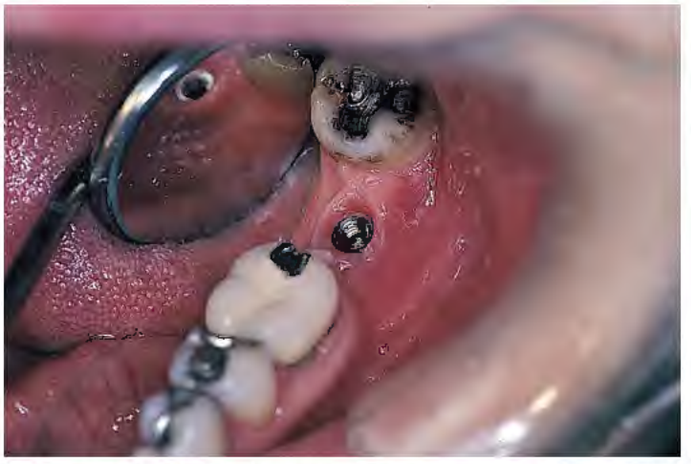


FIGURE 8-18. The site is re-entered to remove the GTRM. Satisfactory soft tissue healing with good lingual and buccal zones of fixed gingivae are seen 1 month after removal of the membrane.

areas, other intraosseous defects, voids that remain after implants have been placed in immediate extraction sites, and ridge maintenance after extractions with accompanying synthetic grafting materials.

Some membranes require rehydration, and others have a crystalline or granular composition; some are grossly porous, whereas others are microporous or nonporous.

The resorbable membranes generally are polymers that hydrolyze over time (usually about 40 days). A homologous resorbable membrane that serves as more than just a barrier is laminar bone, which is retrieved from human specimens and treated with demineralization and sterilization techniques.

The nonresorbable groups are synthesized. They most often consist of polytetrafluoroethylene (PTFE) or nonporous or microporous material. They may require primary soft tissue coverage (i.e., Gore-Tex), or they may be used without the wound flaps coming into direct contact, allowing the membrane to be exposed (i.e., TefGen or Cytoplast GBR 200). The surgeon must make the choice. The decision is influenced by the surgeon's familiarity with the product, its ease of use, the cost, compliance, and the desire to avoid a second or retrieval operation.

Membranes require reliable fixation. In most instances, undermining the surrounding mucosa and wedging the membrane periphery firmly beneath it satisfies this requirement. If this technique is not practicable, membrane tacks or miniscrews can be placed at strategic sites. Ordinarily, the device (membrane, slurry, or laminar bone) should fit intimately over the operative site. Its purpose is to discourage epithelial ingrowth, and an accurate adaptation helps prevent this. Tucks and alterations are made when indicated; these maneuvers are completed, and the ability to achieve primary flap closure is determined before the graft material is placed. If not performed in advance, membrane manipulations and flap undermining disturb the stability of particulate graft material. On completion of the operative procedure and graft placement, the precontoured membrane is slipped back into position, fastened and tucked as needed, and a primary closure is performed.

At sites that require dimensional enlargement, the guided tissue device must be "tented." This sometimes is a challenging procedure, particularly when a soft or compliant membrane is used. Contour corrections are most readily made with firmer devices, such as laminar bone or Gore-Tex with titanium reinforcement. Of course, a less stiff membrane is required when it is supported by underlying graft material.

To enable the GTRM to fulfill its function, which is promoting bone proliferation into a defect, a space equivalent to the area that needs filling must be left beneath the membrane. With saucerization defects and similar problems, this space occurs quite naturally, because the lesion's peripheral bone margins keep the membrane in a tented configuration. With cortical plate perforations, protruding implant apices or bodies, and knife-edge ridges, however, graft material must be used in block or particulate form, and the membrane is placed over it.

Before using any graft material, the surgeon must eliminate all residual infection, treat the implant appropriately (see Chapter 28), and make sure that adequate tissue is available for primary closure with mattress sutures.

Incisions should be crestal, not S-shaped or visor type, to protect the vascularity of the flaps.

After the site has been exposed adequately (4 to 5 mm of normal bone on all sides of the defect), a membrane of the closest proper size is selected, and sharp scissors are used to trim it to fit competently over the entire area. Sharp corners must be avoided, and a 3-mm overlap must be created to cover adjacent cortex. If a natural tooth exists adjacent to the operative region, its periodontal space is circumvented. The GTRM is tailored with precision. If space beneath the membrane is required, a selected bone-grafting material is chosen and firmly tamped into position, and the membrane is then implanted (Figs. 8-19 through 8-29). If a convex configuration is required, one or several nips and tucks are made to allow an additional dimension to be formed. Fibrin should be allowed to maintain it in its new shape before closure.

Fixation of the GTRM before wound closure is essential to the ultimate success of bone-generation procedures. The peripheral margins of the membrane may be wedged gently beneath the periosteum or even sutured with an absorbable material to the periosteum at strategic peripheral locations. Small fixation tacks are available from Steri-Oss, and in most maxillae, they can be forced into the bone with finger pressure. These sharp, titanium tacks are available in a set that includes an instrument that grasps a tack's head and carries it to the site where the membrane is to be stabilized. The mandible, which has a denser cortex, usually does not yield to the sharp point of the tack unless a preliminary bur hole starts the process (the bur is supplied in the kit), followed by a few light mallet

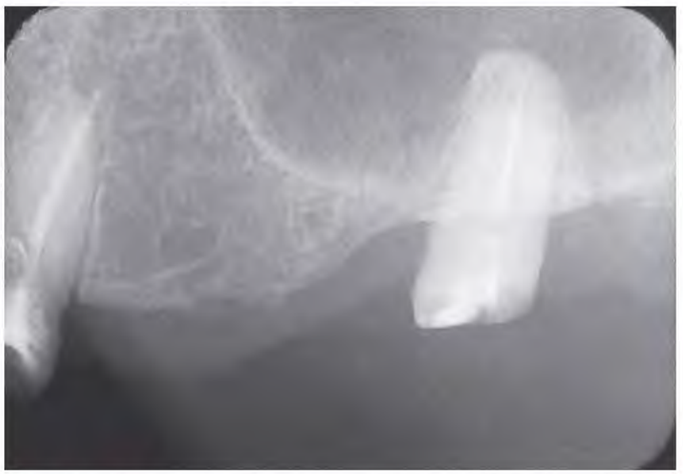


FIGURE 8-19. Preoperative radiographic assessments cannot determine the buccolingual dimension of the alveolar ridge.

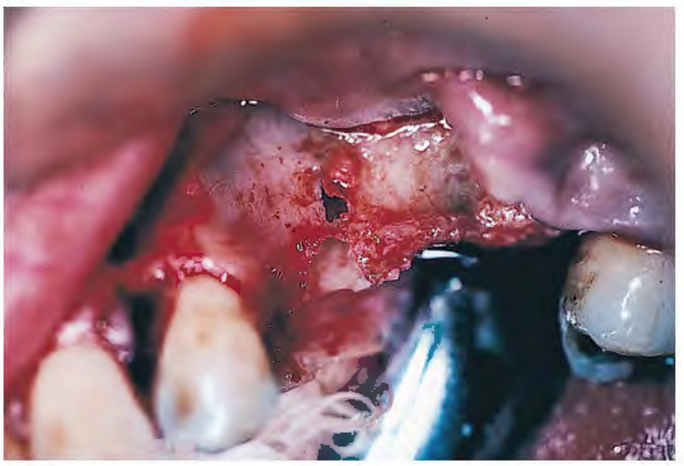


FIGURE 8-22. Preparation of the uncorrected implant host site may lead to buccal plate fenestration of the bone in narrow ridges, such as this one.

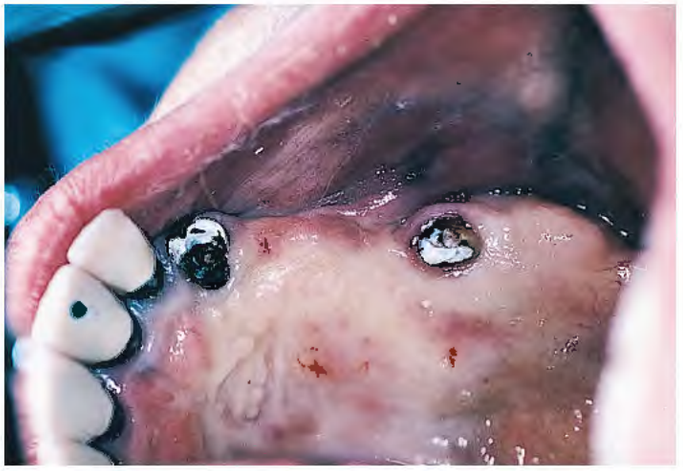


FIGURE 8-20. Clinical visual examination and bone sounding sometimes fail to define the osseous topography of the area.

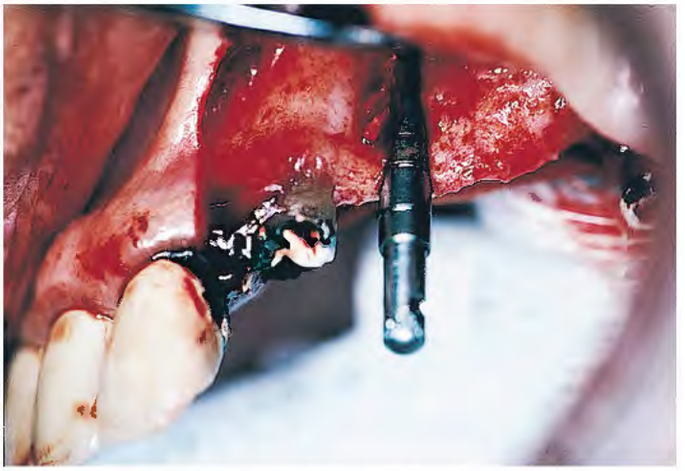


FIGURE 8-23. An implant body try-in helps determine the surface area of exposure of the planned implant. If the try-in device is unstable, grafting of the host site is required.

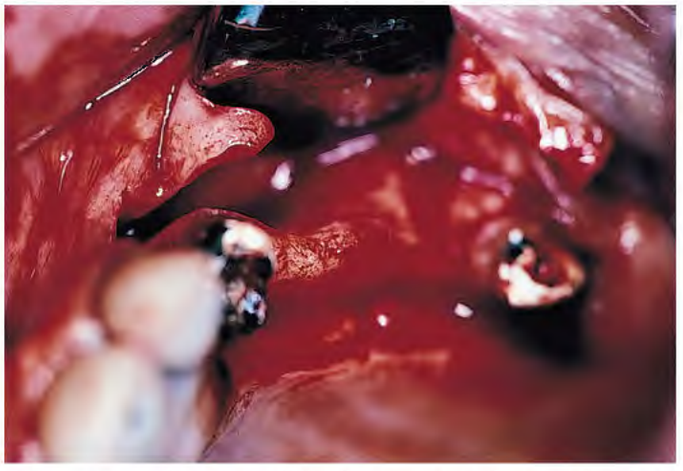


FIGURE 8-21. Reflection of the flap reveals an inadequate width of bone. This problem can be managed through bone grafting with a GTRM.

FIGURE 8-24. When positive retention can be achieved, the implant is placed. Its exposed surface is covered with a GTRM, with or without graft material, depending on the tenting capabilities.

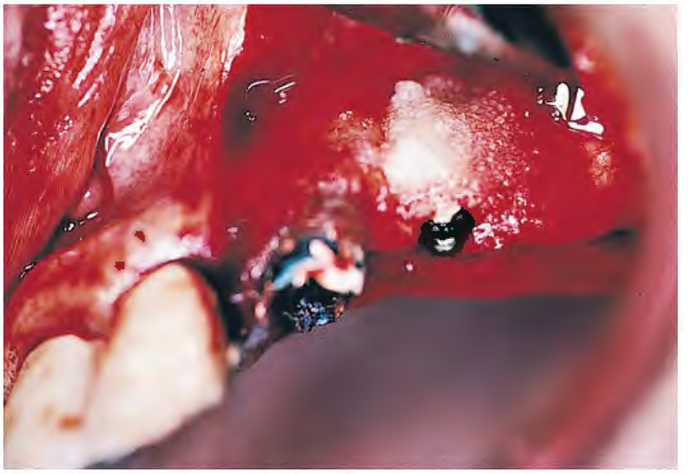


FIGURE 8-25. A space for bone ingrowth between the implant surface and the membrane is required. If this cannot be achieved by tenting with a firm GTRM (e.g., Lambone), a graft material should be selected to elevate the membrane away from the implant.

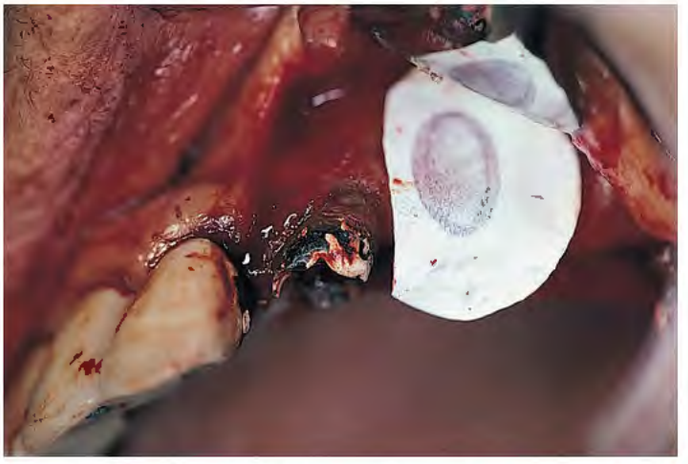


FIGURE 8-26. The GTRM is trimmed to overlay intact peripheral bony margins.

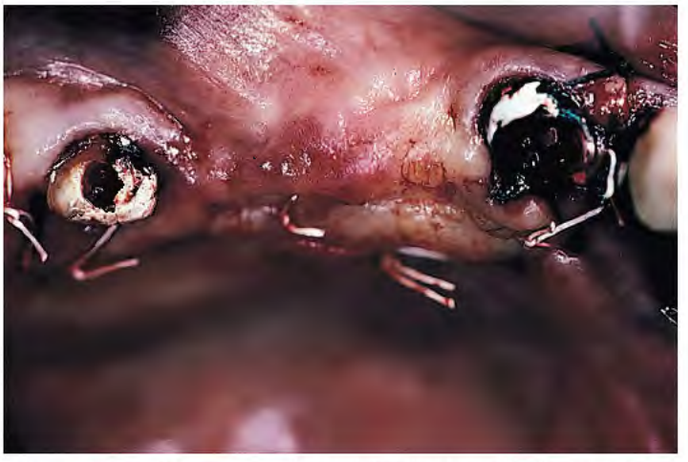


FIGURE 8-27. The mucoperiosteal flap is closed in the usual fashion. Polytetrafluoroethylene (PTFE) suture should be used, because it causes few adverse reactions.

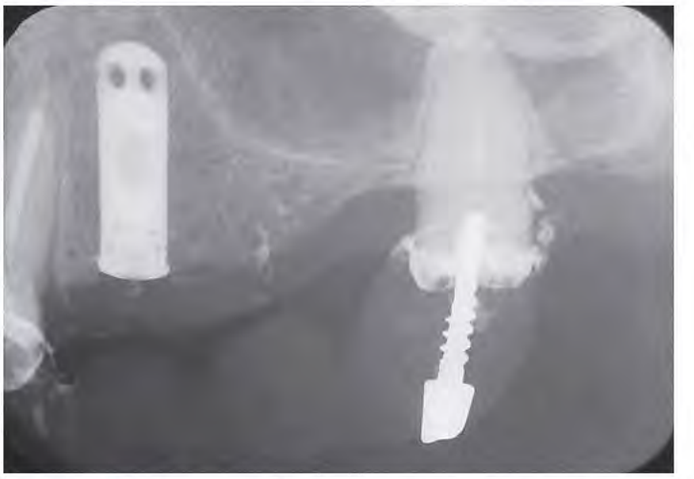


FIGURE 8-28. A postoperative radiograph shows proper implant placement and good osseous support.

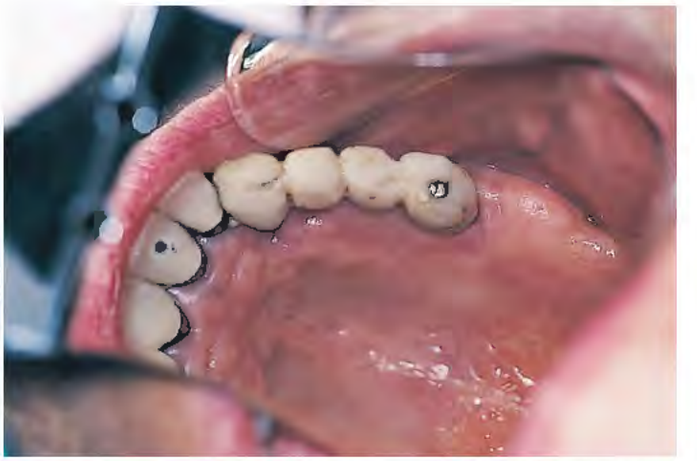


FIGURE 8-29. Two weeks after surgery, clinical healing has taken place without complication.

taps applied to the end of the seating instrument (Figs. 8-30 through 8-35). Additional tack and screw systems are supplied by Straumann, 3i, Ace Surgical, and others.

If the repair area is pericervical and the ailing implant has a healing screw, a hole is cut in the membrane with a diameter that is only large enough to allow entry of the threaded portion of the screw. After the graft material has been placed, the GTRM is positioned poncho fashion, and the cover screw is tightened to anchor it firmly (Figs. 8-36 and 8-37).

Closure is done with polyglactic sutures using the horizontal mattress technique. Care must be taken to ensure that the membrane does not become wrinkled, that it is firmly fixed, and that its rounded margins extend well beyond the defect on the cortical bone. The overlying flaps should not be sutured under tension (see chapters 6 and 7), and an absolute primary closure must be achieved (Figs. 8-38 through 8-42).

The sutures are removed after 7 to 10 days or allowed to resorb. If the selected membrane is nonresorbable, it can be removed at any time after 3 months. If allowed to remain longer, the intimate relationship of the overlying soft tissues to the membrane may make removal troublesome and threaten the integrity of the mucosa.

If the membrane becomes exposed because of a dehiscent suture line, the prognosis becomes less positive; however, the membrane's continued presence should be encouraged by gentle Peridex

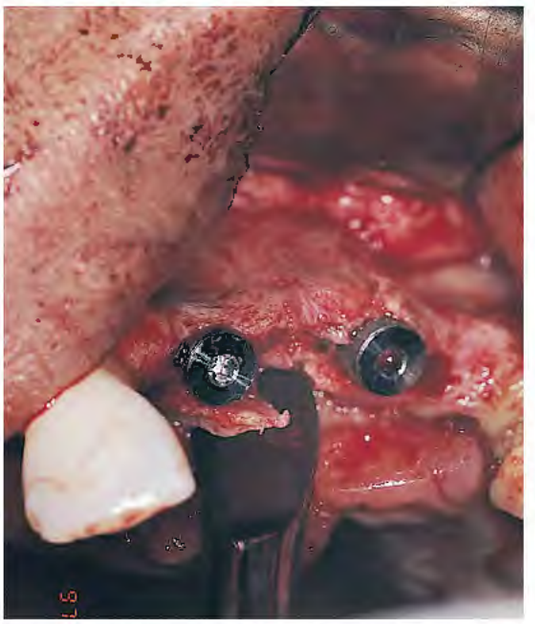


FIGURE 8-30. Two Paragon implants have been placed in this osteotomized split ridge. The adjacent defects between the implants require grafting.

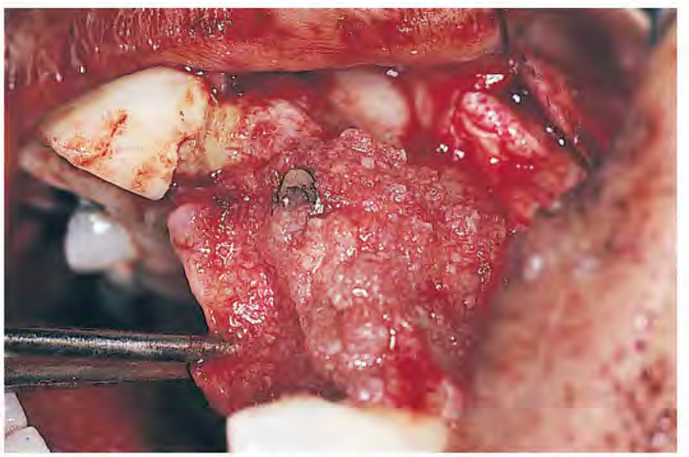


FIGURE 8-31. Generous amounts of the graft material (i.e., demineralized freeze-dried bone moistened and carried with the patient's blood) are placed over the entire operative site and tamped into the defects and osteotomy grooves adjacent to each implant.

irrigation and debridement. The patient should be taught to practice this on a daily basis between professional visits. Bone regeneration may take place successfully despite the wound's loss of integrity.

Ridge Maintenance

In most cases, maintaining the alveolar ridge morphology after dental extractions is a worthy preventive measure and may offer patients the ridge form, height, and shape that make denture fabrication simpler and more successful and fixed prosthesis pontic construction more realistic looking, hygienic, and comfortable. In addition, if implants are planned, larger and more generous host sites may be available in which to place them.

Maintenance procedures may be more immediately and tangibly valuable to a patient in two circumstances: after mandibular third molar extraction and after molar hemisection procedures. In the latter case, endodontic therapy must be performed on the planned

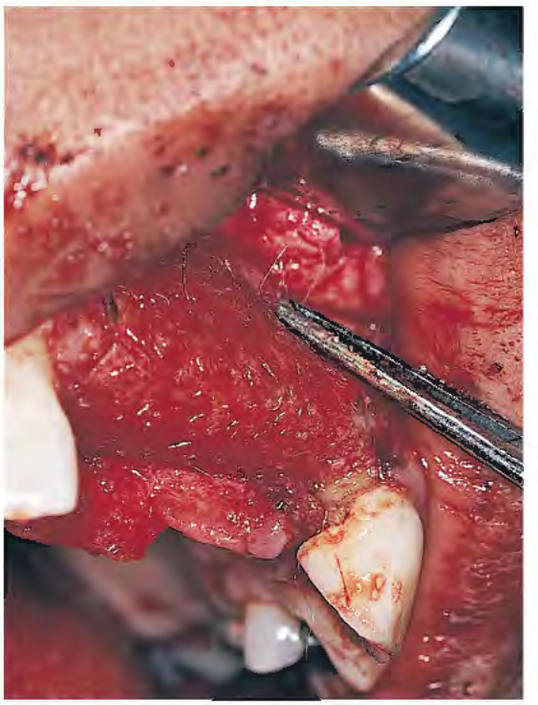


FIGURE 8-32. After contouring of the graft, a tailored, resorbable membrane, such as this Resolute design, is fitted over the site and extended to intact peripheral bone margins. The instrument shown here is being used to tuck the membrane beneath the adjacent soft tissue flaps.

FIGURE 8-33. The sharp-pointed membrane fixation tack in its delivery instrument.

residual root before sectioning. In both cases, grafting prevents the potential hazards of significant bone loss to adjacent teeth and spares a predictable array of periodontal complications. In each situation, the technique of placing particulate graft material and membrane at a deficit site is performed by completing the extraction with preservation of as much bone as possible. Sectioning molars makes this goal easier to achieve. The vacated sites are debrided thoroughly, all granulomas and epithelia are removed, and fresh bleeding is encouraged. The 20-mesh graft material (650 to 850 μm in diameter) is introduced by syringe or periosteal elevator and tamped firmly to eliminate spaces. Then, after overlapped bone is covered with a membrane, the procedure is completed with primary closure. If tissue is inadequate, interdigitation of facial and lingual papillae often solves the problem.

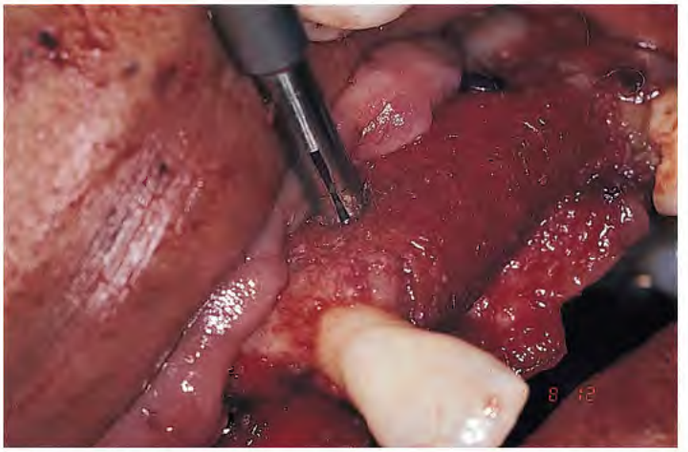


FIGURE 8-34. The delivery instrument applies pressure through the membrane into the underlying bone, forcing the tack into place.

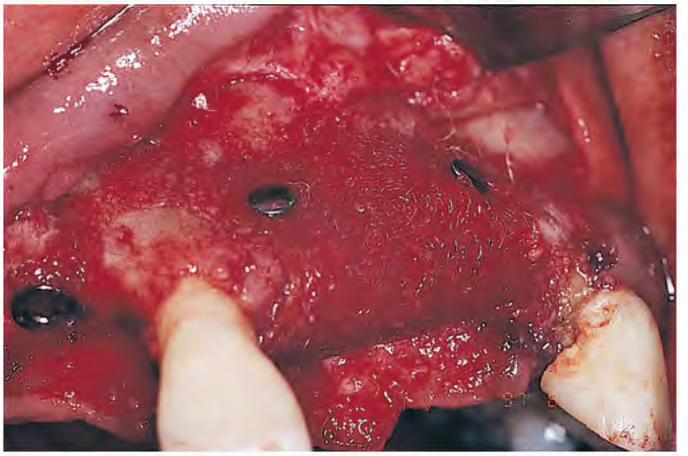


FIGURE 8-35. After the membrane has been fixed with tacks placed in strategic locations, suturing is performed.

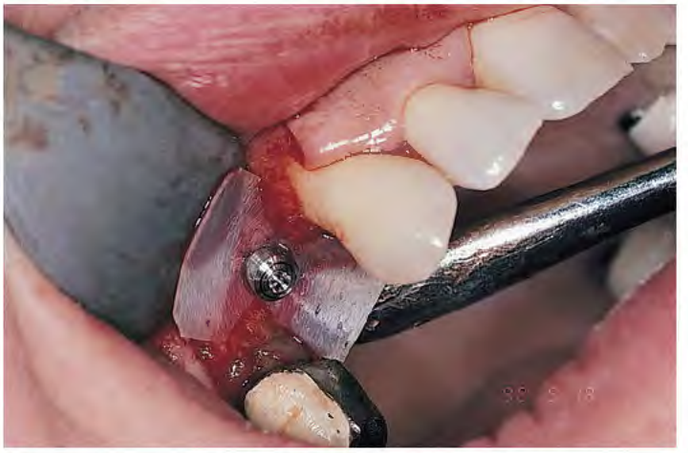


FIGURE 8-36. After hydration in saline, this laminar bone (Lambone) is shaped to fit over the implant host site. A hole is made to accommodate the healing screw, which stabilizes the Lambone when tightened.

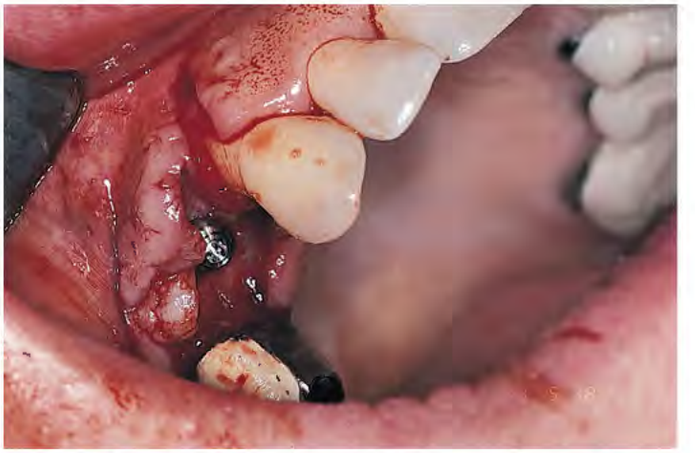


FIGURE 8-37. After the membrane (in this case, laminar bone) has been fastened firmly in place, the wound is sutured.

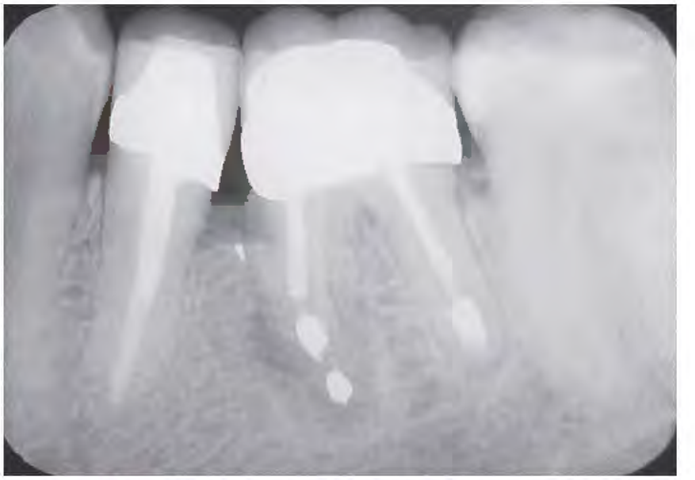


FIGURE 8-38. GTRMs are particularly helpful when used with immediate placement of implants into extraction sockets. Radiographic evaluation shows a planned extraction site.

FIGURE 8-39. The extraction is performed as atraumatically as possible to preserve the integrity of the buccal and lingual plates. The surgeon must make sure that no acute infection is present before inserting any implants. All soft tissue must be thoroughly debrided. Curettes are used judiciously to prevent any injury to vital anatomic structures. The implants then are placed, and the maximum amount of apical bone available is used to ensure their stability. The GTRM is laid over the implant in the classic manner, grafting materials are tamped peripherally, and the flap is closed.

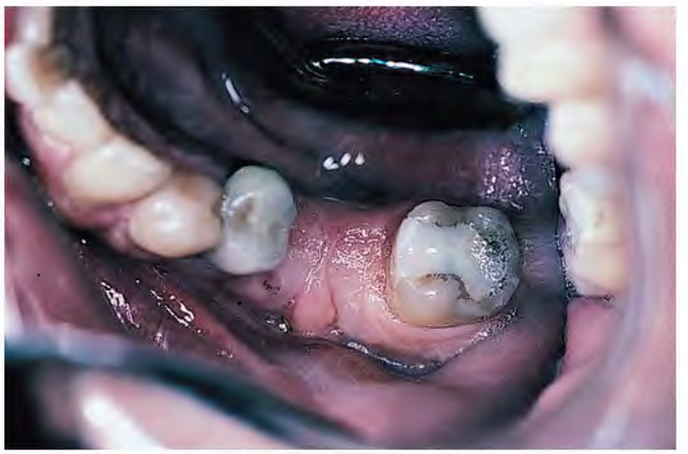


FIGURE 8-40. If the healing process is uneventful, the membrane is left in position until the second-stage surgery or until the membrane resorbs.

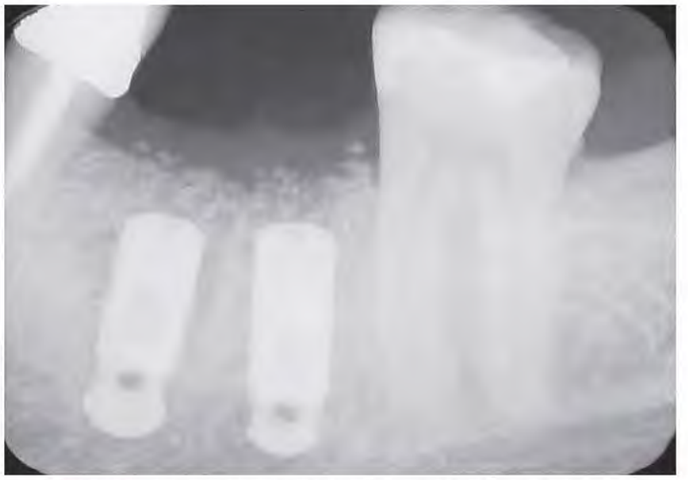


FIGURE 8-41. The grafting results appear satisfactory in a standardized radiograph. It is important to note that two implants should be used to replace molars whenever possible (see Chapter 22).

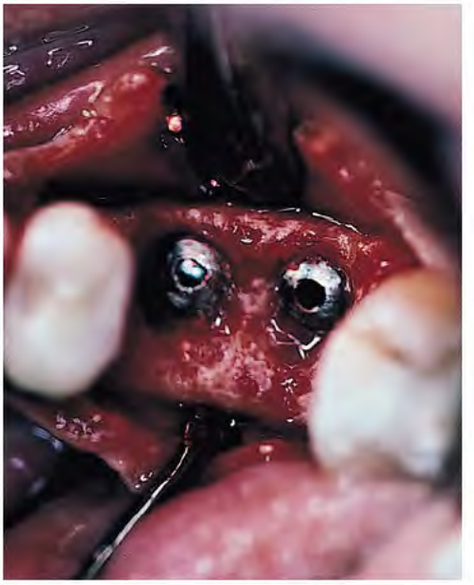


FIGURE 8-42. A scalpel blade and toothed forceps are used carefully to remove the nonresorbable GTRM by sharp dissection. Exuberant bone overlying the cover screw must be removed meticulously with a sharp operative chisel or small round bur.

Technique

Broad-based facial and lingual full-thickness crevicular incisions are made before tooth removal. The incisions should include whole papillae and produce well-vascularized flaps of generous dimensions. Mucoperiosteal reflection is done with great care down to but not beyond the vestibular level.

IMPORTANT NOTE

To avoid packing graft material into the antrum or mandibular canal, the surgeon should determine whether an opening has been made into one of these structures. (Chapter 28 presents the symptoms of antral or canal penetration.) If such a finding is confirmed, or even suspected, a piece of Colla-Cote or Colla-Plug is tailored to fit the defect and laid or tamped gently at its base with a saline-moistened plug of cotton. This serves as a protective dam, against which the particles can be placed. Bleeding must be controlled before implantation, or the graft material will be carried away. Tamponade is a sound maneuver for achieving hemostasis and stabilizing the fibrin-particulate slurry.

Next, the extractions, hemisections, or impaction removals are performed in the usual manner, with care taken to preserve as much of the bony socket as possible (Figs. 8-43 and 8-44).

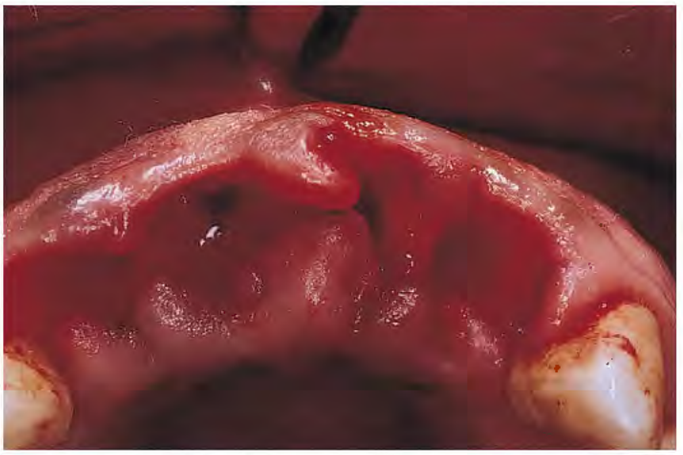


FIGURE 8-43. Existing bone is preserved through surgical extraction after full-thickness mucoperiosteal flaps have been elevated.

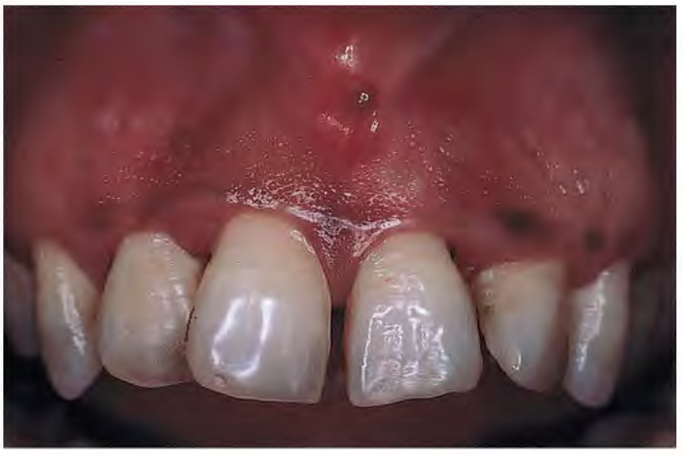


FIGURE 8-44. Removal of teeth that are severely periodontally involved often results in osseous defects caused by bone loss in both buccolingual and occlusocervical dimensions.

The operative sites are inspected carefully. All forms of follicles, cysts, and granulomas are eliminated by sharp dissection with a No. 12 or No. 15 blade (described in Chapter 6); this is followed by aggressive application of periodontal and surgical curettes.

When clean, bony beds are evident, the flaps' ability to close primarily over the entire operative site must be confirmed. If the flaps do not come together anatomically, an attempt should be made to slide the facial and lingual flaps one-quarter tooth in opposite directions from one another. This often allows the papillae to interdigitate into a sawtooth relationship. Bone is valuable and should not be removed to allow the flaps to close. The buccolingual plates are necessary for long-term maintenance of ridge width and height. The graft materials alone cannot supply the area with bone, nor will the achieved level result in a dimension greater than the highest level of bone. If all else fails, the surgeon must use the undermining technique to achieve primary closure (see Chapter 7). When primary coverage capabilities have been assured or created, the assistant should retract the flaps to allow irrigation, debridement, and hemostasis.

Depending on the size of the defect, a special syringe or amalgam carrier may be used to deliver the graft materials (Fig. 8-45). If the plan is to use a particle-loaded syringe, moisture is added to the material while it is still in the barrel. A nonvasoconstrictive local anesthetic solution, sterile saline, or the patient's blood can be used for this purpose. Blood derived from bone marrow appears to offer greater possibilities of osteogenesis than peripheral blood. In addition, it is easier and more convenient to aspirate blood with a 3-mL syringe (without a needle) from a bony wound than from a phlebotomy.

A simple method of moistening the graft material is to place the chosen diluent in a sterile dappen dish and add the particles of graft material. Then, an amalgam carrier or the blade of a periosteal elevator is used to carry the mixture to the host site, where it can be tamped firmly into the defect (Fig. 8-46). In an alternative method of wetting the particles, the plunger of the syringe with the graft particles is withdrawn almost to the breach of the barrel; then, while the syringe with the graft particles is held in one hand, the blood or fluid has been withdrawn and stored in a separate syringe, the blood or fluid then is injected with a fine needle that has been inserted directly into the syringe with the particles (Fig. 8-47).

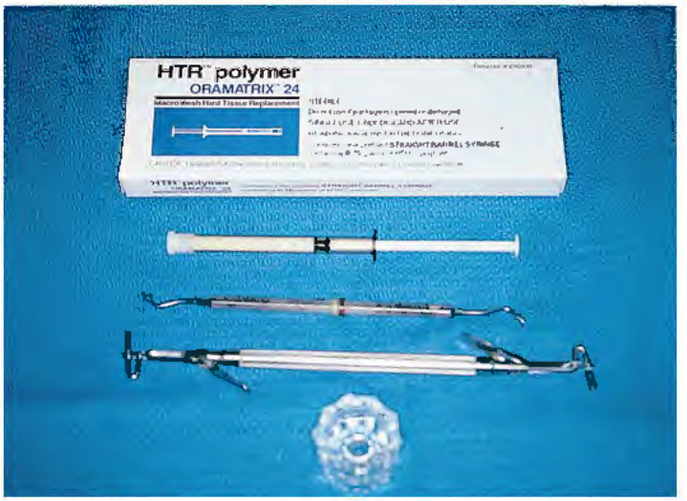


FIGURE 8-45. To deliver the bone substitute material into the fresh extraction sockets, the practitioner needs a sterile dappen dish, a Teflon-coated amalgam carrier, and a condenser. Alternatively, a syringe can be loaded to transfer the material to the socket.

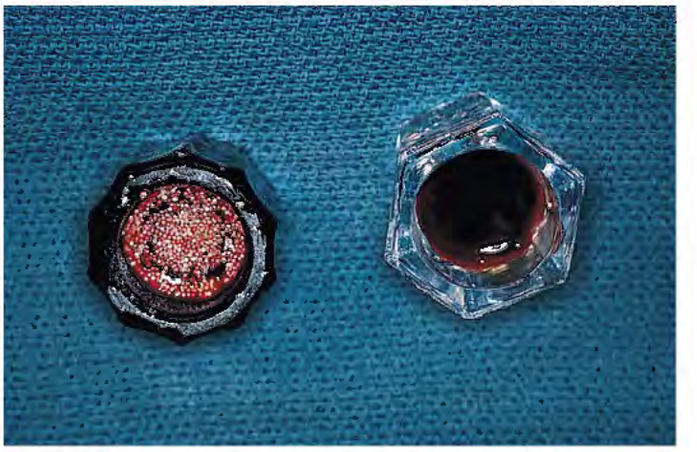


FIGURE 8-46. The patient's blood is drawn, preferably from an intraosseous site, and mixed with the graft material.

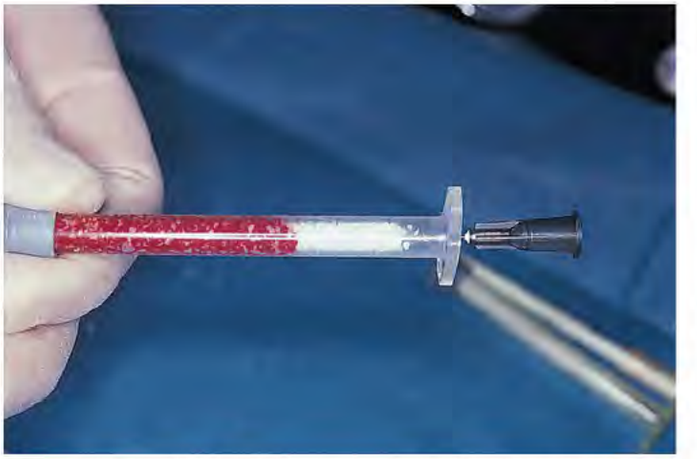


FIGURE 8-47. When a syringe is used, the blood can be injected into the barrel to inundate the graft material completely. The needle extending from the syringe serves as a vent.

The syringe or carrier remains untouched for 2 to 3 minutes. Then, gently but firmly, a slurry of particles is introduced into each well-controlled, well-visualized defect, to a level just to the highest point of bone. The particles are tamped with a moistened cotton applicator to condense them. The surgeon must confirm that blood has impregnated the entire mass. Closure is best accomplished with a continuous box-lock technique using 4-0 dyed polyglactic suture. Stable hemostasis is confirmed before the patient is dismissed (Fig. 8-48, *A* and *B*).

Also before the patient is dismissed, the surgeon should take well-oriented, long cone, standardized, reproducible radiographs, because a baseline must be established for future comparisons of particle retention and host site density and morphology.

Prosthodontic work should wait until at least 12 weeks have elapsed. If endosteal implants are to be placed in these ridges, 6 months are allowed for osseous maturation (Fig. 8-49). Also, if endosteal implants are planned for the grafted sites, nonresorbable HA cannot be used, because it prevents precise, effective drilling for implant placement. Instead, the surgeon should use a resorbable ceramic (TCP, osteogen), an allograft (DFDB), a xenograft (Bio-Oss), an alloplast (hard tissue replacement [HTR]) or, preferably, autogenous bone from a nearby tuberosity.

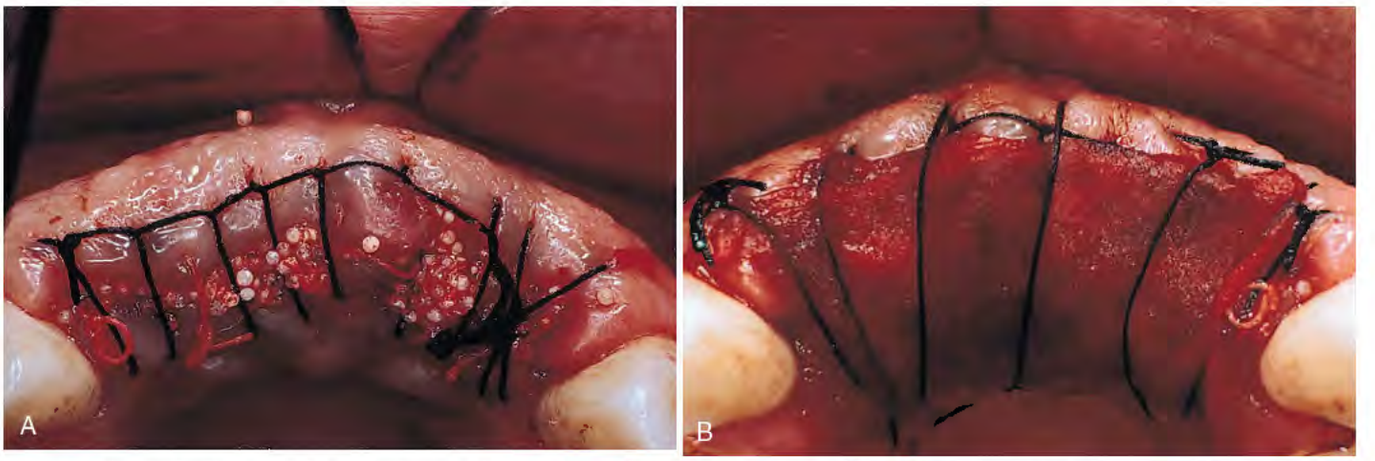


FIGURE 8-48. **A,** The bone replacement material is firmly condensed, and primary closure is attempted. **B,** If primary closure cannot be achieved, a collagen sheet is sutured over the graft.

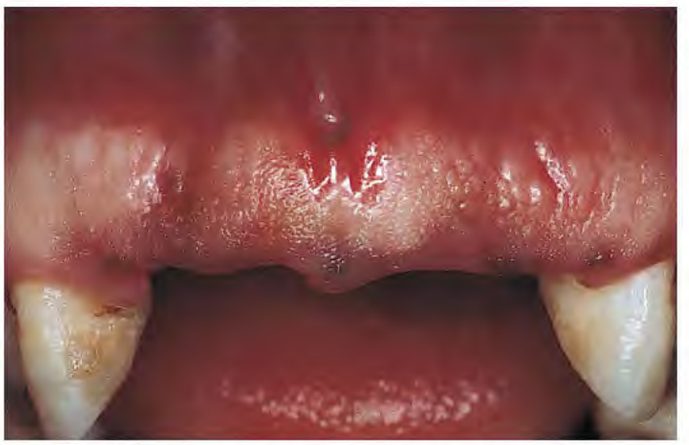


FIGURE 8-49. At 3 months after surgery, healing shows maintenance of the ridge morphology.

Ridge Augmentation

Even if a ridge has not been maintained with grafting materials at the time of extractions and is found to be resorbed, it can be augmented with a natural or synthetic biomaterial. Flat, atrophied, or knife-edged ridges can be treated with a variety of resorbable and nonbiodegradable materials (see Table 8-1). These materials are available in two forms, particulate (syringe loaded) and porous block. They can be inserted either by a "closed" technique (i.e., tunneling) or an "open" technique (incision, flap creation, and flap reflection). Each approach has its advocates, and both forms have their proponents.

From a surgical point of view, tunneling would seem to be less invasive and certainly faster. Fewer sutures are used and much shorter incisions are made, and closure is not done over or even near the implanted allograft. However, other factors may influence the selection of this surgical approach. If the mandibular canal appears to be dehiscent radiographically or the mental foramen is seen to be less than the width of the periosteal elevator blade from the ridge crest, the potential exists that tunneling will result in an iatrogenic neuropathy. In such cases, open procedures are safer, because vital structures can be seen and avoided.

Tunneling Technique

The following steps are used if a closed procedure is chosen for the mandible.

1. Infiltration, not block, anesthesia is used.
2. If the ridge is high but knife edged and the mentomandibular bundles are well below the crest and encased in canals, a vertical incision is made in the labial gingiva of each canine area from crest to vestibule (Fig. 8-50). The dimensions of the incision must be sufficient to admit the wide end of the periosteal elevator and the muzzle of a delivery syringe or an augmentative block.
3. The elevator is inserted beneath the periosteum using the palm-thumb grasp, with the palm upward, and it is slid beneath the periosteum over the defective portion of the ridge. Enough room must be available above the mental bundle to allow continuous passage of the elevator blade all the way back to the retromolar pad. After this has been done on both sides, the right or left incision is re-entered and tunneled anteriorly until the elevator blade protrudes from the opposing incision. In this way, one anterior and two posterior tunnels have been created (Fig. 8-51).
4. Each of the three tunnels is elevated with a Gerald forceps or silk retracting suture as if the mucoperiosteum were a tent. The

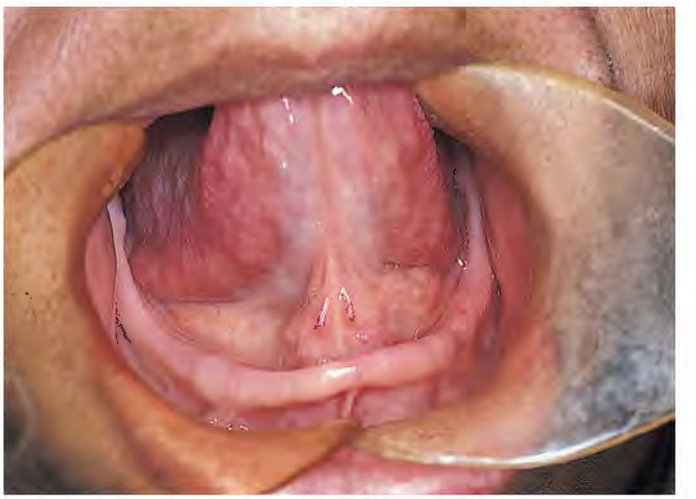


FIGURE 8-50. Edentulous ridges often require augmentation. They may be atrophied or, as in this patient, may require the correction of undercuts.

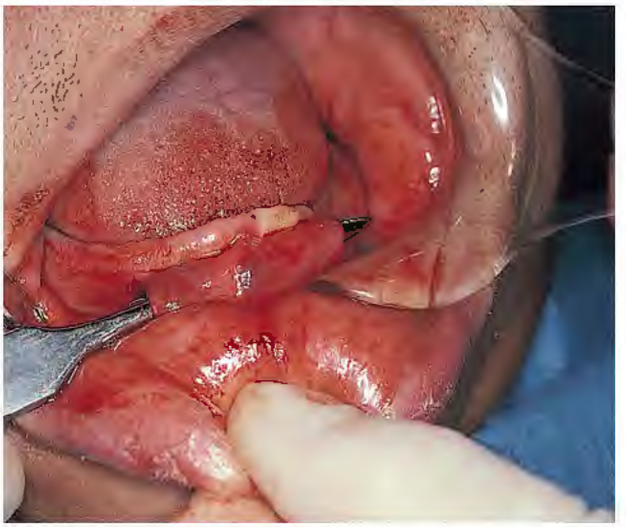


FIGURE 8-51. Many ridge augmentation procedures can be performed by elevating the mucoperiosteum through several strategically placed, small, vertical incisions, a technique called *tunneling*. Each tunnel is created by passing the elevator beneath the periosteum in the area to be augmented.

surgeon then assesses whether sufficient dimensions exist for an adequately augmented ridge shape. If not, the tissues at the vestibular level may need to be detached, and a subsequent secondary vestibuloplasty will be required using free or pedicle natural or reconstituted (AlloDerm) mucosal grafting (see Chapter 7 for further instructions on these procedures).

5. If the ridge is knife edged, elevation labially and buccally must allow for lateral augmentation. If the mental foramina are near the ridge crest but tunneling, nevertheless, is the procedure of choice, two incisions, each distal to the foramen, are required. A third incision is made in the anterior midline. Tunneling can be carried out posteriorly to the retromolar pads from each lateral incision, and the anterior tunnel can be started in the midline and carried to the right and left sides up to, but not including, the mental areas. If this second technique is selected, the areas just over the foramina remain unaugmented.
6. The decision to use a block or particles requires analysis. Blocks are valuable because they can be easily placed and their shape does not change, whereas particles have a tendency to drift, migrate, and settle. Several kinds of porous blocks are available. Permanently rigid ones are available in the replaminaform (coraline) design. Rigid blocks that become compliant after implantation because of their dehydrated collagen matrices also may be used. Blocks consisting of HA beads strung together with polyglycolic acid threads (Ceramed) may be chosen. These blocks consist of HA particles bound together with a collagen floss that becomes hydrolyzed by body fluids (or water); as it softens, it releases the HA particles, allowing blood to infiltrate. Upon completion of that process, wound organization is well advanced.

Rigid blocks are soaked in a mixture of the patient's blood and an aqueous antibiotic solution (e.g., 80 mg of gentamicin in 10 mL of sterile saline) for 20 minutes before implantation. The collagen vehicle cannot be treated in this fashion, because it allows the block to become soft before insertion, which impedes placement.

The major disadvantage of rigid porous blocks is that if dehiscence occurs and causes exposure of even the tiniest portion of the block's surface, the chance of preserving the block or even a part of it is lost. No matter how aggressively surgical efforts are made to salvage a dehiscent porous block, they will fail. Exposure requires removal of the block.

Autogenous bone blocks from the ribs or iliac crest or precut DFDB slivers or wedges from the Pacific Coast Bone Laboratory offer the best chances for success.

7. Once a decision has been made regarding the material to be used and its form, the implantation is performed.
8. If the particulate form of graft material has been chosen, the tunnel opening is elevated and retained with a suture or toothed Gerald or Adson forceps. After the particles have been moistened (and the breech cap, if present, has been removed), the barrel of the syringe is inserted into the tunnel to its most distal extent (Fig. 8-52). The plunger is stabilized with the opposite hand as the barrel is withdrawn; this allows extrusion of a smooth, symmetric, blood-soaked, cylindric slurry of particles, which is deposited in the center of the tunnel. Care must be taken not to make the tunnel larger than the minimal size required to accommodate the syringe or to allow it to penetrate beyond the vestibular attachment. Impeccably made tunnels determine the stability of the particles after implantation and, ultimately, the success of the graft (Figs. 8-53 and 8-54).
9. If a block is planned, the lip of the tunnel is retracted. A rongeur forceps is used to trim the block to the correct size (Fig. 8-55). Blocks may not be ground or adjusted with rotary instruments, because grinding clogs the surface pores. The surgeon slides the block into place by pushing it gently with a cotton-tipped applicator, and it is maneuvered into position using the thumb and forefinger on the overlying tissues (Figs. 8-56 through 8-58).
10. The augmentations in the two other tunnels are completed, and the incisions are closed with a few 4-0 polyglactic interrupted sutures (Fig. 8-59). A panoramic radiograph is taken so that the positions of the blocks can be evaluated.
11. Fixation of the particles or blocks is a valuable adjunct to implantation. If the patient has a denture, its saddle is reamed aggressively, and it is relined with a tissue conditioner (e.g., Coe-Comfort or Viscogel). After the denture flanges have been trimmed and polished, the denture is stabilized with circummandibular or circumzygomatic ligation (discussed later in the chapter); this keeps the blocks or particles in position.
12. The patient is prescribed a puréed diet. The opposing denture should be removed whenever possible, and a week of antibiotic therapy should be started.

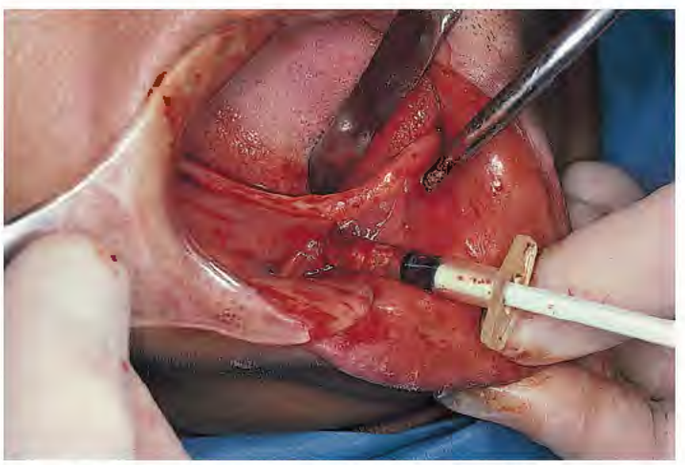


FIGURE 8-52. When particulate grafting material (often supplied in syringes) is to be used for the enhancement, the syringe is inserted into the full depth of the tunnel, and the material is expressed evenly into the undercut areas or at the ridge crest.

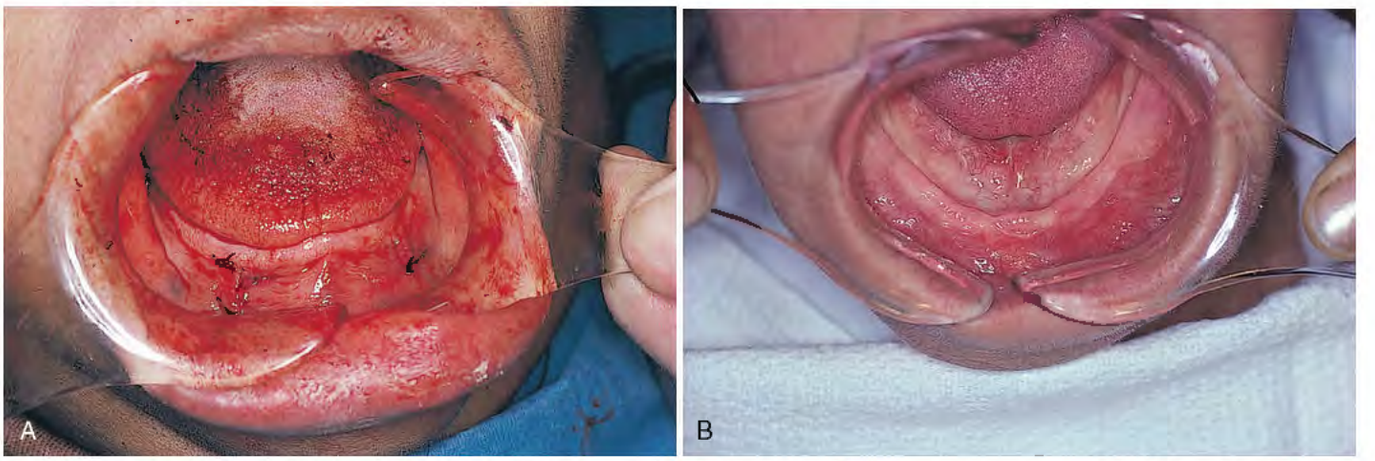


FIGURE 8-53. **A,** After deposition of the graft material, each small incision is closed with several simple sutures. **B,** After healing, the ridge shows an improved morphology.

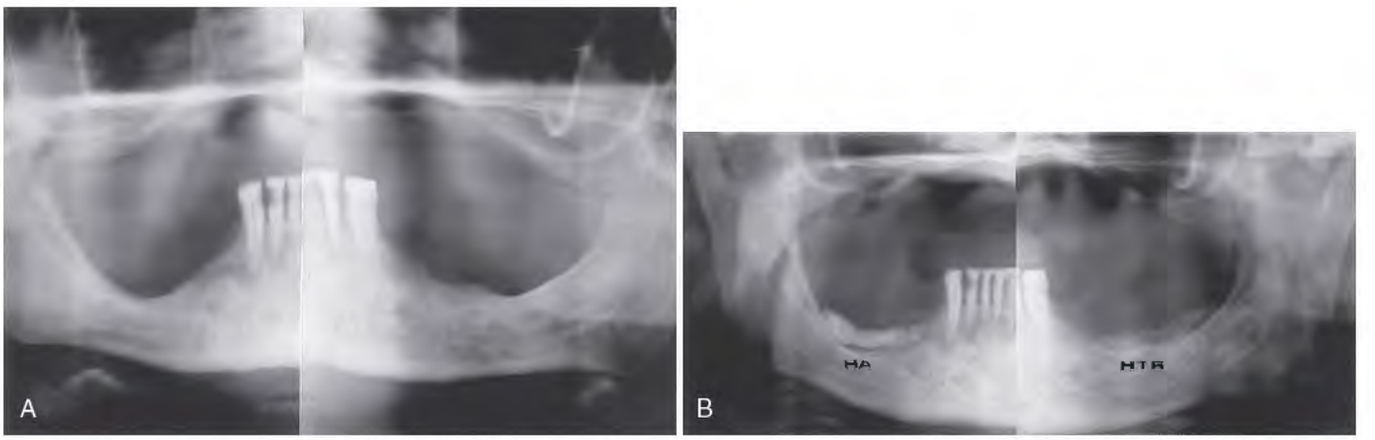


FIGURE 8-54. **A,** The preoperative radiograph of this mandible with posterior ridge atrophy shows a significant need for augmentation. **B,** The ridges are augmented by tunneling, and two different but equally effective grafting materials are used. The difference in radiodensity does not reflect their stability or competence.

FIGURE 8-55. The block is a more reliable form of synthetic bone material for augmentation. It is less likely to migrate, and portions of it will not be lost. However, if it becomes dehiscent, the entire graft will be lost.

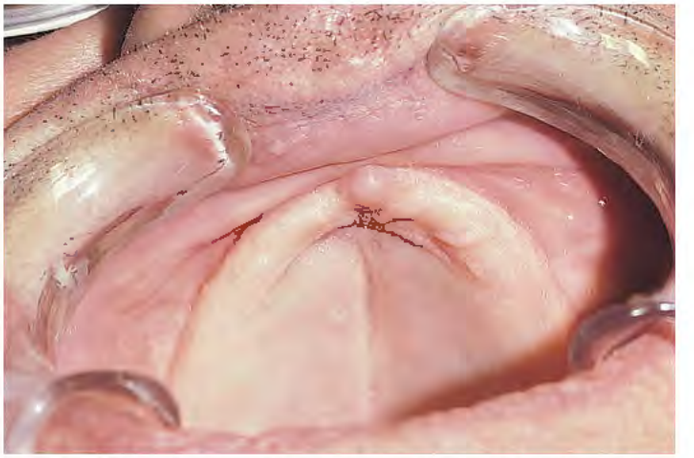


FIGURE 8-56. These maxillae are severely atrophied. The palate is flat, and the tuberosities are nonexistent.

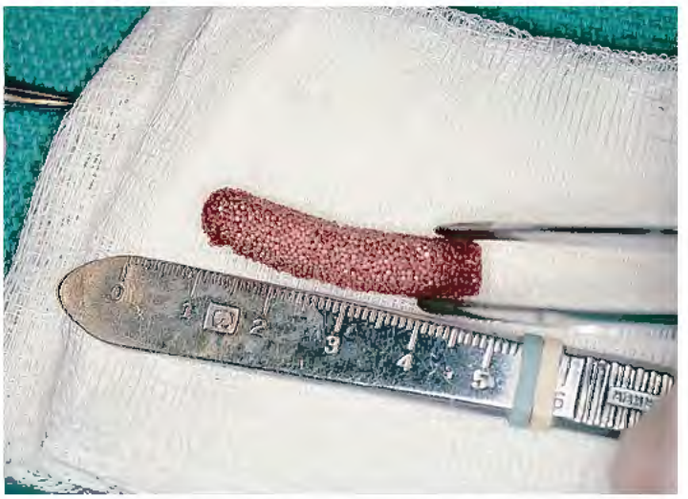


FIGURE 8-57. Porous blocks are soaked in the patient's blood and a soluble antibiotic solution (gentamycin) before they are inserted.

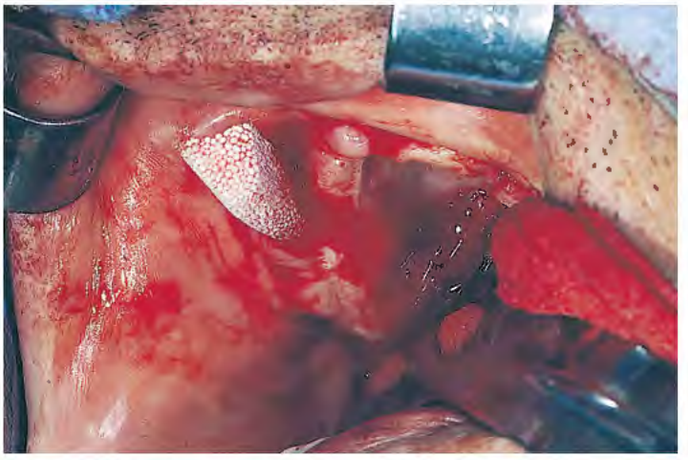


FIGURE 8-58. Tunneling is the most appropriate technique for block placement. After the block is removed from the solution, it is inserted into the tunnel and gently advanced to its position of repose. Simple suturing closes the small vertical incisions.

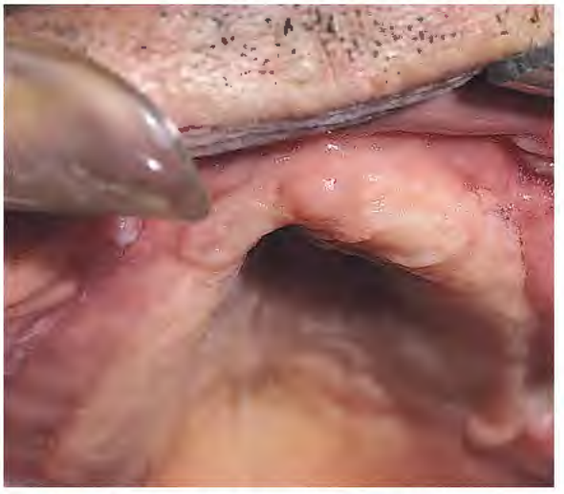


FIGURE 8-59. Postoperatively, the ridge morphology is changed significantly as a result of porous block augmentation.

Maxillary augmentation is somewhat easier, because the tissues are thicker, and no significant foramina or vital structures pose problems.

Open Techniques

Flap

If the flap technique is chosen for ridge augmentation, the procedure is as follows.

1. An incision is made at the crest of the ridge in the linea alba.
2. The flap is reflected, and the graft materials are placed directly against the bone. The mental neurovascular bundle is circumvented, and attempts are made to keep the particulate graft material in integrated form by allowing the patient's blood to clot within it before suturing. The fibrin acts as a preliminary cementing medium.
3. In open procedures, the operating team must be prepared to retain the grafted particles with a splint. The splint is made in advance to a projected ridge shape by rebuilding the ridge on a study cast with wax and then using the augmented model to fabricate a clear acrylic template. The flaps are closed, and the clear plastic splint is seated to make sure it does not cause any blanching. If this criterion has been met, the flaps are closed with a horizontal mattress suture (see Chapter 6).
4. Undermining is performed when necessary to allow a tension-free flap relationship. The splint, with significantly shortened flanges, is fixed to the mandible or maxilla with No. 2 stainless steel, monofilament, ligature wire as described in this chapter. The splint is kept in place for at least 3 weeks.

Blocks

If block augmentation is to be performed by an open surgical procedure, the steps are as follows.

1. The tissues are incised and reflected.
2. A rongeur forceps is used to adapt the blocks to the residual ridge, and they are placed in position (Figs. 8-60 through 8-62).
3. Suturing is performed and, if necessary, so is ligation with a prefabricated splint (see the earlier discussion of particulate graft material) (Figs. 8-63 and 8-64).
4. If an HA-collagen block is used, it is not trimmed, because it adapts itself to the bone's morphology as it becomes hydrated with body fluids.
5. The pressure from an overlying fixation splint may flatten an HA-collagen block, therefore a splint is not used. When splints are indicated, 3 weeks of fixation protects the grafts and offers greater possibilities for their adhesion to the underlying bone. Both root form and blade implants are placed in such sites after 6 months of maturation, but only if a graft material has been used that allows preparation of an osteotomy (e.g., DFDB, autogenous bone) (Fig. 8-65).

Maxillofacial Reconstruction

Lesions and defects of the facial soft and hard tissues can be managed with bone-grafting materials. However, certain exclusion criteria apply:

- Any acute or chronic infectious process at or near the intended implant site
- Severe cardiovascular, respiratory, endocrine, renal, hepatic, or collagen disease that contraindicates elective surgery or anesthesia
- Uncontrollable diabetes mellitus
- Progressive, severe, or malignant blood dyscrasias

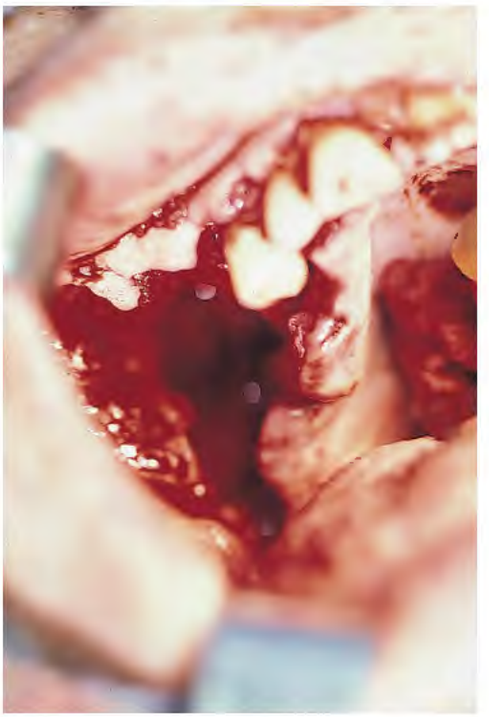


FIGURE 8-60. Blocks may be used to reconstruct major jaw defects. In this case, a recurrent ameloblastoma was responsible for a hemimaxillectomy. The resultant discontinuity was significant.

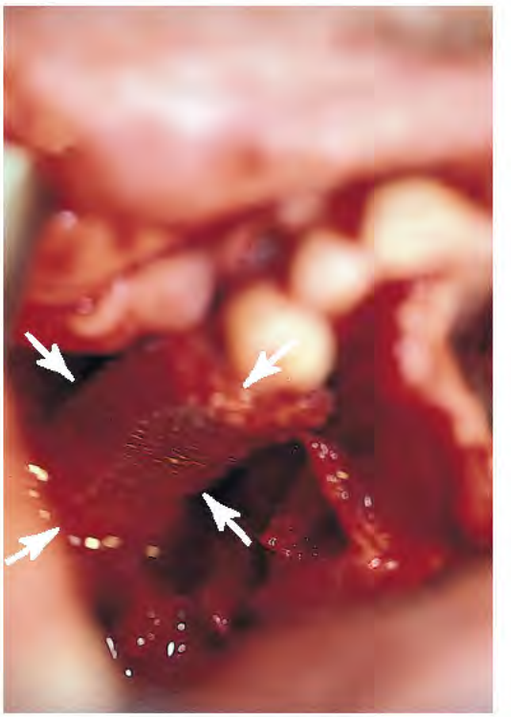


FIGURE 8-62. The porous block *(arrows)*, if sized properly, is self-retained by wedging it between the alveolus of the canine and the anterior surface of the pterygoid plates.

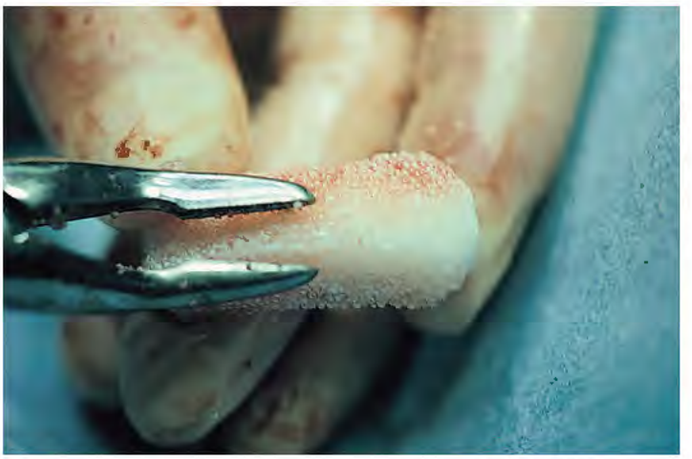


FIGURE 8-61. Rongeur forceps are used to trim a hard tissue replacement (HTR) polymeric block to fit the defect.

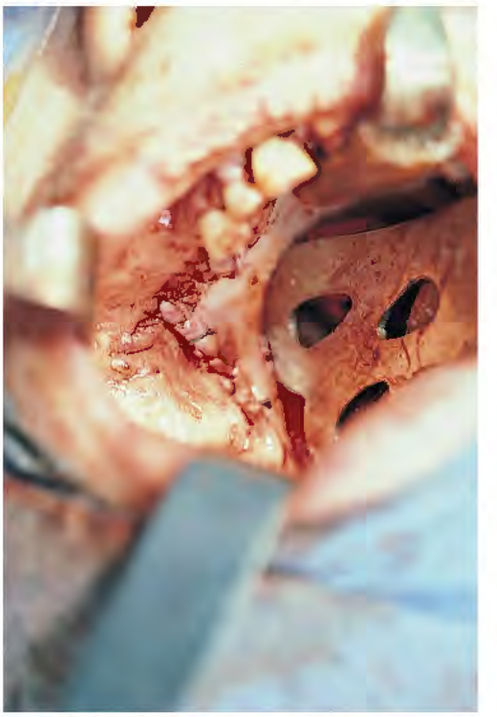


FIGURE 8-63. Undermining to create a primary closure with well-vascularized pedicle grafts completes the reconstruction.

- A malignancy with an associated short life expectancy
- Uncontrollable hypertension
- Any disease causing marked demineralization of bone (e.g., severe osteoporosis, hyperparathyroidism, multiple myeloma. sarcoidosis, Paget's disease, or vitamin D deficiency or intoxication)
- Patients receiving or who recently have received radiation therapy to the areas to be treated
- Immunologically suppressed individuals
- Hypersensitivity to all antibiotics
- A documented history of mental incompetence or deficiency
- Anticipated patient nonavailability for regular follow-up procedures and evaluations

Workups should include preoperative panoramic and periapical radiographs and photographs, medical and dental evaluations, photographs, and study casts. Surgical procedures should involve careful flap design, thorough curettage, proper creation of well-vascularized host sites, preparation and stabilization of the graft material, and impeccable primary closure.

Implanted grafts in either particulate or block form are used as plumpers for cosmetic purposes or in bony defects to serve as scaffolds to encourage new bone growth. The block forms are used as cosmetic prostheses for genioplasty and malar prominence matrices and to solve problems caused by large fistulas and continuity defects.

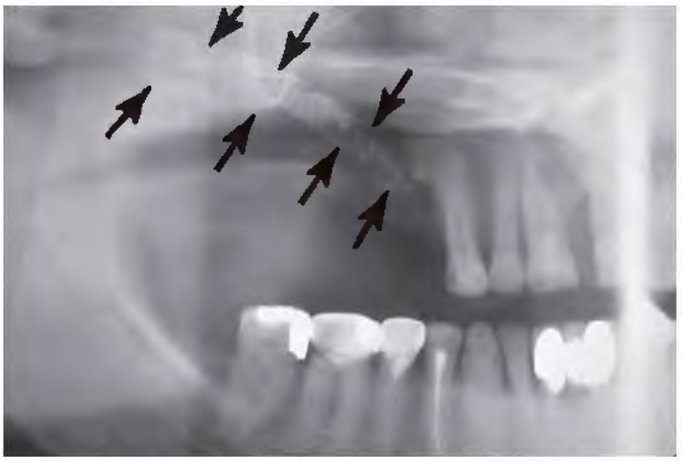


FIGURE 8-64. A postoperative radiograph indicates that the block *(arrows)* has served well to recompartmentalize the antrum.

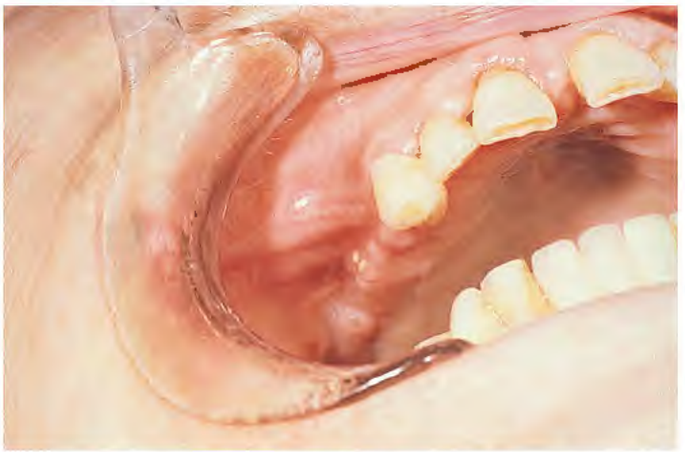


FIGURE 8-65. Clinically, primary healing has taken place, and the graft material has been incorporated as a biologic substitute. Vestibular and ridge morphology have been restored.

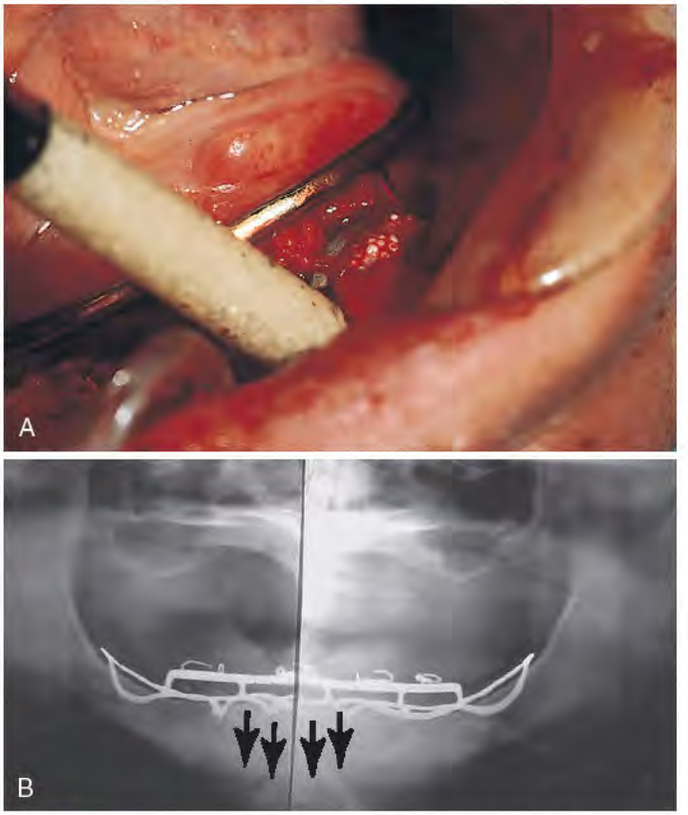


FIGURE 8-66. A, A submandibular fistula, caused by a blow to the chin 11 years after placement of a subperiosteal implant. An incision was made in the vestibule, the drainage tract was excised, and a syringe was used to insert an hydroxyapatite (HA) barrier. **B,** The postoperative result separated the oral from the submandibular spaces (note the HA barrier) *(arrows)* and restored health to the implant host site.

The procedures undertaken often require use of a specific form of graft material and respond most successfully when autogenous bone is used.

Procedures Requiring Particulate Graft Material

Vestibular compartmentalization (Fig. 8-66)
Mandibular inferior border augmentation (Fig. 8-67)
Mandibular fracture defects (Fig. 8-68)
Large cyst reconstruction (Fig. 8-69)
Mandibular continuity defects (Fig. 8-70)

Procedures Requiring Block Graft Material

Infraorbital rim, malar defects (Fig. 8-71)
Ridge augmentation, maxillary and mandibular (see Figs. 8-50 through 8-54)
Hemimaxillectomy repair (see Figs. 8-60 through 8-65)
Genioplasty (Fig. 8-72)
Mandibular continuity defects (Fig. 8-73)

Platelet-Rich Gel

Natural cementing media offer the benefits of stability when the surgeon uses large amounts of particulate graft material. The cementing medium might be pure marrow, marrow mixed with ground cortex, or combinations of synthetic, autogenous, and alloplastic shavings. Often, even when the patient's blood or fibrin is used as a vehicle, maintaining its integrity in a mass becomes difficult because of the large amount of graft material and the complex anatomic role the medium must serve. Platelet-rich gel has been proven to provide predictable benefits of stability.

Although the preparation of this biologic glue probably is too complicated for most practitioners to use with small grafts, large ones (i.e., major ridge replacement, inferior mandibular border augmentation, continuity defects) benefit greatly from the addition of platelet-rich gel.

At the start of the procedure, 50 to 500 mL of blood (depending on the volume and size of the graft) is drawn from the patient by phlebotomy. The blood is placed in a centrifuge and spun to separate the plasma from the cells (Fig. 8-74) (some machines do the entire procedure, but for small quantities, a manual operation is available). The platelets, which are buff colored, are removed from the precipitated cell mass. If a large amount of blood was drawn from the patient, the cell-free plasma is returned to the patient intravenously.

The platelets are kept in a covered container until the graft material (usually in an anatomically designed titanium mortise form) is ready to be transferred to the host site. At that time, gel activity is induced by adding a mixture of calcium chloride and thrombin, creating a physiologic glue that is placed atop the particles just before implantation of the complex (Fig. 8-75). Manipulation, fixation with screws, and other adjustments that might otherwise

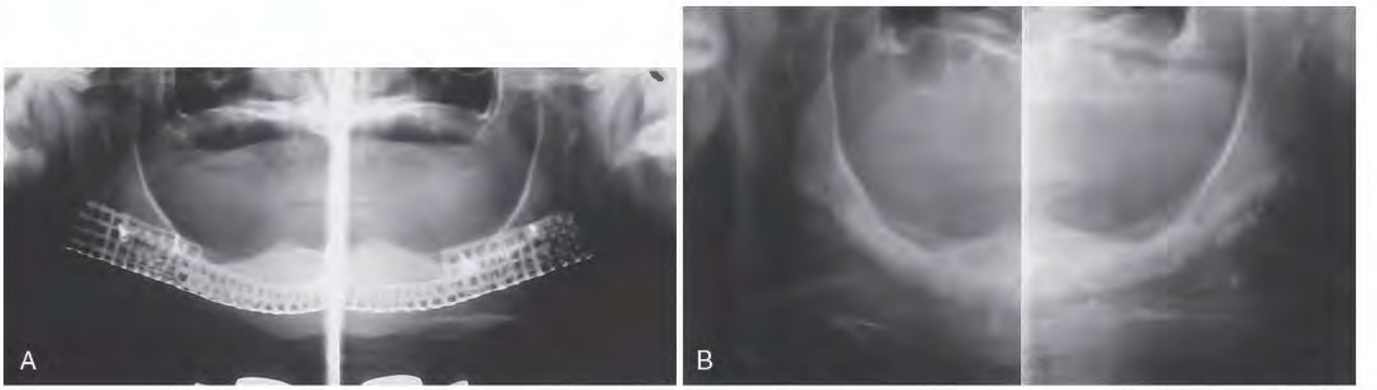


FIGURE 8-67. **A,** If a mandible is severely atrophied, autogenous bone grafts placed in titanium mortise forms can double the mandible's height and volume (the original height of the mandible can be seen through the mesh). **B,** When the mesh is removed (to prevent stress shielding), the amount of well-mineralized augmentation is clearly visible.

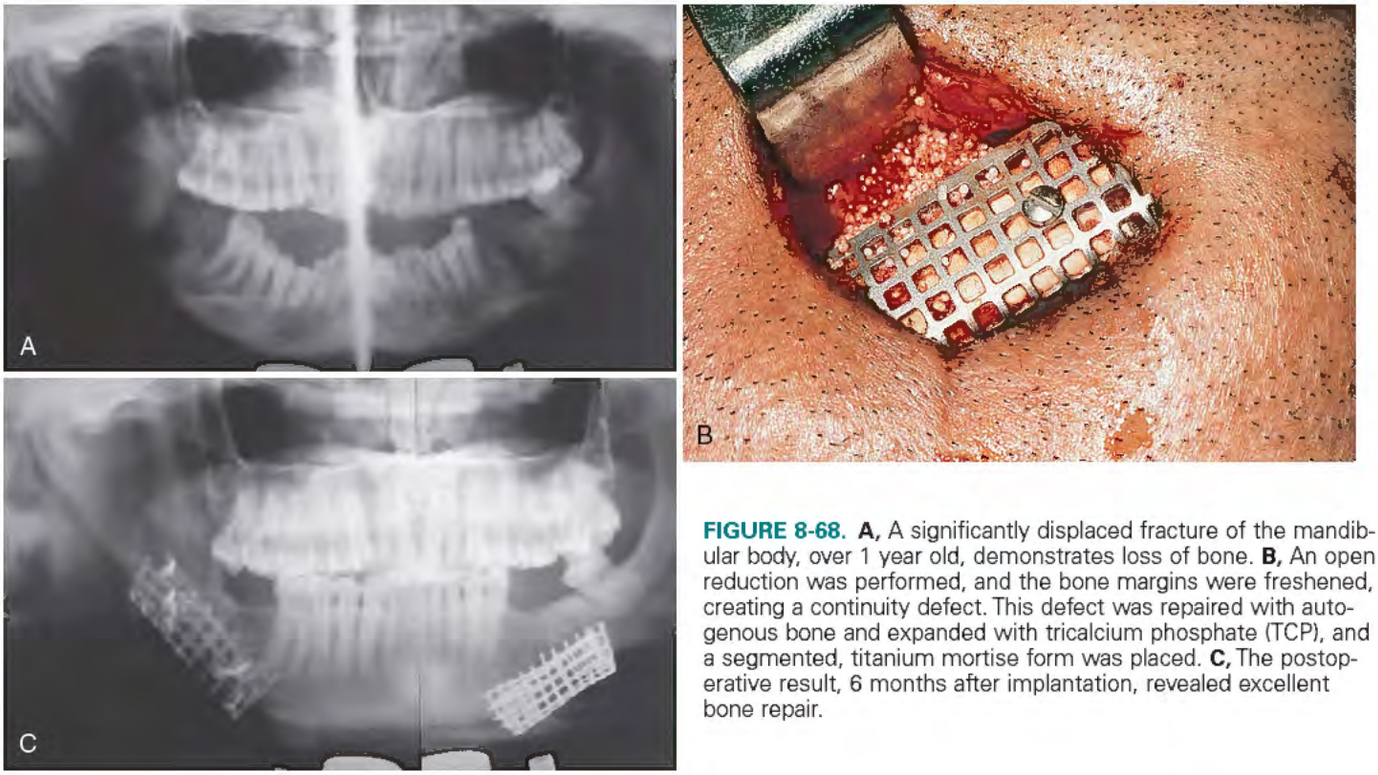


FIGURE 8-68. **A,** A significantly displaced fracture of the mandibular body, over 1 year old, demonstrates loss of bone. **B,** An open reduction was performed, and the bone margins were freshened, creating a continuity defect. This defect was repaired with autogenous bone and expanded with tricalcium phosphate (TCP), and a segmented, titanium mortise form was placed. **C,** The postoperative result, 6 months after implantation, revealed excellent bone repair.

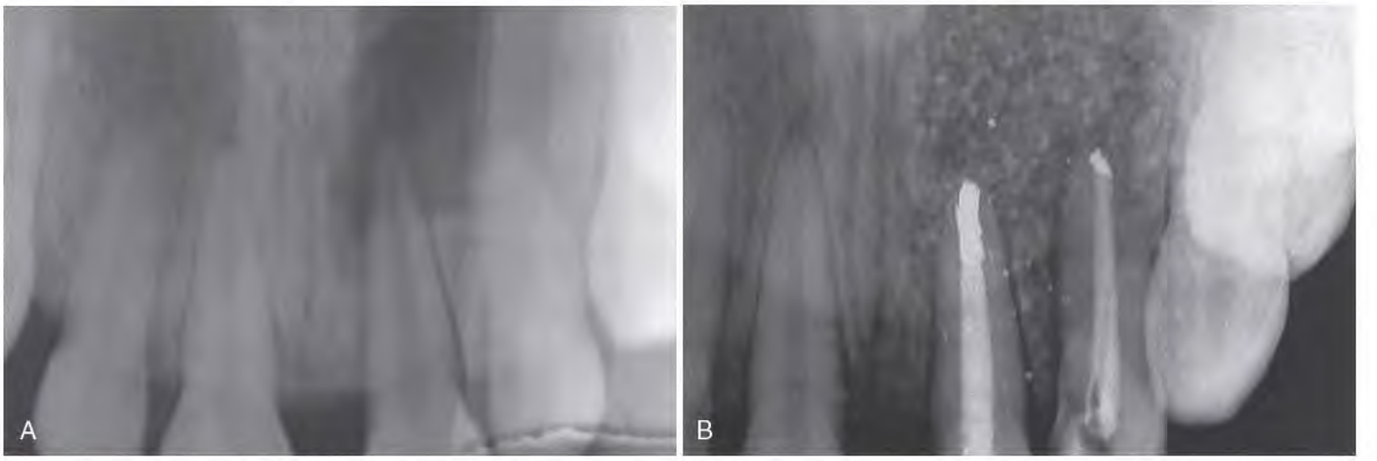


FIGURE 8-69. **A** and **B,** Cysts should not be repaired with graft material, because it prevents radiographic evidence of recurrence. However, grafting is acceptable if both facial and palatal cortical plates have been lost. These defects never fill in with bone; therefore they have a permanent radiolucency if not grafted.

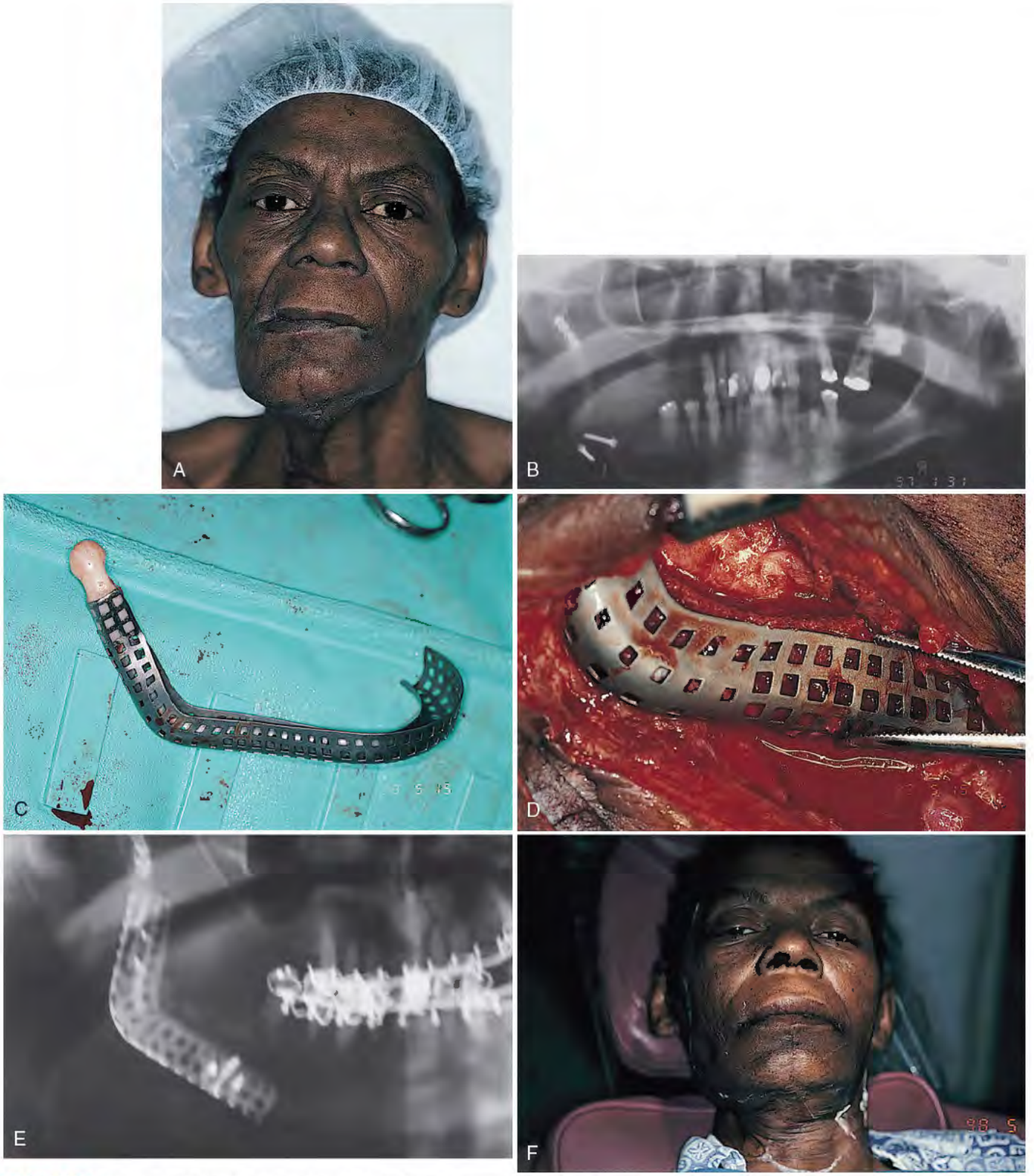


FIGURE 8-70. **A** and **B,** A significant continuity defect was created after an intraoral squamous cell carcinoma required mandibular resection. **C,** A titanium mortise form prosthesis with an added acrylic condyle was fabricated to serve as an anatomic replacement. **D,** Intraoperative view of the titanium mortise form, which contains particulate autogenous cortical and cancellous bone harvested from the anterior iliac crest and augmented with Hydroxyapatite (HA-N). **E,** Postoperative radiograph of the mortise form in place. **F,** Postoperative photograph shows restored facial symmetry.

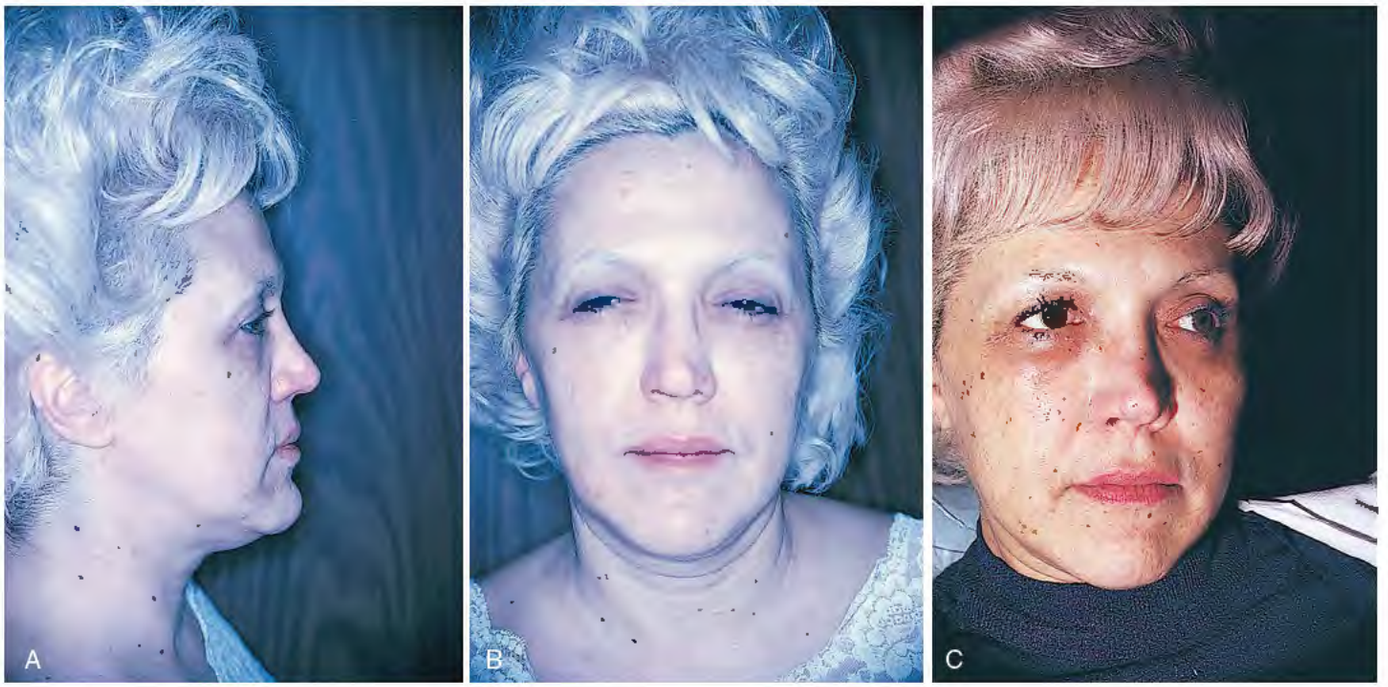


FIGURE 8-71. **A** and **B,** Profile and frontal views of a patient with congenitally deficient malar prominences. **C,** This postsurgical view after bilateral augmentation with carved silicone blocks shows a significantly enhanced malar region and an overall improvement in facial esthetics.

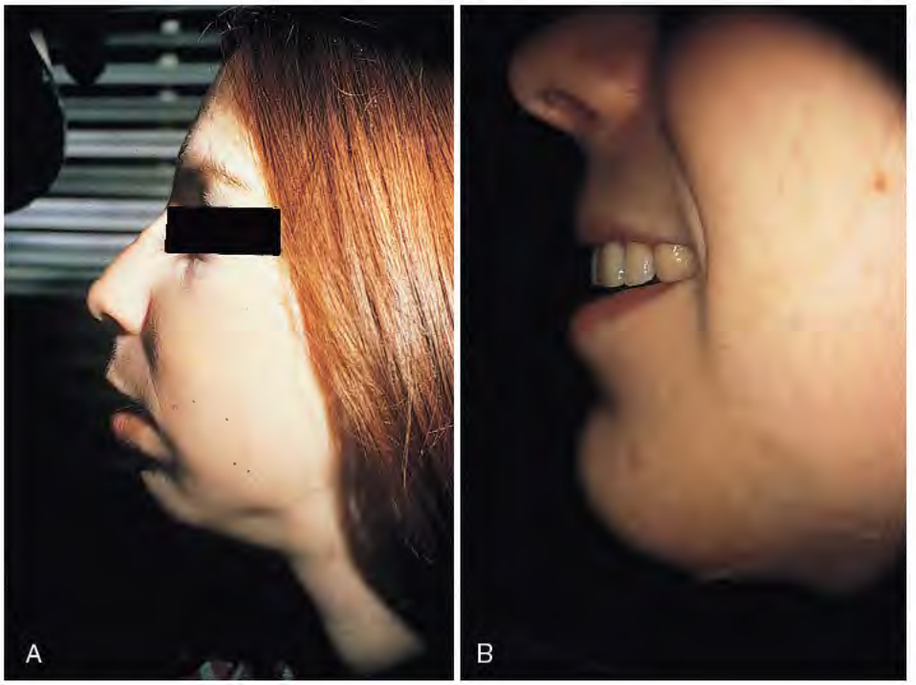


FIGURE 8-72. Before **(A)** and after **(B)** profile views of a patient whose deficient chin was augmented with a contoured silicone block. The approach was through a submental skin incision.

disturb the integrity of the graft are discouraged because they might disrupt the stabilizing influence of the adherent, glutinous, biologic addition. Upon the formation of a gel, any material left over can be molded into a flat shape to be used as a barrier over the bone substitute graft or even sutured as a wound dressing under or over the flap.

For minor grafting procedures performed in the dentist's office, platelet-rich gel can be produced from small amounts of blood with an inexpensive countertop centrifuge. In these cases, the plasma is not returned to the patient intravenously.

Bone Marrow Stem Cells

Stem cells are among the human body's master cells; they can grow into any one of the body's more than 200 cell types. All stem cells are unspecialized (undifferentiated) cells that characteristically have the same family type (lineage). They retain the ability to divide throughout life and give rise to cells that can become highly specialized and take the place of cells that die or are lost. Stem cells contribute to the body's ability to renew and repair its tissues. Unlike mature cells, which are permanently committed to their function, stem cells can both renew themselves and create new cells of whatever tissue to

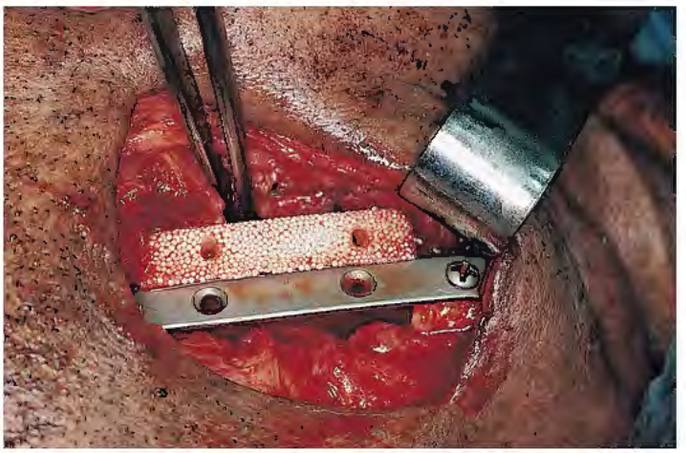


FIGURE 8-73. Although the structural strength of porous blocks is poor, they can serve as plumping or scaffolding devices for maxillofacial reconstruction in conjunction with metal plates or armatures that offer the necessary rigidity. This HTR block accepts drilling and tapping to accommodate the self-tapping Vitallium screws, which attach it to the Luhr fracture plate. This arrangement has already been used to splint these two mandibular segments.

FIGURE 8-74. The Electromedic centrifuge separates blood cells from plasma. This is the first step in preparing a platelet-rich gel.

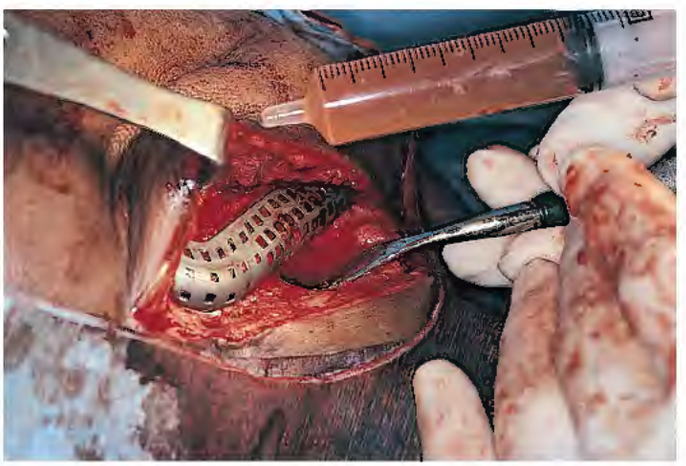


FIGURE 8-75. Addition of the platelet gel to the graft before implantation lends stability to the graft and simplifies management of the bone-filled titanium mortise form.

which they belong (as well as other tissues). Bone marrow stem cells, for example, are the most primitive cells in the marrow. All the various types of blood cells are descended from them. Bone marrow stem cell transfusions (or transplants) originally were given to replace various types of blood cells. Quite remarkably, stem cells from bone marrow also can give rise to nonmarrow cells.

Bone marrow stem cells can be acquired relatively easily and inexpensively from the anterior iliac crest. This aspiration can be done chairside and using local anesthesia. The patient lies flat in the side-lying position with the anterior iliac crest uppermost. The skin over the crest is prepared and draped. A small amount of lidocaine (5 to 10 cc of 2% lidocaine with 1:100,000 epinephrine), depending on the thickness of the skin and underlying tissues, is infiltrated directly over and around the iliac crest. An intraosseous cannulation procedure is used, and the needle is held at 90 degrees to pierce the skin. When the needle reaches the skin, a bradawl motion is used to penetrate into the marrow. The needle–hand section is removed, and the sharps are discarded. A 5-mL syringe is attached to the needle, and the practitioner attempts to aspirate 5 to 10 mL of blood and bone marrow; this is done very slowly, because a sudden drop in intraosseous pressure could cause the patient to faint. When the needle is in the bone marrow, it must be secured firmly in place. A bulky sterile dressing is used to buttress the cannula, as an impaled object would be, and a dressing is applied. The potential hazards of this procedure are infection and infiltration.

- *Infection.* Osteomyelitis has been reported in a small number of patients who have undergone the procedure. Strict attention to aseptic technique, therefore, is essential.
- *Infiltration.* Incorrect placement of the intraosseus needle can lead to infiltration of the surrounding tissues. This can be prevented by confirming that the needle is within the marrow cavity before fluids are infused through it. Infiltration also may occur at the point where the needle enters the bone. Infiltration becomes evident by signs of tissueing around the cannulation site.

Once the aspirate has been collected in the syringe, it should be stored immediately in a basin filled with ice water until it can be mixed with the bone graft material.

Peri-Implant Support and Repair

Many blade, transosteal, and root form implants that show radiographic signs of host site deterioration can be treated as if they were periodontally involved teeth. This is done by making flaps, followed by curettage and implantation (see Chapter 27 and section II of this chapter). Repair or salvage of endosteal implant host sites should not be undertaken unless the implant is completely firm and a reasonably sized bony defect is involved. GTRMs offer greater assurance of repair stability (Fig. 8-76). Subperiosteal implants also may be found in failing modes. Chapter 28 describes how particulate grafting can contribute to salvage operations in this category (Fig. 8-77).

Blade implants do well when, on their placement in the slotted osteotomies, particles are used to support ridge contours over and about their shoulders.

Root form implants can be inserted into extraction sites that are larger in diameter than the implant bodies or infrastructures by using graft materials and membranes (see Chapter 8).

The new bone interface, after extraction, should be developed either from 40% of additional bone apical to the alveolus or from within it if its diameter is narrow enough to permit a freshly cut enlargement to accommodate the implant.

FIGURE 8-76. Implants with periodontal defects can be salvaged using grafting materials if management of the problem is controlled carefully and the principles governing periodontal surgery are observed strictly.

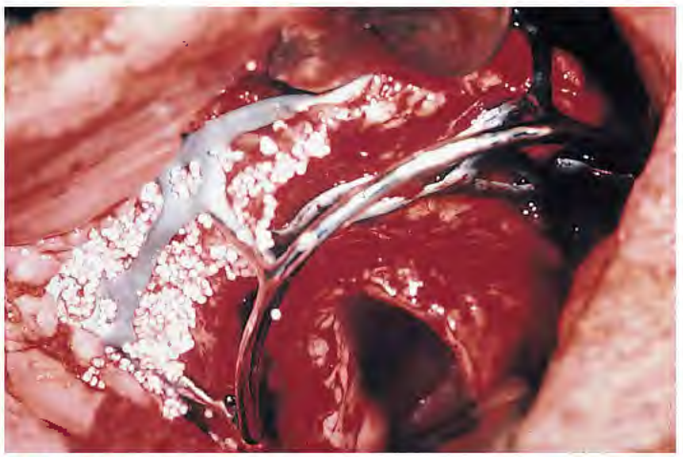


FIGURE 8-77. When host bone has been resorbed, subperiosteal implants (either at the time of insertion or subsequently) respond well when particulate grafting material is used to augment osseous deficiencies. Thorough curettage and adequate soft tissue flaps for primary closure are mandatory.

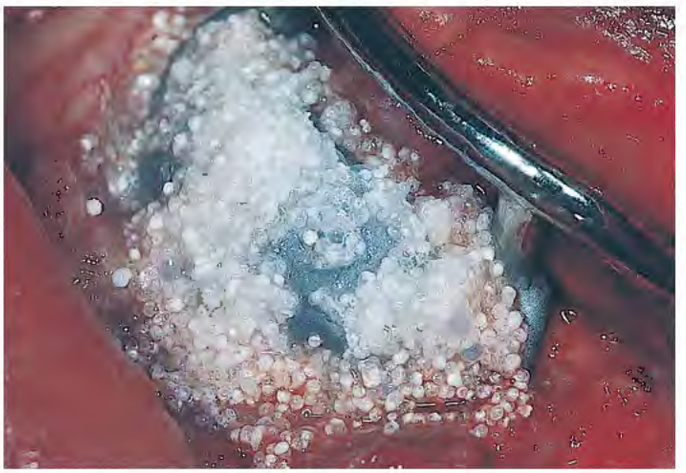


FIGURE 8-78. When accuracy is lacking, particularly with CAD-CAM castings, particulate graft material serves as a satisfactory grout.

If inadequate bone is available in the cervical area after the implant has been placed, but it is found to be stable, particulate grafting is used to correct the deficiency. The implant is placed below the alveolar margins, the graft material is tamped meticulously around its periphery, and a healing screw is placed, which should be used to stabilize a GTRM and encourage postintegration healing. Primary closure requires the creation of pedicle flaps through undermining, as described in Chapter 7.

In cases of inaccurate apposition, CAD-CAM subperiosteal implants, particularly maxillary implants, require particulate augmentation (Fig. 8-78) (see chapters 14 and 15).

BONE GRAFTING FOR ROOT FORM IMPLANT HOST SITES OF INADEQUATE DIMENSION

The following discussions are devoted to the management of potential implant host sites that are not sufficiently wide or high to allow placement of implants. This section of the chapter describes the methods of obtaining graft materials. In addition, it is divided into four anatomic sections: the anterior and posterior mandible and the anterior and posterior maxilla (see the accompanying box).

I. Mandible
- A. Anterior
  - 1. Width
    - a. Alveoloplasty
    - b. Monocortical block grafting
  - 2. Height
    - a. Monocortical block grafting
    - b. Inferior border augmentation
- B. Posterior
  - 1. Width
    - a. Alveoloplasty
    - b. Monocortical block grafting
  - 2. Height
    - a. Mandibular nerve repositioning

II. Maxilla
- A. Anterior
  - 1. Width
    - a. Alveoloplasty
    - b. Splitting and expanding
    - c. Osteotome expansion
    - d. Monocortical block grafting
  - 2. Height
    - a. Nasal floor elevation
- B. Posterior
  - 1. Width
    - a. Alveoloplasty
    - b. Splitting and expanding
  - 2. Height
    - a. Antroplasty
    - b. Antroplasty and miniplate
    - c. Osteotome (Summers)

CAVEATS

Harvesting of autogenous bone (the most reliable of materials) is not without complications.

Care must be taken so that as little trauma as possible occurs in these second operative sites.

At the primary or host sites, sharp, full-thickness incisions are made, and the periosteum is elevated, without tearing them.

Constant attention must be paid to the neurovascular bundles, as well as to the foramina, when the symphysis is used as a source of bone. Arterial bleeding from the mandibular artery beneath the incisor apices, which may be brisk, is stopped with either bone wax or an electrosurgical tip.

The drill holes for bone graft fixation screws should be the proper size to encourage firm fixation. Stripped holes can cause bone loss and often deprive the surgeon of a second strategic site for screw placement.

The lag screw technique makes monocortical block placement simple by eliminating the awkward event of graft spinning. A lag screw achieves firm fixation by pressure from the screw head as its shaft passes unencumbered through the graft. The hole in the graft is made large enough that the screw threads do not engage its sides; the hole in the host is made small enough that the threads lock into the underlying bone. Of course, the hole in the graft must be small enough that the head serves as a locking device (Fig. 8-79).

When osteotomes are used, mallet taps must be controlled to prevent penetration of vital structures.

Osteotome techniques for ridge splitting and expansion cannot be used in the mandible, because the bone is too dense and inelastic. In the maxilla, good judgment, experience, and tactile skills are essential tools for ridge expansion and splitting. The danger of fracture always threatens the effort to expand the bone beyond its physiologic limit. The surgeon must acquire a sense of the elastic limits of the operative site if fracture is to be avoided. If fracture occurs, of course, the procedure must be abandoned. Chapter 28 offers instruction on how to proceed in such cases.

Minimal reflection of the mucoperiosteum at the site to be grafted or expanded is beneficial, because it ensures optimum vascularity. In addition, if a fragment of bone is fractured and remains attached to its overlying periosteum, the chances are excellent that it will heal properly after an anatomic closure.

Management of the inferior alveolar neurovascular bundle in nerve repositioning must be gentle, and the osteotomy performed to expose it must be sufficiently wide to allow impeccable manipulation. Nonetheless, transient paresthesia should be expected.

The maxillary sinus membrane must be handled skillfully to avoid tearing it. Tatum instruments can help achieve this goal. If the membrane is torn, it is repaired by suturing or the placement of collagen sheets.

Most surgeons use a round bur to scribe the bony lateral wall overlying the maxillary sinus. However, as the bur passes through the eggshell-thin bone, it sometimes catches and tears the membrane. Use of a round diamond, instead, allows the surgeon to perform a definitive, oblong osteotomy with virtually no threat to the translucent, fragile membrane.

Although autogenous bone can be harvested from the cranium, fibula, tibial plateau, anterior or posterior iliac crests, and ribs (as well as a variety of intraoral sources), not all of these sites are described in this section. Those selected were chosen because of their excellent yields and because of maxillofacial surgeons' broad familiarity with them. Of course, morbid complications are related to bone harvesting in all situations; therefore the surgeon must weigh the risks against the benefits.

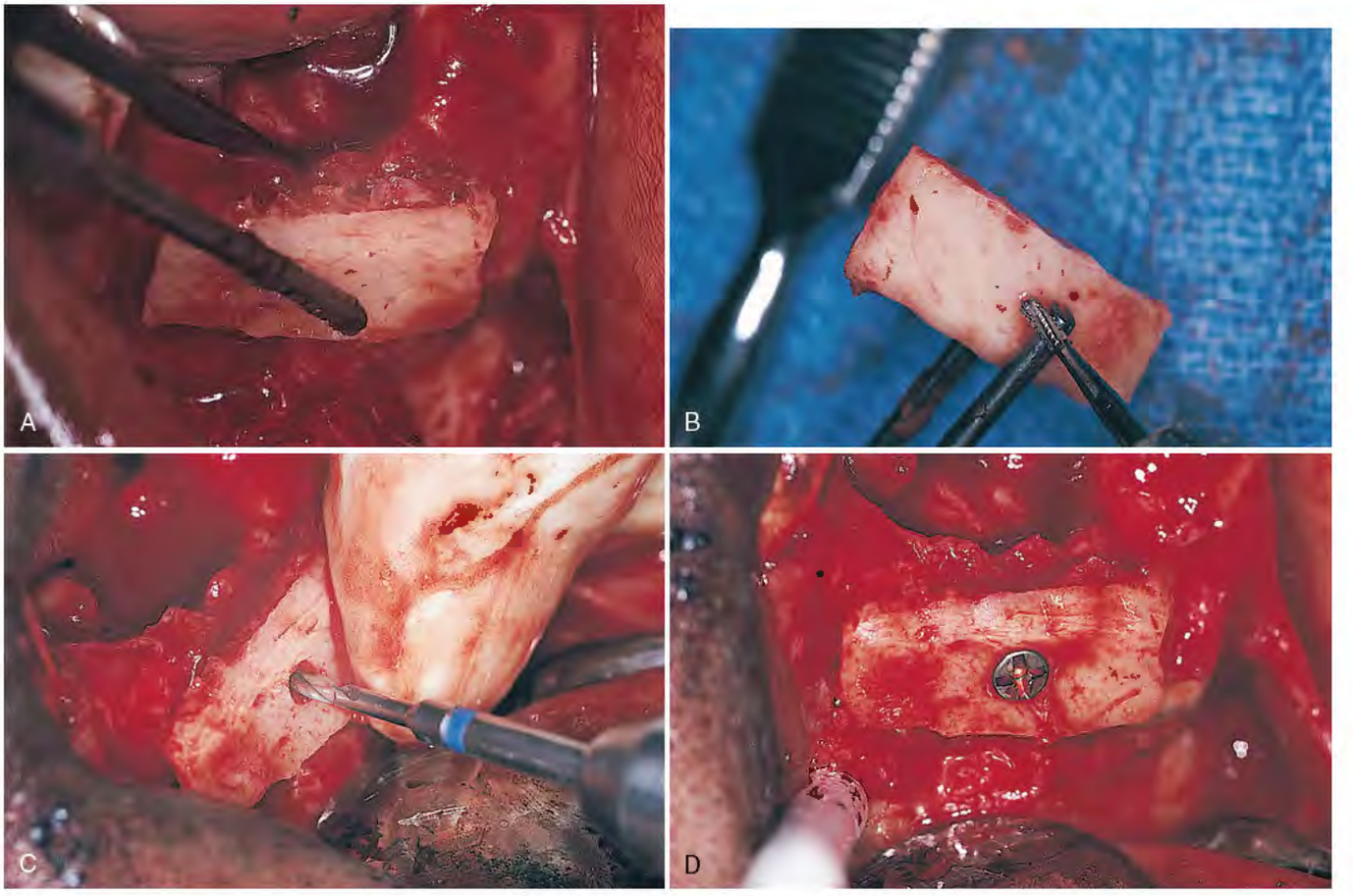


FIGURE 8-79. Lag screw technique. **A,** The monocortical graft is placed marrow side down against the potential host site. **B,** A 701 bur (which has a larger diameter than the planned fixation screw shaft) is used to make an osteotomy in the graft. **C,** The graft is refitted, and the center of the osteotomy in the host cortex is marked and then deepened with a 700 SL bur; this pretaps the screw hole in the host bone. **D,** The final screw is placed through the graft without touching its walls. The screw's threads cut into and grasp the host bone beneath it. As the screw is tightened, its head locks the graft firmly against the host site.

Intraoral sites, such as osteomas and palatal and lingual tori, should not be seriously considered for service as grafts, because they are composed of almost pure cortex; as such, they cannot supply significant sources of osteogenic or osteoinductive activity. However, they may be used as expanders when minced and added to marrow, increasing graft quantity.

Techniques for Obtaining Autogenous Bone

Anterior Iliac Crest

The most reliable and predictable graft material is autogenous bone marrow; the easiest and safest place from which to harvest it in adequate amounts is the anterior iliac crest.

A few complications are possible in exposing the anterior iliac crest and the several vital structures encountered during the dissection, which should be performed in an operating room under general anesthesia. The surgeon should be aware of the femoral cutaneous nerve, which is encountered lateroinferiorly in rare cases.

After the skin has been prepared, a Steri-drape is applied. The crest is palpated, and then an incision is made through the overlying skin and fascia (Fig. 8-80, *A*). The femoral cutaneous nerve should be sought and safeguarded, because if it is damaged, the patient is left with a sensory deficit of the skin overlying the anterolateral thigh. Bleeders are clamped and electrocoagulated, and the sharp dissection is continued through fat, muscle fibers, fascia lata, and periosteum.

The periosteum is reflected medially just over the full thickness of the crest and laterally down over its undercut for 4 cm. This is done from the anterior to the posterior tubercles. A sharp osteotome 2 cm wide is used to bisect the crest in its long axis to its fully exposed length (Fig. 8-80, *B*). This osteotomy is connected with two vertical cuts, one anterior and one posterior, which are carried down through the lateral cortex just beneath the periosteal attachment. The osteotome then is used as a lever to pry this "trapdoor" open laterally, allowing it to rotate downward on its periosteal hinge.

Bayonet medullary gouges are used to lift the marrow from between the cortical plates with gentle, undulating, pushing movements (Fig. 8-80, *C*). Care must be taken not to perforate the cortical plates. Perforation of the medial plate could lead to a pelvic infection, therefore pressure of the gouge against this cortex must be avoided.

The harvested marrow is stored in a saline-filled medicine glass (Fig. 8-80, *D*). When the marrow cavity has yielded a sufficient amount of material, thorough irrigation is performed (Fig. 8-80, *E*). Tamponade or platelet gel is used to minimize intraosseous bleeding, and when the bleeding has been controlled, the cortical trapdoor is reset into its anatomic position. Two fine holes are drilled through it and the adjacent intact crestal cortical plate, and fixation is achieved with two 2-0 Biosyn sutures (Fig. 8-80, *F*).

If an insufficient amount of bone is harvested, the cortical trapdoor may be removed, particulated, and added to the harvested material. When the cortex is sacrificed, anatomic contours can be

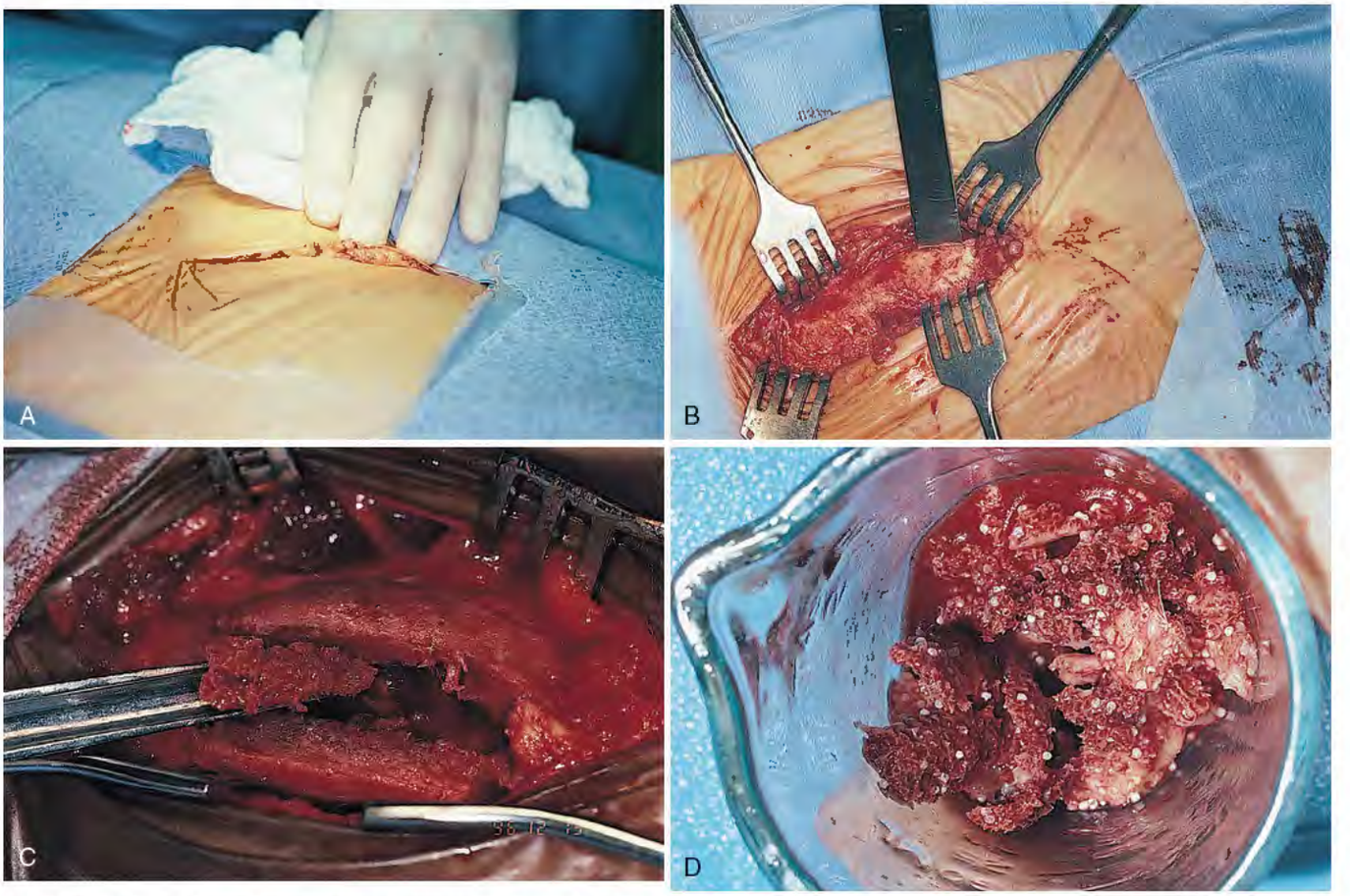


FIGURE 8-80. **A,** A Steri-drape is placed over the prepared skin in the region of the anterior iliac crest. A Bard-Parker (BP) No. 10 blade is used to make an incision through the plastic drape, the skin, and into superficial fascia. **B,** After the crest has been exposed, an osteotome (2 cm wide) is used to make a midcortical groove from the anterior end to the posterior end. Vertical osteotomies are used at either end to create a trapdoor, which is wedged open with the osteotome. The hinge of the trapdoor is the intact periosteum at its base. **C,** Bayonet-shaped gouges are used to remove the osteogenic marrow. **D,** The graft complex, spongiosa, synthetic particles (and when needed, particulated cortex) are stored in the patient's marrow-derived blood to which 80 mg of gentamycin has been added.

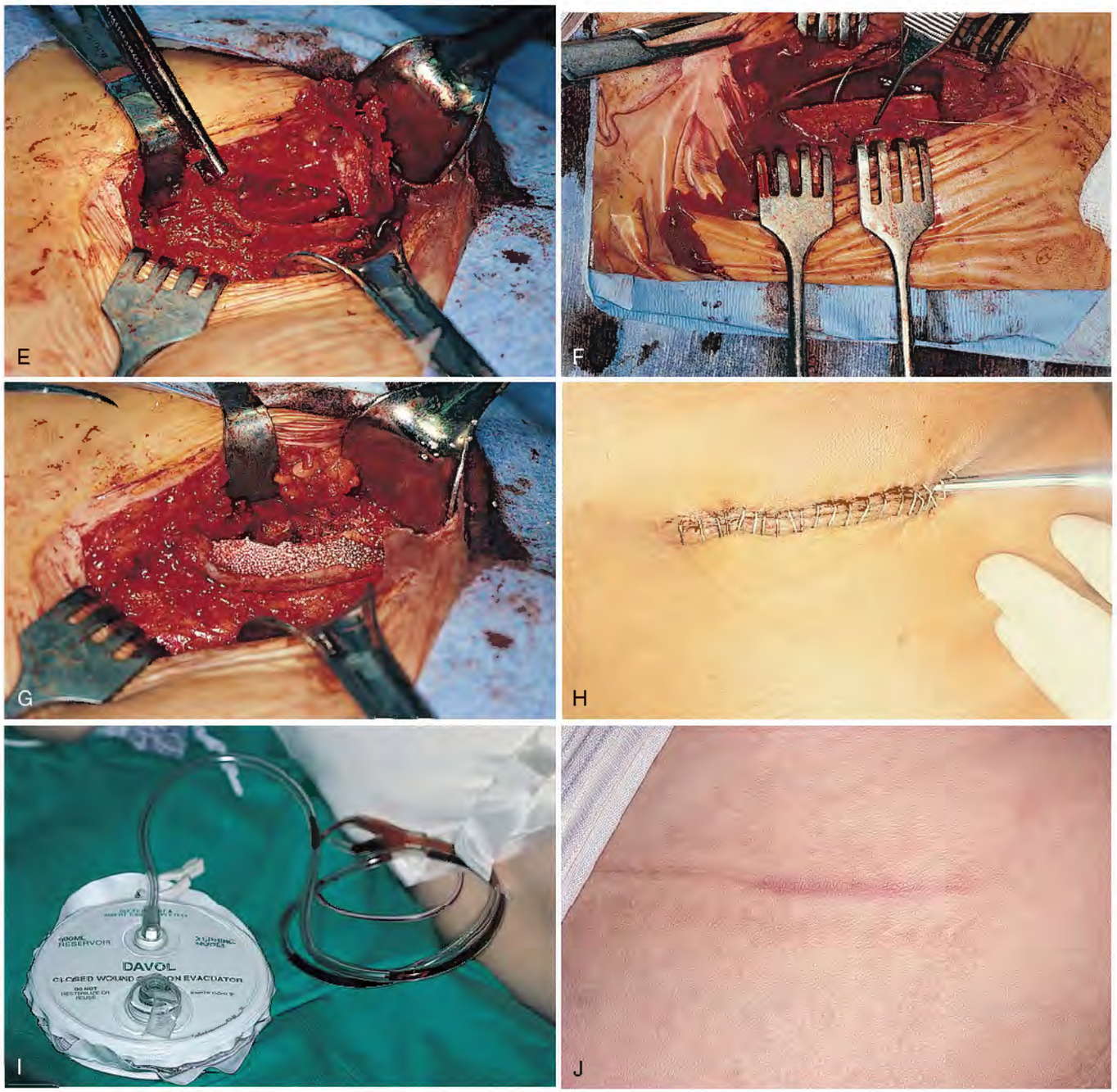


FIGURE 8-80, cont'd. E, The required amount of bone has been removed from between the cortical plates, and hemostasis has been achieved. **F,** Two holes are drilled in the trapdoor, and matching holes are made in the stable medial crest. Biosyn sutures (2-0) then are placed to close and stabilize the trapdoor. **G,** If a greater bulk of bone is required than was available from marrow harvesting, the cortex is minced and added. To restore contours, a synthetic graft material is used to replace the cortex. **H,** In areas that do not demand the highest level of esthetics, the skin is closed quickly and efficiently with staples. **I,** A Hemovac is manually armed to maintain gentle negative pressure in the depth of the wound and mediated by a multiply perforated polyethylene tube. This evacuates oozed blood and discourages pooling and subsequent infection. **J,** The operative site after removal of the staples.

retained by grafting the donor site to the former level of the crest with particulate or block (HA) graft material (Fig. 8-80, *G*). Irrigation is then performed, and the soft tissues are sutured in carefully restored layers. Attention must be paid to the fascia lata and other structures so that an anatomic closure results. A 3-0 chromic suture is used for the subcuticular tissues, and the skin is closed quickly and efficiently with an AutoStapler (Fig. 8-80, *H*).

A small Hemovac, which applies constant, gentle suction to the interior of the wound for evacuation of pooled blood, is placed under the periosteum and exits at a point 2 cm beyond the inferior end of the incision (Fig. 8-80, *I*). This is made possible by its sharp-tipped trocar. The tube is withdrawn so that its perforations are left deep in the wound. The trocar is removed, and the tube is trimmed to the proper length. It is then sutured to the skin with 2-0 nylon and connected to the bellows. The wound is then dressed, and the Hemovac is armed by compressing its walls. The container should be examined periodically and, when necessary, recompressed (about every 8 hours). It is removed in 24 to 48 hours, depending on how profuse the bleeding appears to be.

The patient is ambulated no later than day 2 with the help of a walker or crutches, and physical activity is encouraged. On day 14, the

operated area is carefully prepared with povidone-iodine (Fig. 8-80, *J*), and a specialized extractor is used to removed the staples.

Rib

If marrow is to be harvested from a rib, the patient's back is wedged with sheets to support the rib cage in an upward direction. A Steridrape is then applied. To best hide the scar, an incision is made in the inframammary crease (Fig. 8-81, *A*). This incision should be carried through the periosteum overlying the donor, which is either the fifth or sixth rib. The periosteum is incised sharply to bone, and an elevator is used to expose the rib (Fig. 8-81, *B*). Care must be taken not to pierce the lung or enter the thoracic cavity. If this happens, pneumothorax results, requiring placement of a chest tube.

If cartilage is required, it can be harvested with the rib by incising with the scalpel 1 cm medial to the costochondral junction. If this cartilage is not needed, the rib graft may be sectioned at the costochondral junction and at a lateroposterior site that is determined by the length of bone required. If an acute curve of the rib is desired, it should be scored deeply so that it can be bent without fracturing (Fig. 8-81, *C* and *D*).

Bone sectioning is performed with a rib cutter or a small oscillating saw cooled with saline irrigation. The graft is stored in saline, and an anatomic closure is performed in layers with 3-0 chromic gut and Autostaples for the skin. If the periosteum is allowed to remain, a new rib ossifies. If periosteum is desired (as it might be for a mandibular continuity defect), the rib is removed with its investing membrane intact. Natural rib replacement does not occur.

After this harvesting procedure, a firm, occlusive chest dressing is placed, and the operative site should be monitored for 2 weeks. If all has gone well, the skin staples then can be removed.

Tuberosity

The incision made to harvest from a tuberosity is the same as that made for tuberosity reduction (see Chapter 6). First, however, if bone is being sought, the surgeon must carefully inspect a periapical radiograph for mineralized rather than soft tissue and for the location of the antral floor.

After the underlying bone (which is rich in marrow) has been exposed (Fig. 8-82, *A*), a side-cutting rongeur is used to remove the amount required (Fig. 8-82, *B*); special care is taken to circumvent the sinus floor (Fig. 8-82, *C*). Closure follows the technique described for tuberosity reduction (Fig. 8-82, *D*).

Anterior Border of the Mandibular Ramus

The anterolateral border of the mandibular ramus on the same side as the sinus to be grafted should be palpated. The donor site is anesthetized using infiltration procedures laterally and medially. The incision is made with a BP No. 15 blade; it proceeds vertically over the anterior border of the ramus from a point 1 cm below the coronoid tip, downward and forward to a point level with the mandibular third molar area. Keeping the instruments directly against the anterior border safeguards the lingual nerve.

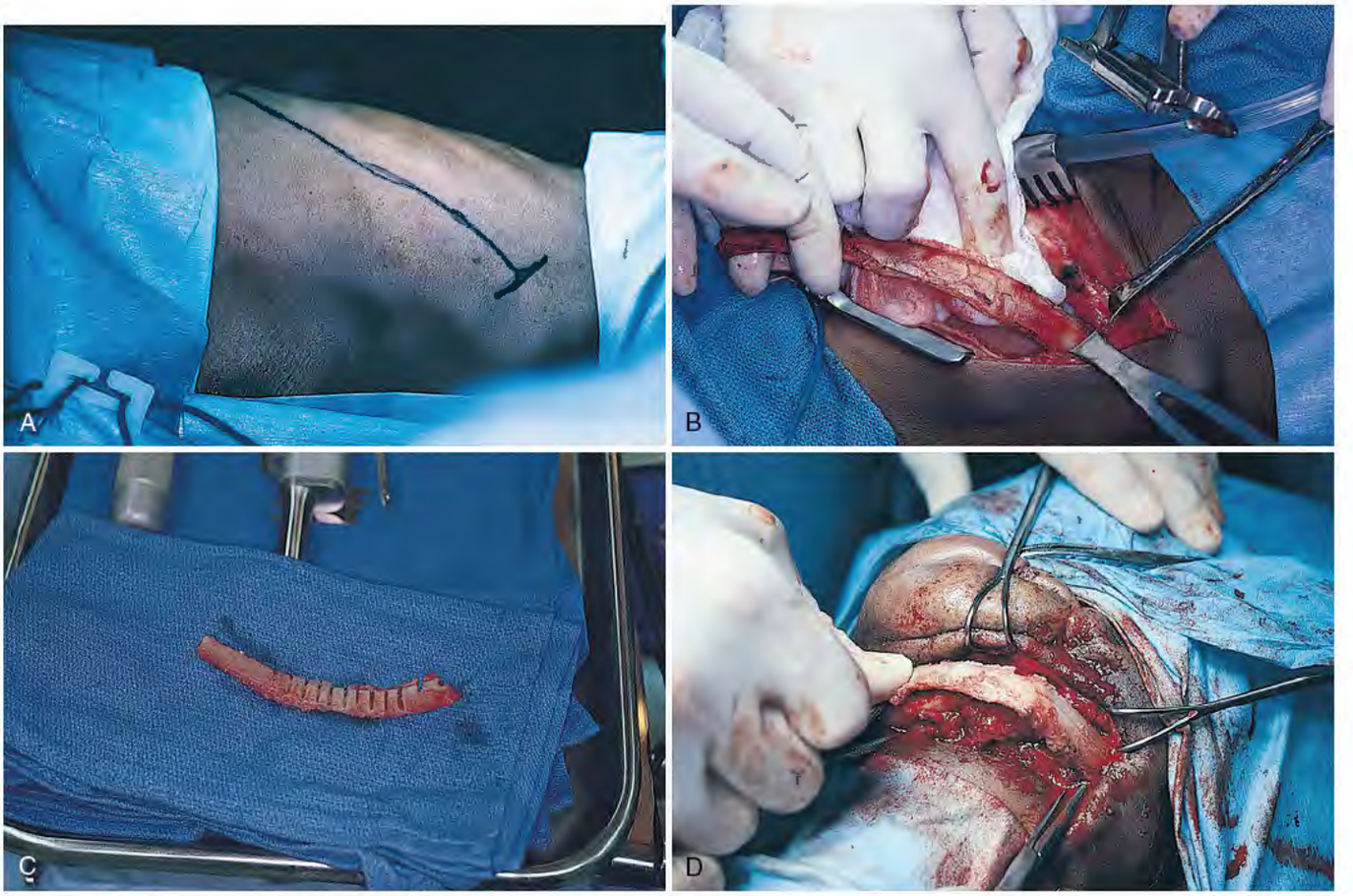


FIGURE 8-81. **A,** The area overlying the rib that is planned for removal is outlined with a skin marking pen. **B,** The rib is exposed by sharp dissection to the full extent required for the graft. Care must be taken not to cause a pneumothorax. **C** and **D,** To create a significant arc in a rib, the side of the lesser curvature is deeply scored to permit bending without fracture. Ribs should be made self-sustaining so that they do not require plates or mesh for support.

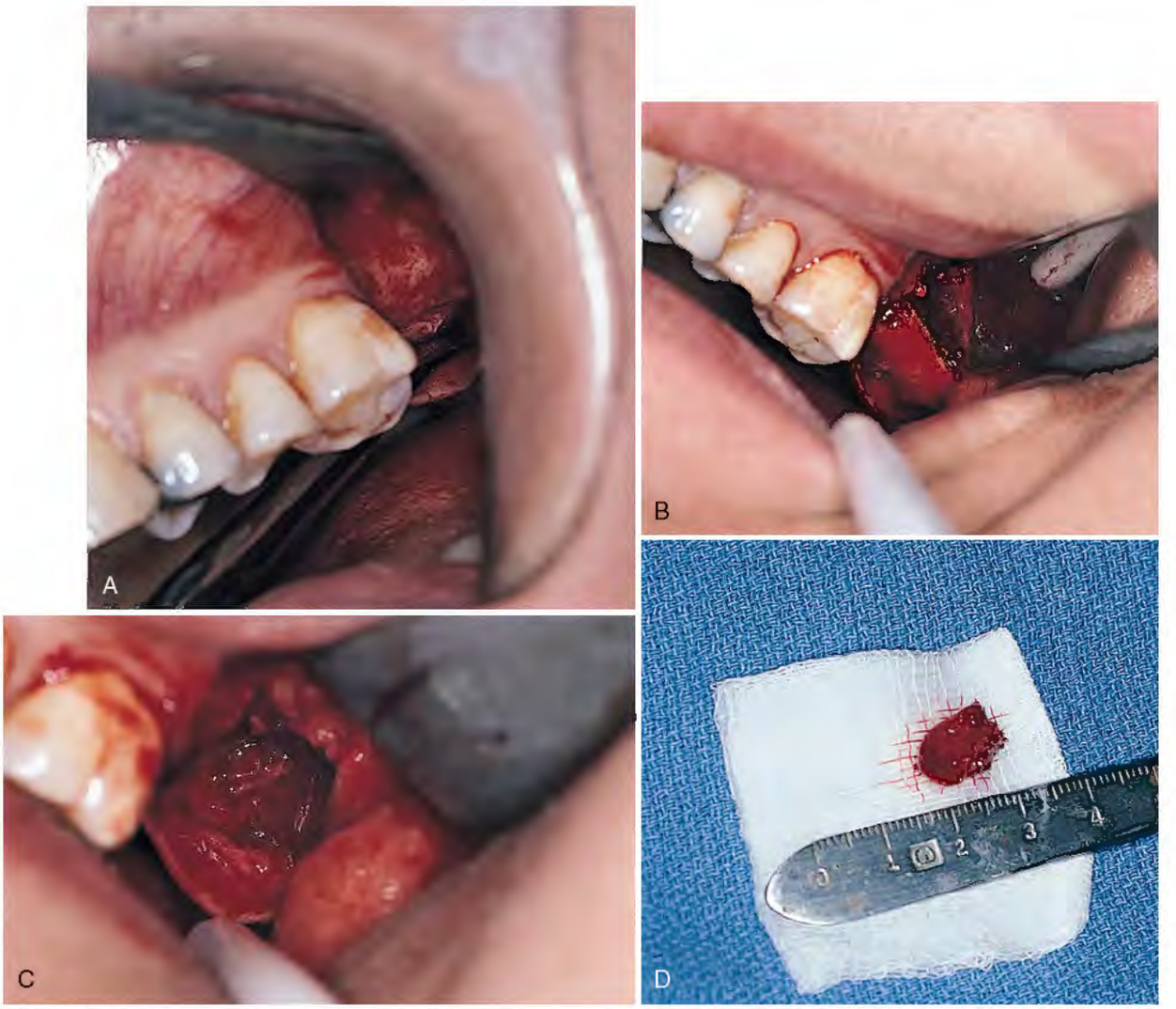


FIGURE 8-82. **A,** The bony tuberosity is exposed by a crestal incision that extends distally to the pterygomandibular raphe, followed by mucoperiosteal reflection. **B,** The portion of the tuberosity designed to serve as a donor is removed with a spatula osteotome. **C,** The residual bone is smoothed, and sharp corners are eliminated. **D,** A generous amount of viable marrow is made available from the tuberosity area.

The flaps are reflected laterally and medially with a sharp periosteal elevator, creating adequate access to the anterior surface of the ramus (Fig. 8-83). The osteotomy is started with a No. 2 round bur in a straight handpiece or Impactair (a regularly designed contra-angle makes placing the bur holes difficult). The holes made with this bur are placed in a semilunar pattern, 2 cm in diameter, in the lateral cortex, at the midlevel of the ramus. They are connected with gentle strokes of a No. 700L bur and copiously cooled with saline.

The groove is deepened until a properly directed tap with a spatula osteotome produces a predictable fracture, and the entire half circle of bone, from lateral to medial cortices, is retrieved in a single piece. The surgeon must be constantly aware of the presence of the mandibular canal. The harvesting may have to be completed using a mallet, curved osteotomes, and rongeur forceps.

Finally, the donor site is filed smooth, and the tissues are closed with a 4-0 Vicryl continuous horizontal mattress suture. The harvested bone is ground into fine particles with the rongeur forceps, mixed with an expander (e.g., TCP or DFDB) as described previously, and stored in sterile saline or the patient's marrow-derived blood.

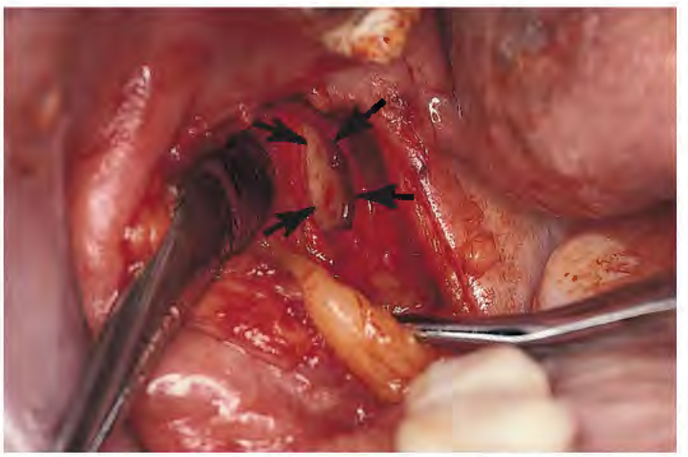


FIGURE 8-83. The anterior border of the mandibular ramus is readily exposed with small risk of injuring vital structures. After the anterior border *(arrows)* has been made available, small burs, rongeur forceps, osteotomes, and a mallet are used to remove a significant amount of bone. Little medullary material is included in the ramus.

Lateral Border of the Mandibular Ramus/Body

Using a unique disposable osteotome/collector, the MX-Grafter (Maxillon), the surgeon can remove thin strips of lateral cortex by a planing action.

The posterior lateral mandible is exposed by crestal incision on the side where the host site is located. After the external oblique ridge and the area beneath it have been adequately denuded, the blade is used to strip the bone surface in narrow lengths. Sufficient amounts can be harvested to fill tooth pockets, repair peri-implant defects and, along with allografts, serve as an osteogenic nidus when larger amounts are required. As the shavings are removed, they are compacted with blood in a posterior storage chamber of the MX-Grafter's handle. The instrument also serves as a direct delivery device (Fig. 8-84).

Mandibular Symphysis

Manual Retrieval

In most cases, the mandibular symphysis offers a rich source of bone marrow. The site should be evaluated on the basis of the presence, location, and length of the incisors and canines, the total mass of the symphysis, and the positions of the mental foramina and canals. If the boundaries appear acceptable, the harvest may be done using regional and field block anesthesia.

Bilateral mandibular blocks are augmented with mental and deep vestibular infiltrations. Then, as the assistant draws the lower lip outward with the thumbs and forefingers, the surgeon makes an incision from canine to canine through the mucosa in the areolar gingiva (Fig. 8-85, *A*). A second, deeper incision is made through the mentalis muscle. Finally, with a new blade, the periosteum at the incisor apical level is incised for the full length of the incision (Fig. 8-85, *B*).

The periosteum is elevated from mental foramen to mental foramen and from above the apical areas of the teeth to the curvature of the inferior border (Fig. 8-85, *C*). Henahan, McBurney, or other retractors are placed, bleeders are electrocoagulated, and a half round bur is used in the Impactair to outline the donor sites with separate dots about 4 mm apart (Fig. 8-85, *D* and *E*). The bur holes should pass through cortex and into medullary bone. If a maximum amount of bone is required, the superior horizontal outline should be below the dental apices, its apposing one just above the inferior border cortex, the posterior vertical dotted lines 6 mm anterior to the mental foramina, and the anterior ones 4 mm lateral to the midline. This leaves an 8-mm central zone that remains untouched. The purpose of preserving the midmandibular spine is to protect the integrity and esthetic appearance of the chin, the mentolabial fold, and the function of the vestibule and mentalis muscle. The overlying cortex is of little value, but its underlying marrow can be harvested.

When the outline of the donor area appears to be satisfactory, the dots are connected transcortically with a No. 700L surgical bur (Fig. 8-85, *F*). The osteotomies are completed with a mallet and spatula osteotome, which can be used as a lever to elevate the cortical plates (Fig. 8-85, *G*).

After the specimens have been removed, they are set aside in saline so that later they can be denuded of any clinging marrow and, if needed, particulated to expand the amount of graft material.

Sharp surgical curettes and small marrow gouges are used to harvest the exposed, highly vascular medullary bone (Fig. 8-85, *H*). The accompanying blood is aspirated by syringe and placed with the stored bone. As this blood clots, it makes a reliable and biocompatible transfer medium and osteogenic matrix.

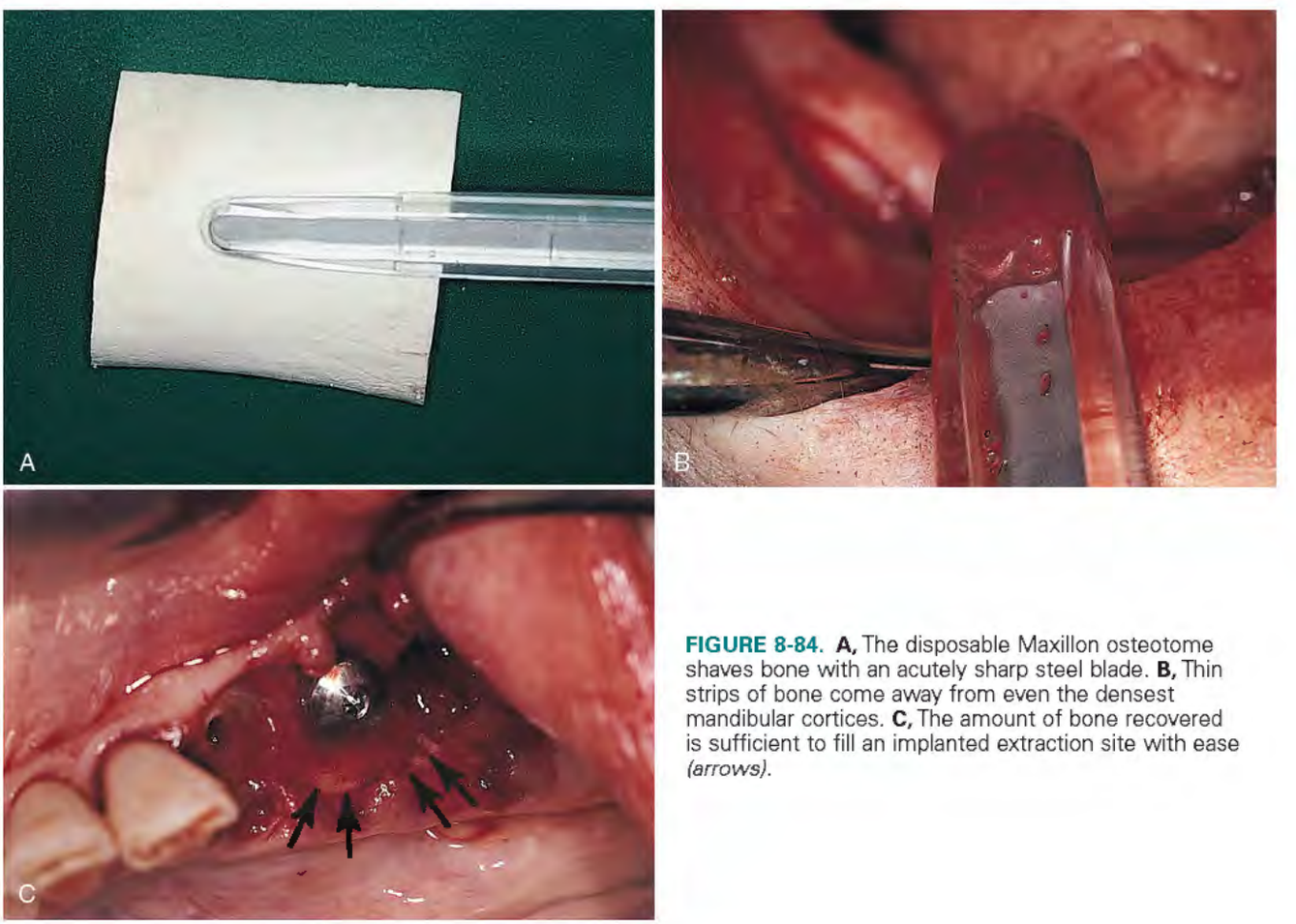


FIGURE 8-84. **A,** The disposable Maxillon osteotome shaves bone with an acutely sharp steel blade. **B,** Thin strips of bone come away from even the densest mandibular cortices. **C,** The amount of bone recovered is sufficient to fill an implanted extraction site with ease *(arrows)*.

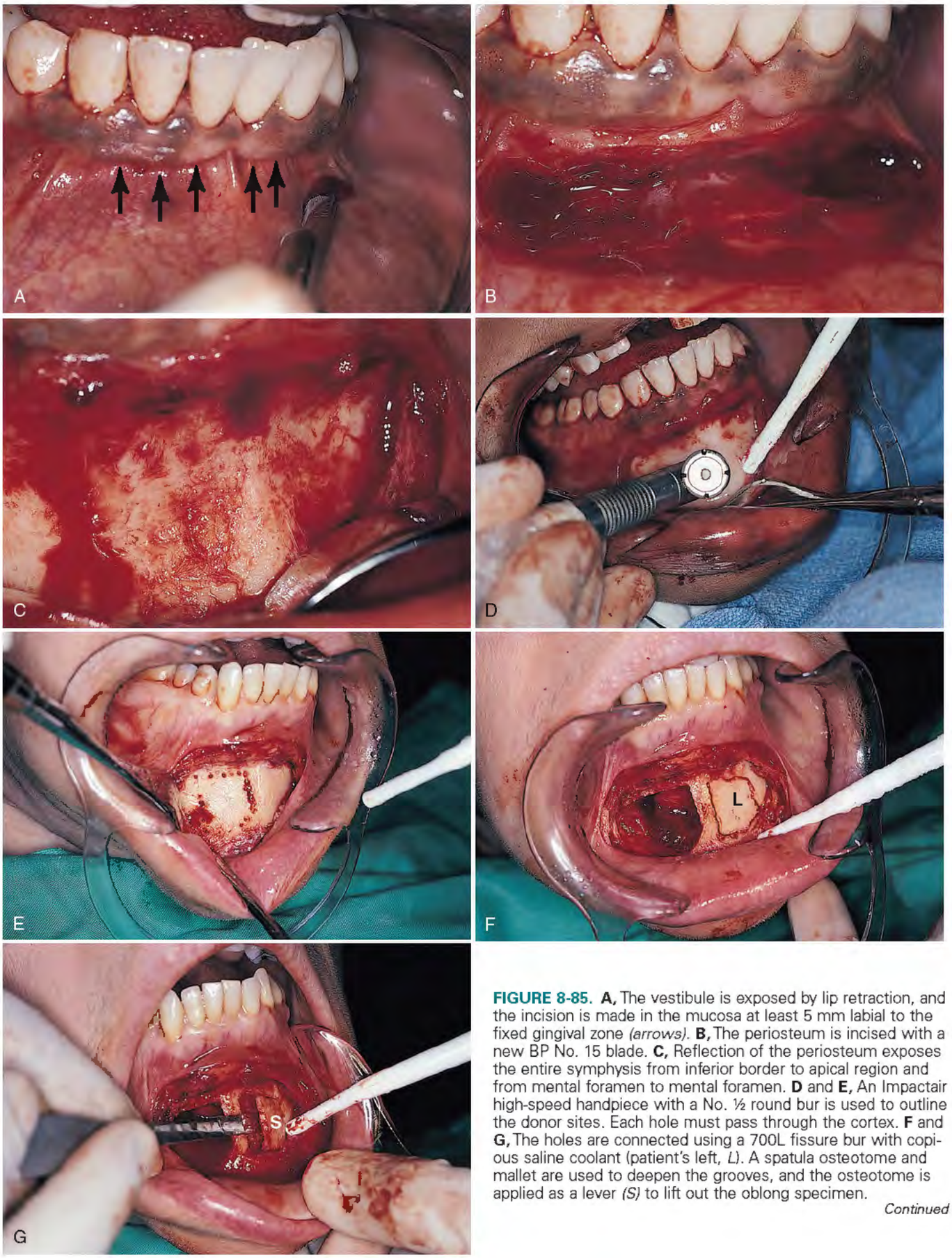


FIGURE 8-85. **A,** The vestibule is exposed by lip retraction, and the incision is made in the mucosa at least 5 mm labial to the fixed gingival zone *(arrows)*. **B,** The periosteum is incised with a new BP No. 15 blade. **C,** Reflection of the periosteum exposes the entire symphysis from inferior border to apical region and from mental foramen to mental foramen. **D** and **E,** An Impactair high-speed handpiece with a No. ½ round bur is used to outline the donor sites. Each hole must pass through the cortex. **F** and **G,** The holes are connected using a 700L fissure bur with copious saline coolant (patient's left, *L*). A spatula osteotome and mallet are used to deepen the grooves, and the osteotome is applied as a lever *(S)* to lift out the oblong specimen.

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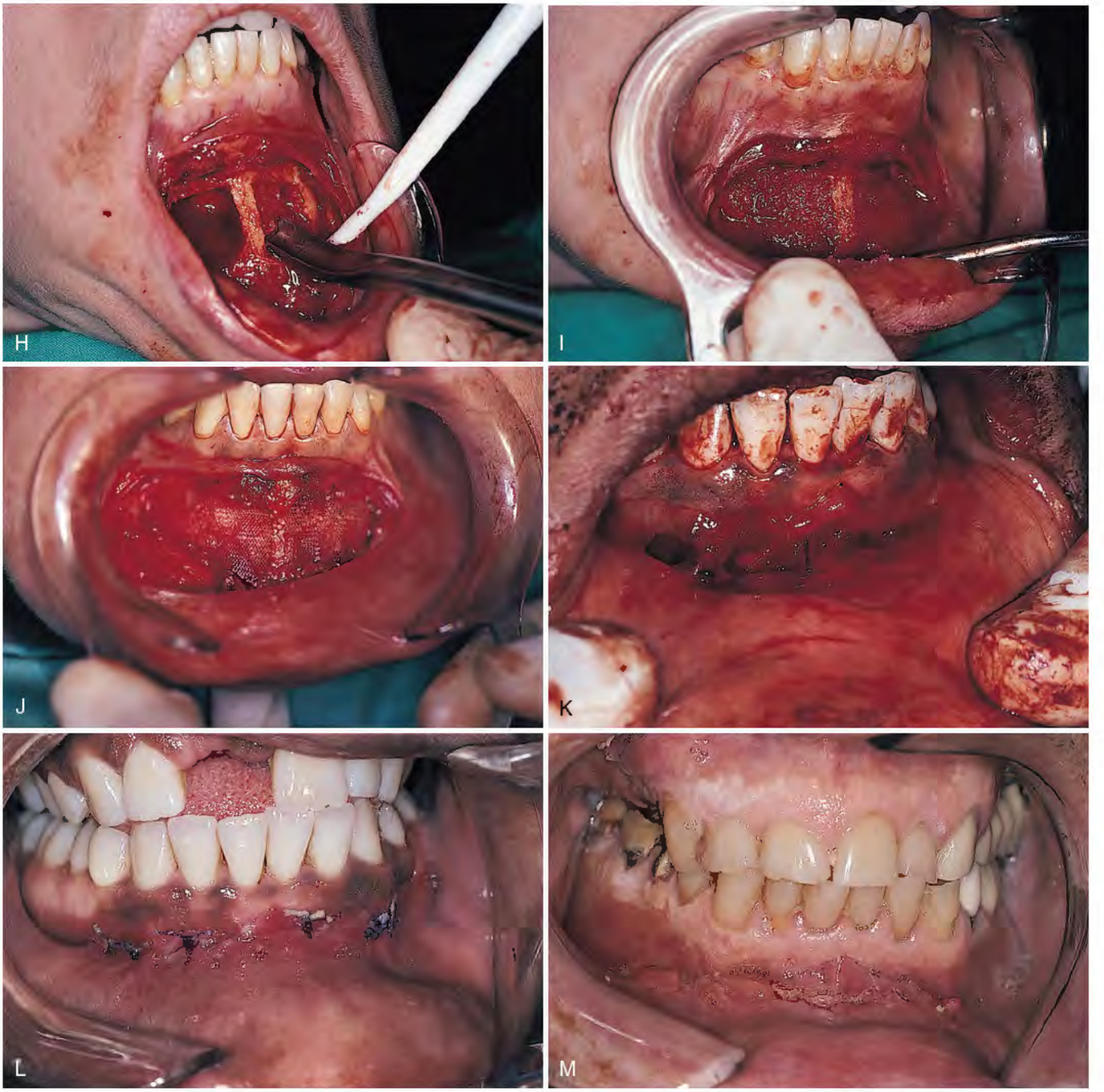

FIGURE 8-85, cont'd. **H,** A narrow gouge or curette (or both) are used to scoop the osteogenic spongiosa from the donor site. After the block has been removed, the marrow from beneath its former site is retrieved, with great care taken not to damage dental apices or mental nerves. **I,** When harvesting is complete, particulate HA is tamped into the defects. **J,** The HA particles are covered with a Vicryl mesh resorbable membrane, which remains stable as a result of the accrued fibrin. **K,** A deep closure of periosteum and mentalis fibers is performed with 4-0 polyglactic acid sutures. **L,** The mucosa is sutured in a horizontal mattress configuration. **M,** Six weeks after surgery, healing shows good tissue tone and a compliant, unencumbered vestibule and lip.

Care must be taken to protect the anteriorly looping mental bundles, the mandibular inferior border, its lingual cortex, and the dental apices.

When all the available medullary bone has been obtained, the surgeon proceeds to control bleeders and tamp dense, 20-mesh HA particles firmly into the oblong defects (Fig. 8-85, *I*). They are then covered with a resorbable membrane (Fig. 8-85, *J*) and closed in two layers: periosteum and muscle first, with interrupted 4-0 Polysorb or Biosyn suture (Fig. 8-85, *K*), and then the mucosa, with the same material, in a continuous, horizontal mattress configuration (Fig. 8-85, *L*). The harvested cortex (which should be particulated), spongiosa, and blood should be kept in a covered glass container.

A firm pressure dressing across the chin assuages postoperative edema and pain and presages a well-healed, functional vestibule (Fig. 8-85, *M*). The patient may note transient postoperative paresthesia of the lips and chin.

When a smaller monocortical graft lined with medullary bone is required, it is retrieved from the symphysis using the technique

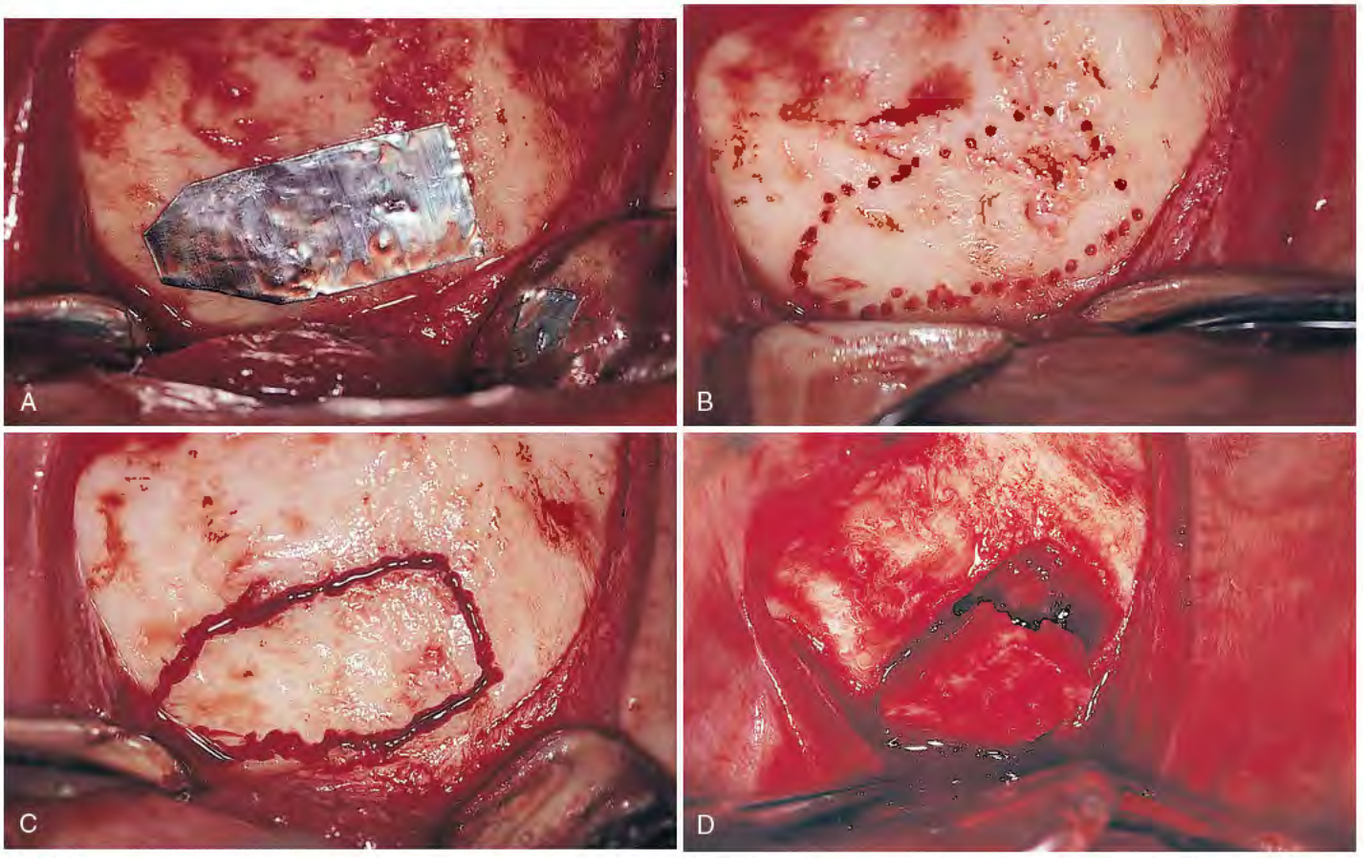

FIGURE 8-86. **A,** A sterilized, lead-sheet template (from a radiographic film) is trimmed over the defect and placed in the parasymphyseal donor area. **B,** A No. ½ round, high-speed bur is passed transcortically to transfer the outline to the bone. **C,** A 700L fissure bur is used to connect the holes, creating well-defined intramedullary grooves. **D,** The graft can be removed easily after the grooves are deepened with a spatula osteotome, which is then used for leverage. The graft is stored in the patient's marrow-derived blood until it can be attached to the host with lag screws.

outlined in the previous section (Fig. 8-86). If a specifically sized specimen is required for a monocortical graft, a smaller block of bone can be harvested. This can be done by using a sterilized sheet of periapical x-ray lead foil as a template and transferring it from the deficient site to the donor. The bur dots are used to outline the template (Fig. 8-86).

Trephine Retrieval

As an alternative to shaping and developing square or oblong osteotomies, which is performed by hand with a high-speed handpiece, burs, osteotomes, and mallets, a far more rapid technique can be performed that involves the use of surgical trephines driven by latch-type contra-angles or straight handpieces. These are available from Ace Surgical in 10-, 8-, 6-mm, and smaller diameters. They cut efficiently and remove plugs of cortical marrow bone quickly and cleanly (Fig. 8-87, *A* to *C*). Each has depth markings on the side to prevent injury of the lingual cortex.

These bony specimens do not yield quite as much graft material as the oblong segments because the osteotomies are smaller. Greater amounts can be harvested if multiple round cuts that overlap are made. After the trephine is used, gouges and curettes are used to retrieve additional marrow from beneath the cortical margins. Care must be taken not to cut through the lingual plate of bone. Because the surgeon's fingers will have developed high levels of tactile sense, brief experience with the trephines is instructive in regard to this important point. After the donor plugs and marrow have been removed, the sites are filled with HA, covered with Vicryl mesh, and closed in two layers (Fig. 8-87, *D*).

GRAFTING TO IMPROVE RIDGE DIMENSION FOR THE ACCOMMODATION OF IMPLANTS

Anterior Mandibular Width Deficiencies

Alveoloplasty

All surgical practitioners should become competent in alveoloplasty. Knife-edged ridges may require planing, and undercut reduction, or removal of sharp, spinous processes, before implant osteotomies are made. The incisions are made at the ridge crest, and soft tissues are reflected with care to preserve the integrity of the mucoperiosteal flaps. With rosette and fissure burs (always saline cooled), rongeurs, and bone files, the reduction, contouring, and smoothing of the bone are performed with precision (Fig. 8-88). Correction of the spinous or knife-edge ridge creates a plateau at the crest, which offers a broad enough surface to accommodate the planned root form implants. Of course, this alveoloplastic procedure sacrifices height, and the available vertical dimensions must be reassessed when the alveoloplasty is finished.

The results of the alveoloplasty can be tested by running a piece of gauze over the bone. The gauze should pass easily over the ridge, without shredding or pulling of any of its threads. When the altered alveolus passes this test, implants are placed, and closure is done

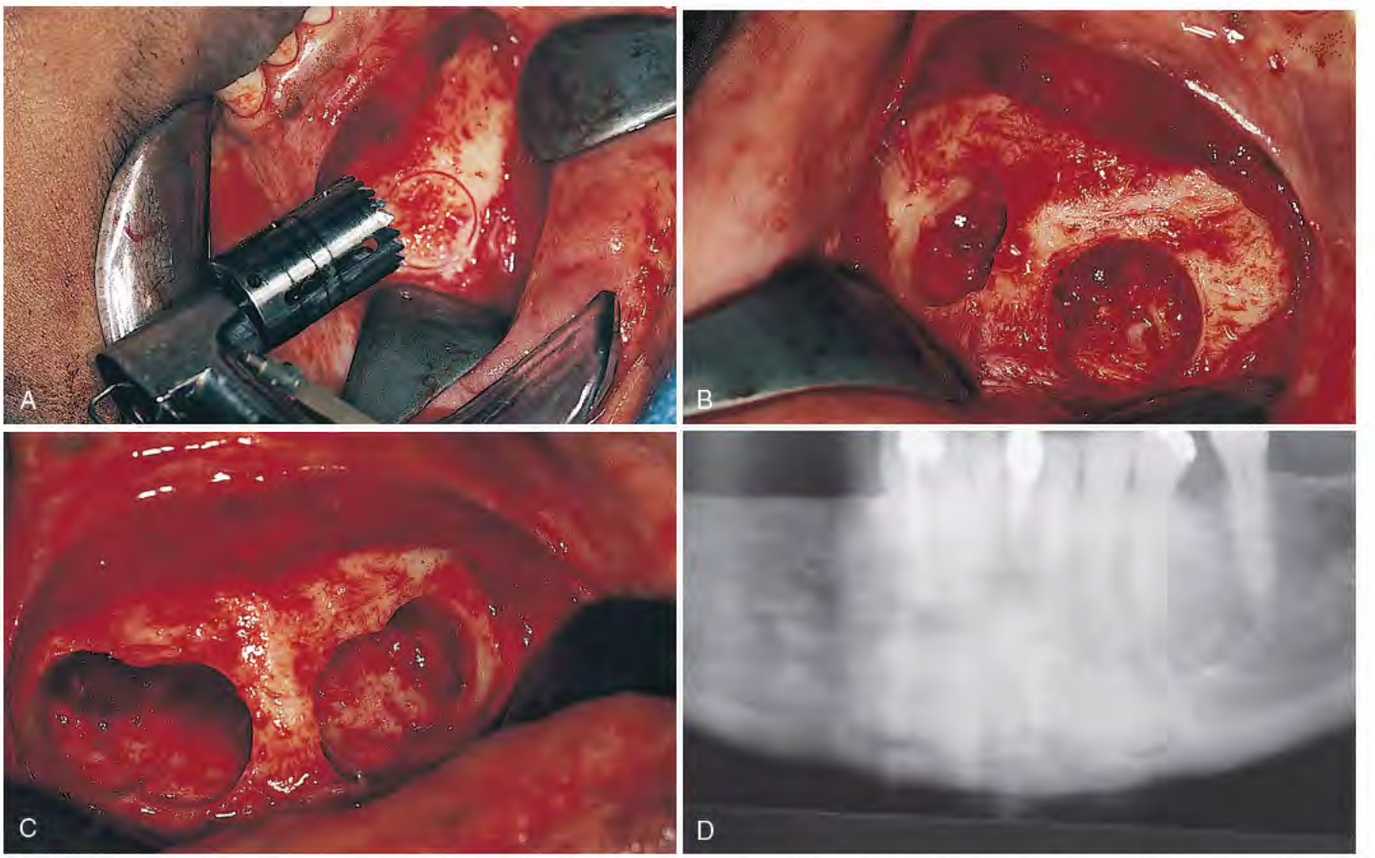

FIGURE 8-87. **A** and **B,** The largest available trephine (10-mm diameter) is used to make two transcortical intramedullary osteotomies. These osteotomies do not need further refinement with burs or osteotomes. Note the depth markers on the surface of the trephine. **C,** Additional bone can be retrieved by superimposing additional circular cuts. Donor specimens are easily removed; they snap out cleanly when leverage is applied. These specimens can be used as monocortical block grafts, or they can be particulated for use in the antral floor or other sites. Each round segment yields approximately 2.5 cc of particulated bone. **D,** A postoperative Panorex film shows the outlines of the grafts, now filled with HA.

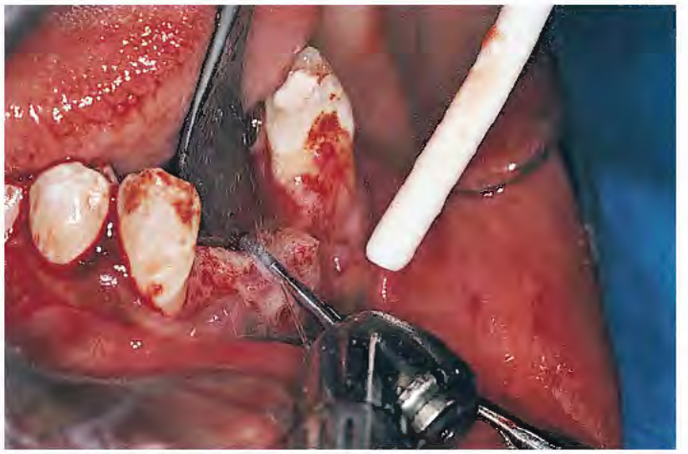

FIGURE 8-88. The Impactair is used with a fissure bur to broaden a ridge before implantation.

with either a box-lock or continuous horizontal mattress suture (see Chapter 7 for a complete set of illustrations).

Monocortical Block Grafting

Affixing a block of bone (Fig. 8-89, *A* and *B*) can augment the width and height of the anterior mandibular ridge. This block can be obtained from a bone bank or (preferably) from an autogenous source. Because some cortex is required, as well as an underlying marrow bed, the mandibular symphysis is an ideal site for harvesting the specimen. It is outlined by using a sterilized periapical film lead sheet as a template (Fig. 8-89, *C* to *E*). Instead of mincing the retrieved bone, the surgeon preserves it in its solid, retrieved condition. After the alveolus has been exposed and smoothed, the block is tailored to satisfy the needs of the deformity (Fig. 8-89, *F*). The block must be wide enough to serve as a labial mantle; it must be wide enough from the crest to its tapered inferior level.

If the defect is so significant that a graft from the symphysis is inadequate, some practitioners use a rib. Ribs have curvatures suitable for anterior mandibular use, and when they are split longitudinally, their interior surfaces contain marrow. Gentle handling permits more acute curvature, but if the rib fails to yield to finger pressure, bur cuts made on the lesser curvature at right angles to the rib facilitates compliance.

Regardless of the type chosen, the outer surface of the host and the inner surface of the graft are prepared so that maximum contact is created. However, cortex-to-cortex and cortex-to-marrow contact are both acceptable relationships. When this intimacy is achieved, either for a small defect or for an arch segment, the graft may be affixed with lag screws placed at strategic sites.

The graft is held in position with a Babcock clamp or manually held by the assistant. An Atwood 347 tapered diamond drill with saline coolant is used to drill through it and well into the host alveolus. The titanium screw can be taken from any microfixation or minifixation kit (Synthes, Osteomed, Leibinger, and others).

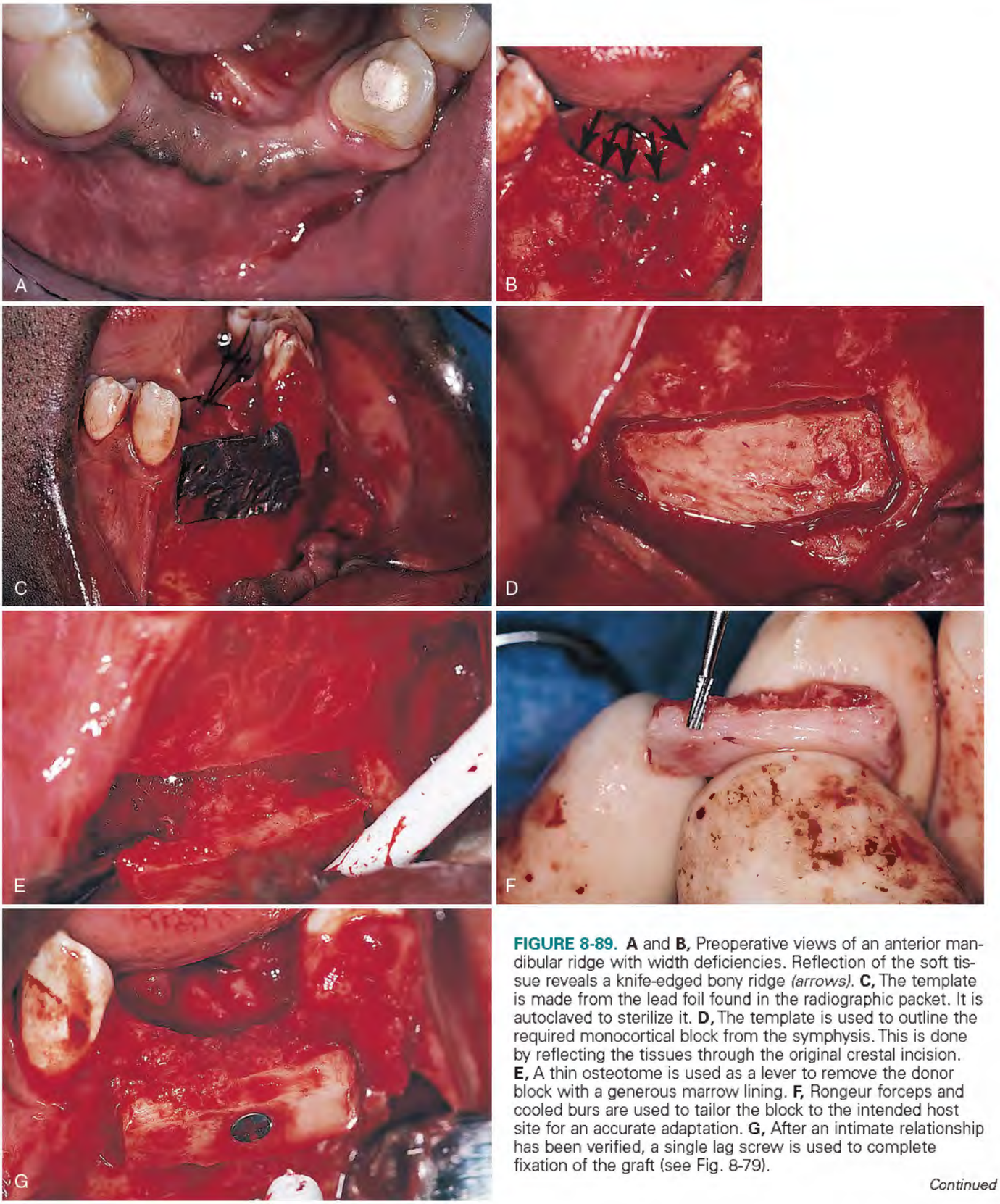

FIGURE 8-89. **A** and **B,** Preoperative views of an anterior mandibular ridge with width deficiencies. Reflection of the soft tissue reveals a knife-edged bony ridge *(arrows).* **C,** The template is made from the lead foil found in the radiographic packet. It is autoclaved to sterilize it. **D,** The template is used to outline the required monocortical block from the symphysis. This is done by reflecting the tissues through the original crestal incision. **E,** A thin osteotome is used as a lever to remove the donor block with a generous marrow lining. **F,** Rongeur forceps and cooled burs are used to tailor the block to the intended host site for an accurate adaptation. **G,** After an intimate relationship has been verified, a single lag screw is used to complete fixation of the graft (see Fig. 8-79).

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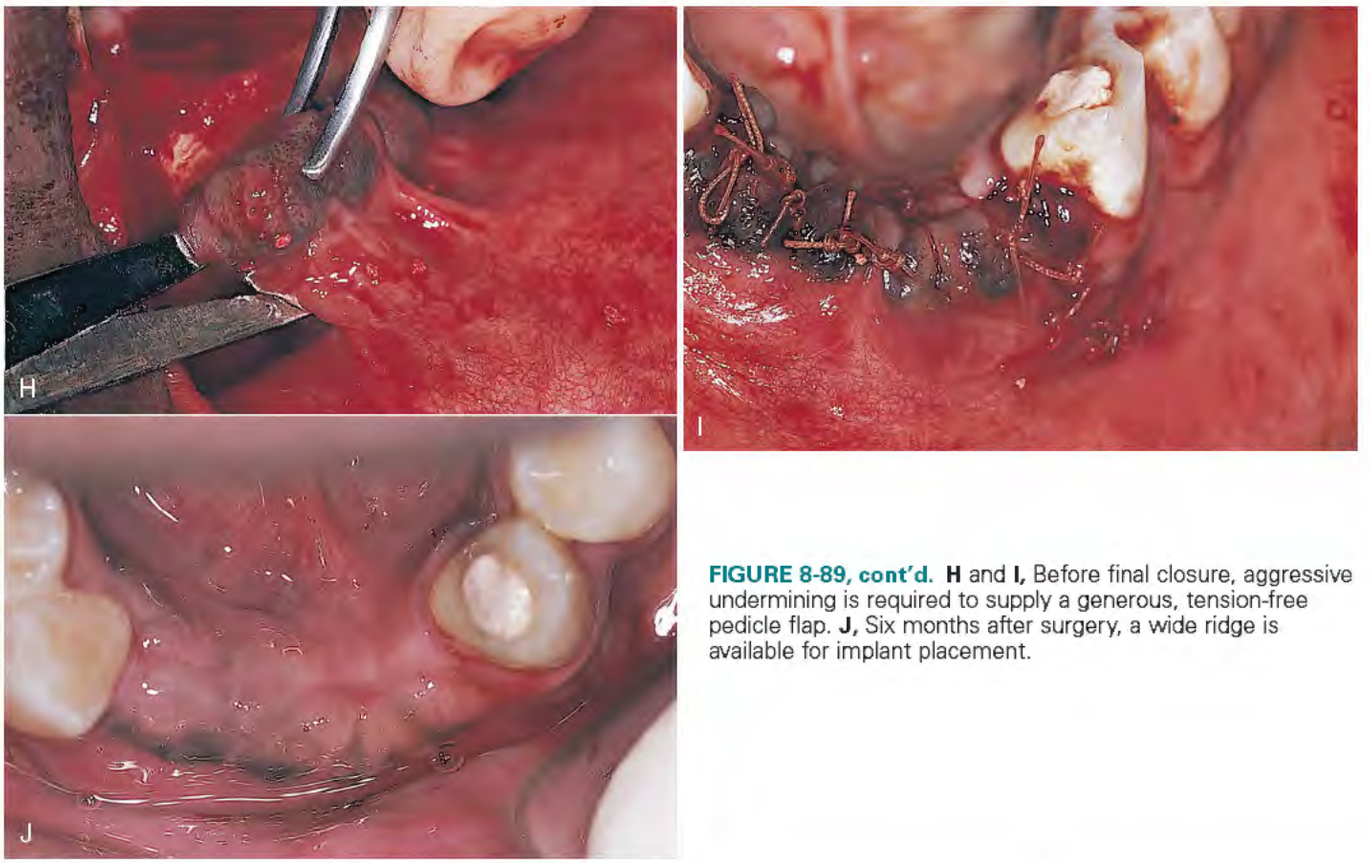


FIGURE 8-89, cont'd. **H** and **I,** Before final closure, aggressive undermining is required to supply a generous, tension-free pedicle flap. **J,** Six months after surgery, a wide ridge is available for implant placement.

The hole in the overlying graft is enlarged with the Atwood drill so that the screw threads do not bite; however, it should not be so large that the head is unable to lock the graft to the host site.

For small blocks, one central screw is satisfactory. For longer ones, two or three are required. After screw fixation (Fig. 8-89, *G*), the donor site is filled with HA and covered with a resorbable GTRM.

Closure of the host site is not simple. The surgeon must be prepared to undermine the labial mucosa to complete a tension-free pedicle suture line (Fig. 8-89, *H* and *I*). The results usually are beneficial, and ridge improvement suitable for the placement of implants usually is seen 6 months later (Fig. 8-89, *J*).

Anterior Mandibular Height Deficiencies

Monocortical Grafts

The technique for adding height to the ridge is the same as for adding width. However, the graft is prepared differently. If additional vertical dimension is required, the block must be hollowed and made to fit over the ridge just as a saddle fits on a horse's back. It is vital that residual marrow be left on the internal surface. Lag screw fixation is best performed on the labial flange of the graft at appropriate inferior locations. Both the labial and lingual aprons are tapered so that they merge gently against the residual ridge.

Inferior Border Augmentation

In patients with an extremely atrophied mandible (i.e., 1 to 6 mm thick), even though subperiosteal implants are the only viable means of rehabilitation, problems may arise because of settling. This may result in total resorption of the residual mandible, with subsequent submental skin fistulization and even exposure of a peripheral strut through the skin (Fig. 8-90). A variety of techniques can be used to increase the size of the mandible before implants are placed. One approach is augmentation of the alveolar ridge with biologic or synthetic materials.

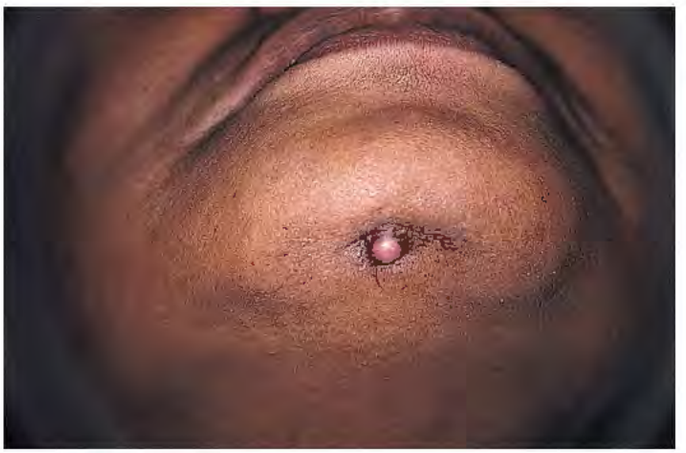


FIGURE 8-90. Submandibular fistulas are created when mandibular subperiosteal implants settle as a result of resorption.

Another therapeutic solution is alteration of a CAD-CAM–generated model by adding up to 1 cm to its alveolar height using wax. The model thus created is reproduced in Vel Mix stone. The implant is designed to rest only minimally on this new area, with the peripheral struts gaining the greatest support by being extended to unaltered original cortical areas (i.e., the inferior border, symphysis, genial tubercles, and rami). When the implant thus produced is seated, a large void represents the areas built up in wax. Before closure, but after the infrastructure has been seated and its stability assessed, the voids and all struts are filled with a synthetic mesh particulate graft material mixed with DFDB.

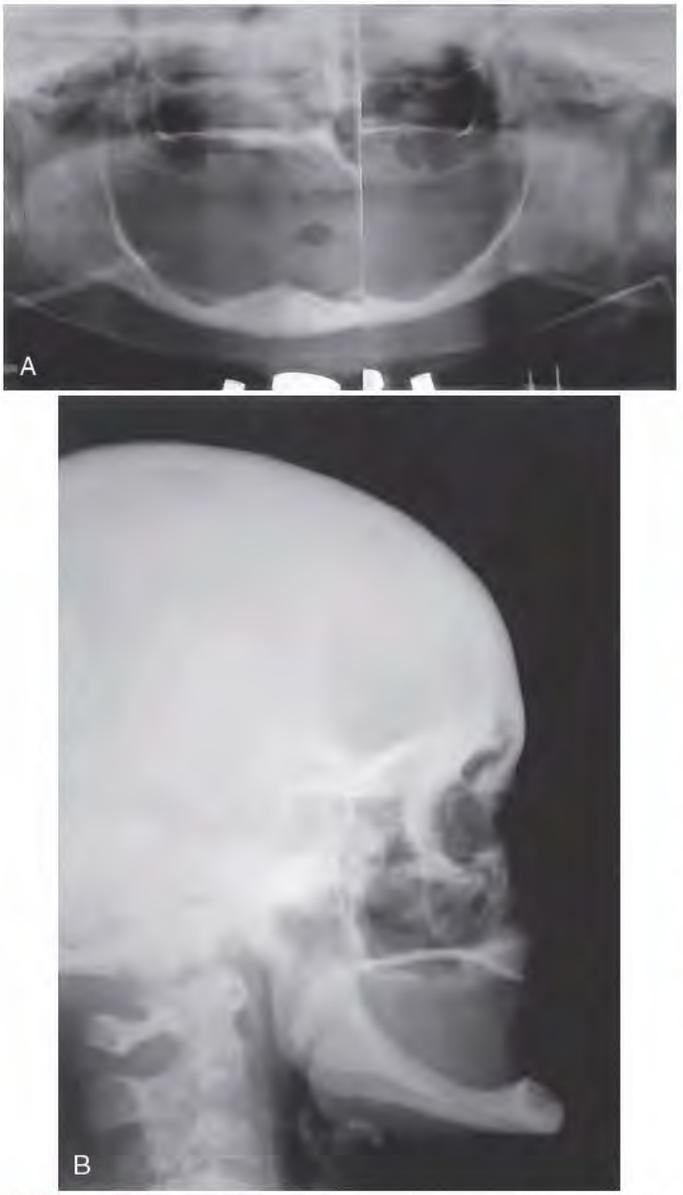


FIGURE 8-91. **A,** A Panorex film of a severely atrophied mandible. In such cases, even a subperiosteal implant may not be sufficient without augmentation. **B,** The cephalometric view offers another dimension showing extreme atrophy.

A third method of increasing mandibular height is to augment the mandible's inferior border (Fig. 8-91). Patients should be advised that problems such as redundant neck tissues, collapsed lower facies, and protruding or pouting lips are not improved by intraoral surgery, changes in ridge structure or morphology, or changes in vertical dimension. After inferior border augmentation, if a subperiosteal mandibular implant or root forms are planned, they should be placed into or atop the original cortical bone. This has the advantage of discouraging subimplant and peri-implant resorption, which is less than would be expected if the implants were placed on or into newly grafted bone.

First-Stage Procedure

As described previously, in the operating room, marrow is harvested from the anterior iliac crest and store in a saline-moistened, covered glass container (Fig. 8-92, *A*).

The patient's head is hyperextended, some sheets are placed under the shoulders, and the face and neck are prepared and draped. A

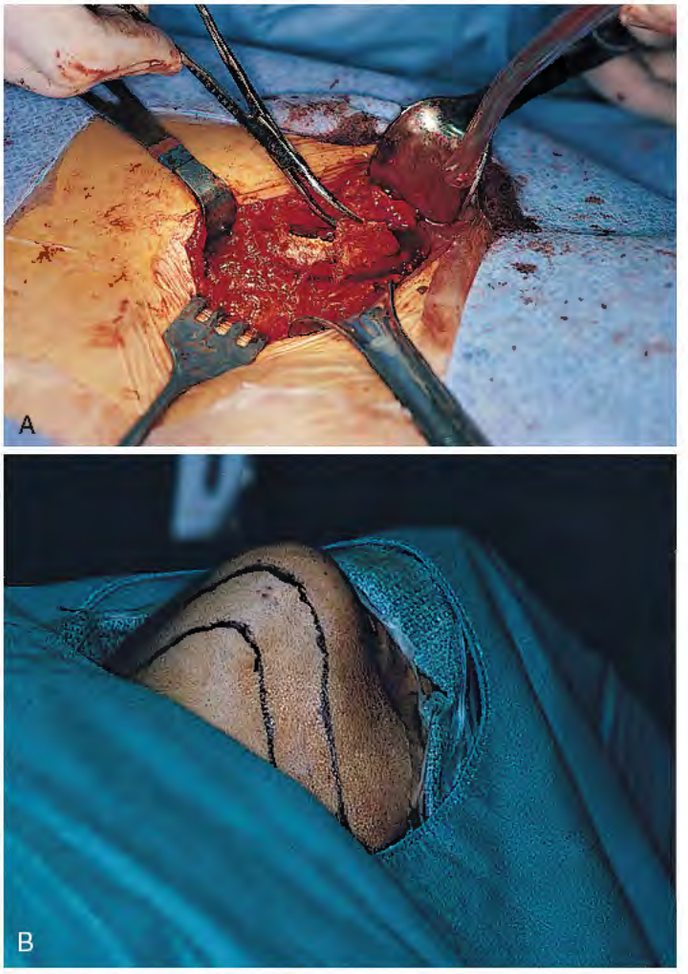


FIGURE 8-92. **A,** Autogenous bone for mandibular augmentation is harvested marrow from the anterior iliac crest. **B,** Inferior border augmentation, performed in the operating room, shows a skin scribe locating the mandible and a second one indicating the location of the incision.

curved incision is made 3 cm medial to the inferior border of the mandible through skin (Fig. 8-92, *B*). The blade is changed, bleeders are clamped and tied, and the dissection is continued through fascia and platysma. The procedure is designed to be sufficiently medial that injury to the rami marginalis mandibulae is unlikely. The digastric muscles appear, and they should be detached from the inferior border to expose the investing periosteal envelope.

A new No. 15 blade is used to incise the periosteum directly at the mandibular inferior border; the lateral surfaces are exposed up to the mental foramina anteriorly and even higher in the rami regions. On the medial (lingual) surfaces, about 4 mm of exposure is required to accommodate the flange of a titanium mortise mesh; therefore the aponeurosis must be elevated to that extent (Fig. 8-93).

With the assistant exposing one side of the mandible only and using Army/Navy retractors, the surgeon inserts the first end of the mortise mesh into place. The contralateral flaps then are retracted so that the other end of the mesh can be slipped into position. The length of the mesh at each end should be noted by palpation and inspection. Its adaptation to the inferior border and the angles is crucial; therefore, it must be cut and trimmed as needed for precise accommodation. Small slits may be made so that the contouring pliers are able to create optimum conformity.

All peripheral margins are smoothed, and the seating of the prosthesis is rehearsed several times until it can be carried out with

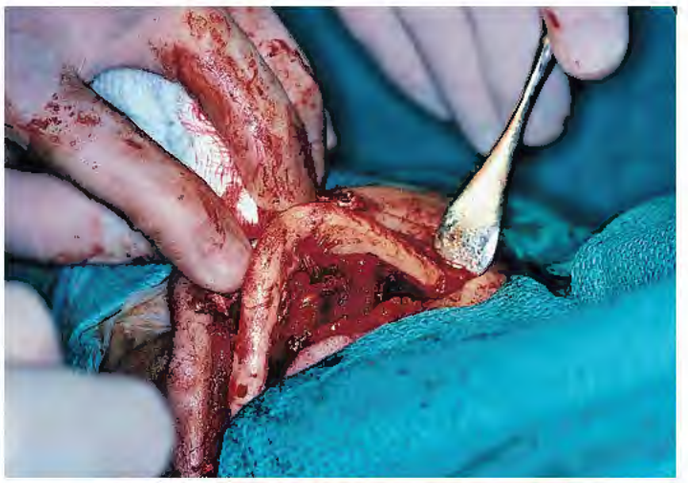


FIGURE 8-93. After dissection and reflection, the inferior border of the mandible is exposed fully.

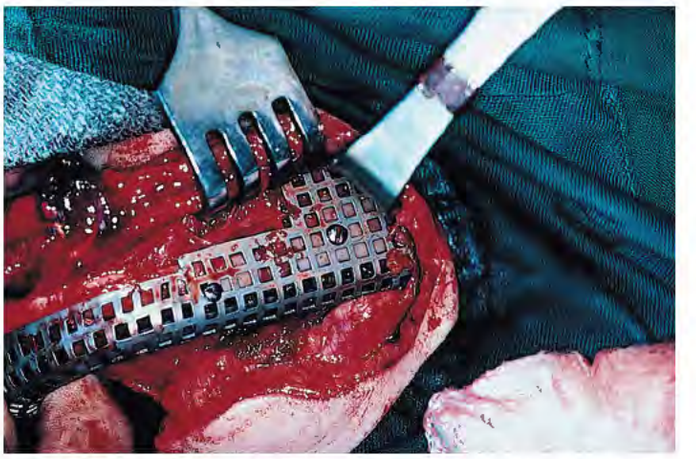


FIGURE 8-95. The mesh prosthesis filled with graft material is fixed to the mandible with self-tapping screws.

predictable ease. The mesh is lined with a precut, sterilized, 4-μm Millipore filter and tamped gently with moist cotton balls to keep it well adapted. It is filled with the harvested marrow, or marrow and particulated cortex if needed, and placed over the inferior border, following the exact rehearsal protocol (Fig. 8-94). The upper layer of fenestrations of the mesh must remain uncovered by the bone graft material to allow it to overlap the mandible for screw fixation. Careful attention must be paid to the posterior ends of the mesh. They should be contoured so that a clear, well-delineated angle is present at each end.

The assistant surgeon keeps the loaded mesh in place with upward pressure as a single hole is tapped through a mesh fenestration into the mandible, at a site near the inferior cortex designed to prevent nerve injury. The Atwood 473 diamond point is used in the Hall drill for preliminary tapping, and a titanium screw (Synthes or Osteomed) is then used with a titanium-tipped screwdriver. Three to five additional, strategically placed screws hold the bone-filled mesh firmly and securely in place against the mandible (Fig. 8-95).

The wound is irrigated and closed anatomically in layers. The detached digastric, mylohyoid, masseter, and medial pterygoid fibers are sutured with 4-0 Polysorb or Vicryl suture on a tapered needle to fenestrations in the mesh, thereby anatomically reattaching them. The skin is closed with 5-0 or 6-0 nylon suture. Redundant skin, if any, is excised, which creates a cervical rhytidectomy, but suturing under tension should be avoided. The skin is dressed with Telfa, fluff, and 4-inch Elastoplast (Fig. 8-96).

Second-Stage Procedure

A period of 6 months is allowed for maturation of the inferior border graft. At that time, the patient is returned to the operating room, and the metal mesh is removed by retracing or excising the old incision. When the mesh has been exposed, the screws are backed out, the mesh is cut into three or four segments with the Atwood diamond drill, and each segment is removed separately (Fig. 8-97). Closure is done in the same manner as previously.

The graft material will have become smoothly incorporated onto the mandible, and both mandibular and lower facial dimensions will have increased attractively (Fig. 8-98). Eight weeks later, a CAD-CAM or classically constructed subperiosteal implant or root forms, as desired, may be placed as described in appropriate sections of this text.

If the patient or surgeon is reluctant to remove the mesh, which prohibits the use of a computed tomography (CT) scan for CAD-CAM fabrication, a two-stage subperiosteal implant by direct bone impression may be fabricated and placed 6 months after the inferior border augmentation (Fig. 8-99).

As an alternative, parasymphyseal root forms may be placed in the newly grafted mandible.

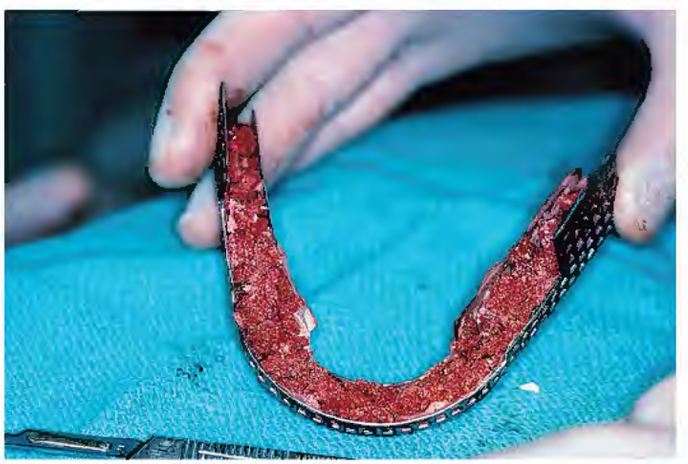


FIGURE 8-94. An Osteomed titanium inferior border mortise form mesh is lined with Millipore filter and filled with the iliac crest marrow harvested in Fig. 8-92, *A*.

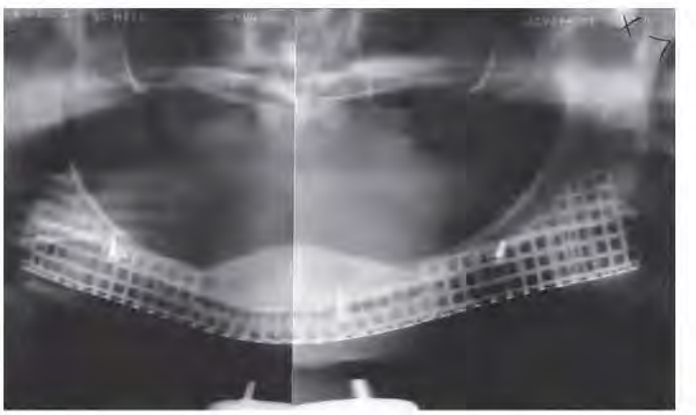


FIGURE 8-96. The graft material consolidates after 3 months and becomes bonded to the inferior border, augmenting it. This acts as a safeguard against implant settling.

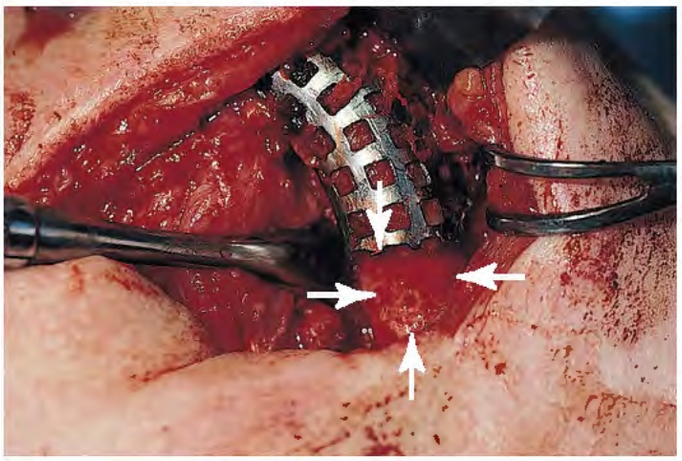


FIGURE 8-97. Removal of the titanium reveals of new, cortically enhanced bone within its contours *(arrows)*.

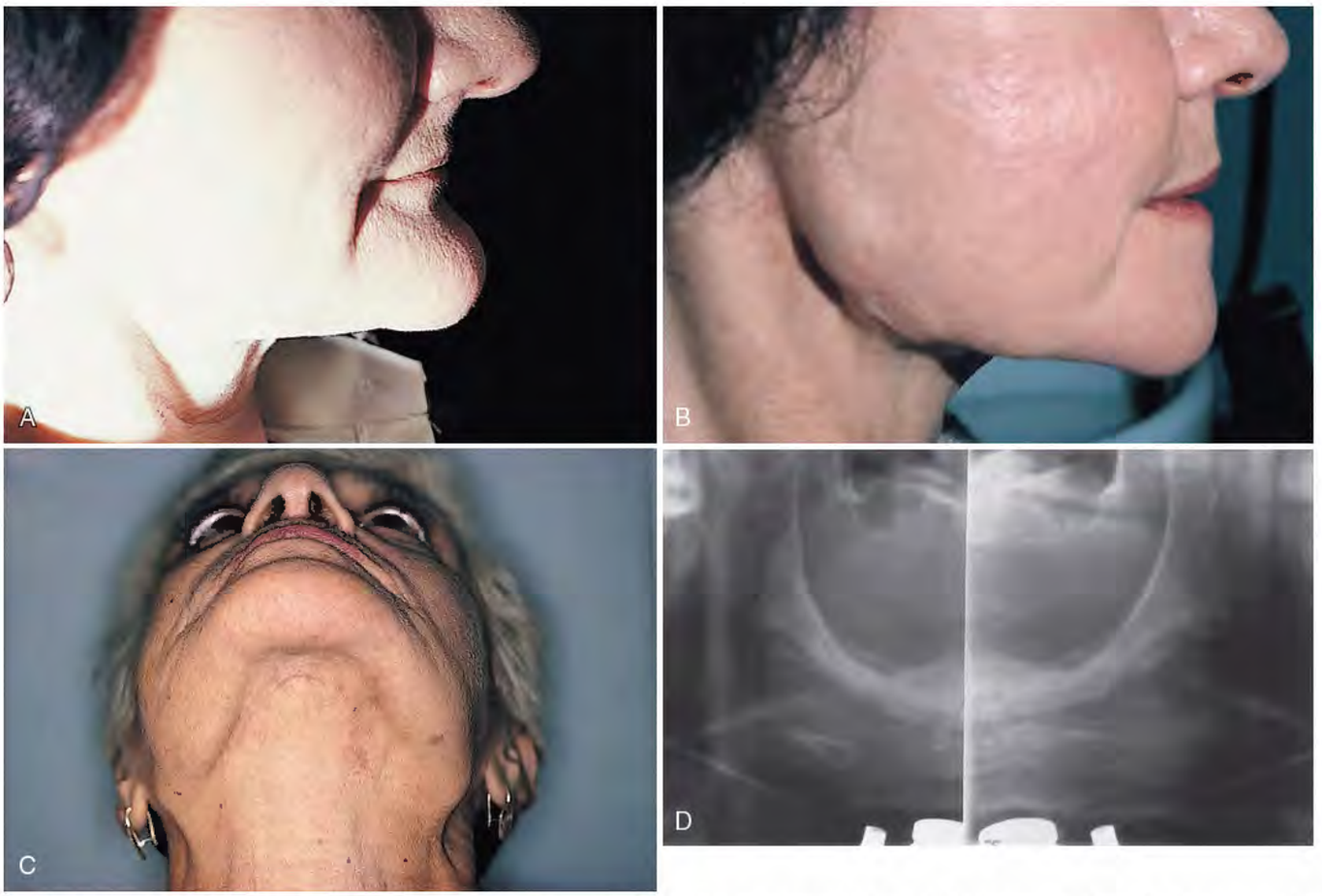


FIGURE 8-98. **A,** Preoperative lateral view of a woman in need of mandibular augmentation. **B,** Postoperative view after augmentation. Note the increased height of the lower face, the improved appearance of the skin of the neck, and the improved mandibular posture. **C,** If the incision is placed strategically, the postoperative results are esthetically pleasing. **D,** A Panorex film of the mandible after the removal of the titanium mesh shows mineralization and consolidation of the inferior border graft.

Posterior Mandibular Width Deficiencies

Alveoloplasty

Alveoloplasty in cases of knife-edge ridges, as described earlier for the anterior mandible, may serve the need to prepare the posterior ridges for implant placement. However, as mentioned previously, height is sacrificed in an alveoloplasty, and the surgeon may be forced to seek a solution by grafting.

Monocortical Block Grafting

Symphyseal monocortical block onlays also can be used in the region posterior to the mental foramina. They can be added to the buccal or lingual surface (or both) in a sandwich-type form (Fig. 8-100). Sufficient alveolar bone must be present above the mandibular canal to allow fixation screw entry without injury to the neurovascular bundle.

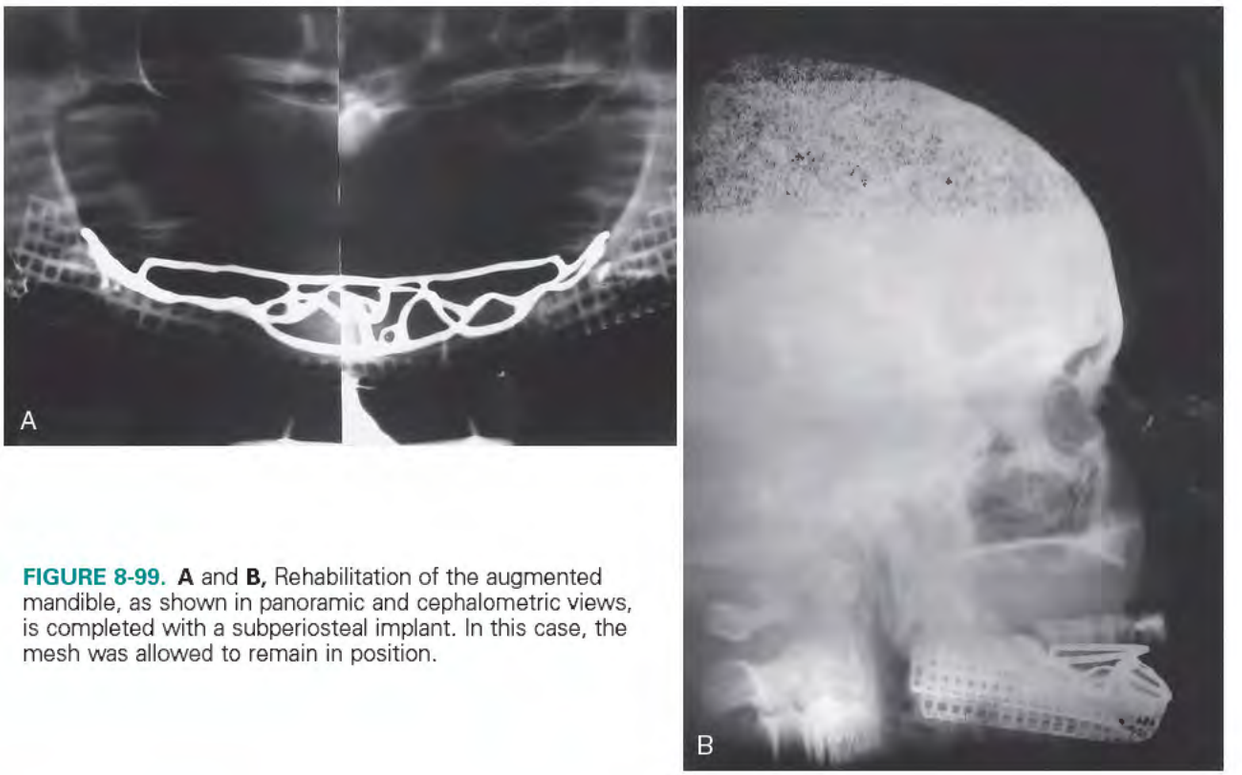


FIGURE 8-99. **A** and **B,** Rehabilitation of the augmented mandible, as shown in panoramic and cephalometric views, is completed with a subperiosteal implant. In this case, the mesh was allowed to remain in position.

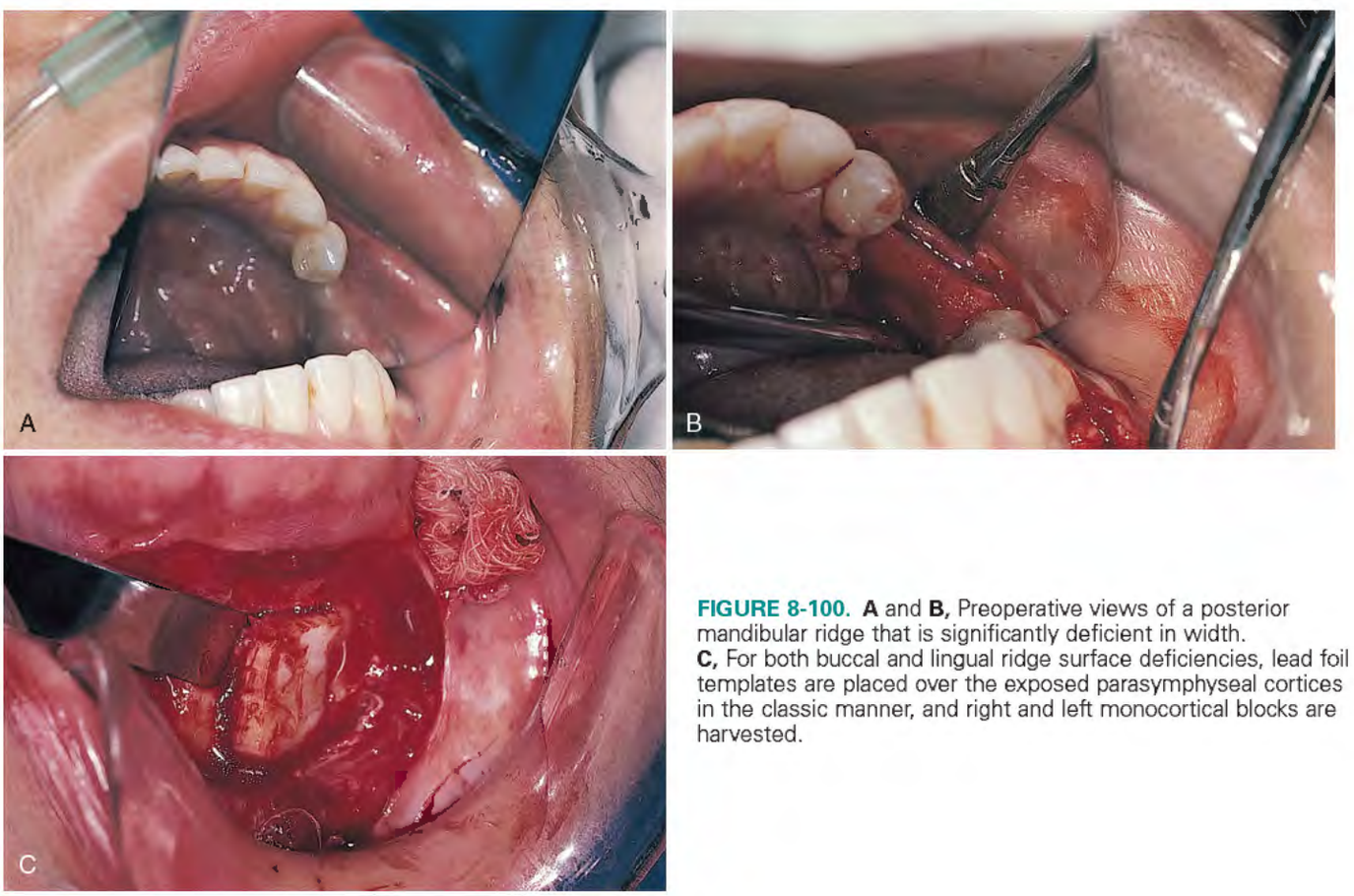


FIGURE 8-100. **A** and **B,** Preoperative views of a posterior mandibular ridge that is significantly deficient in width. **C,** For both buccal and lingual ridge surface deficiencies, lead foil templates are placed over the exposed parasymphyseal cortices in the classic manner, and right and left monocortical blocks are harvested.

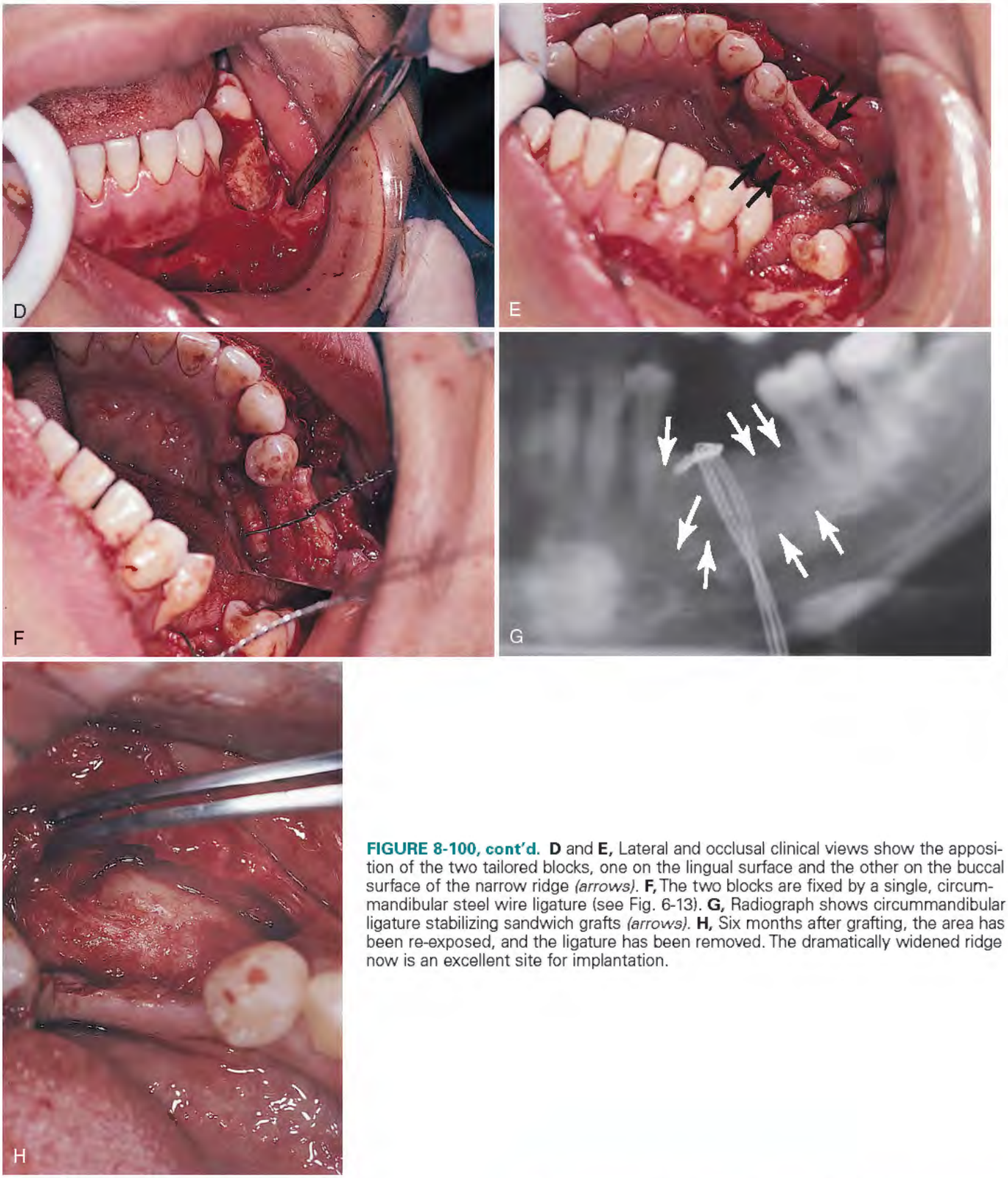


FIGURE 8-100, cont'd. **D** and **E,** Lateral and occlusal clinical views show the apposition of the two tailored blocks, one on the lingual surface and the other on the buccal surface of the narrow ridge *(arrows)*. **F,** The two blocks are fixed by a single, circummandibular steel wire ligature (see Fig. 6-13). **G,** Radiograph shows circummandibular ligature stabilizing sandwich grafts *(arrows)*. **H,** Six months after grafting, the area has been re-exposed, and the ligature has been removed. The dramatically widened ridge now is an excellent site for implantation.

Posterior Mandibular Height Deficiencies

Monocortical Block Grafting

Block grafting may be used to correct atrophy, as previously described for the anterior mandible. If this can be done, significant or total loss of the vestibules is a predictable sequela. Secondary vestibuloplasty (see Chapter 7) is required using free palatal grafts, buccal split-thickness pedicles, or an alloplast (AlloDerm).

Mandibular Neuroplasty and Nerve Management

If finding additional vertical height by placing an implant below the level of the mandibular canal becomes important, the neurovascular bundle is removed from its confines (Fig. 8-101, *A* and *B*). An incision is made at the crest of the ridge from the retromolar pad anteriorly to the most distal tooth in position; it is continued in the crevicular gingivae to the canine and then curved forward toward the inferior border.

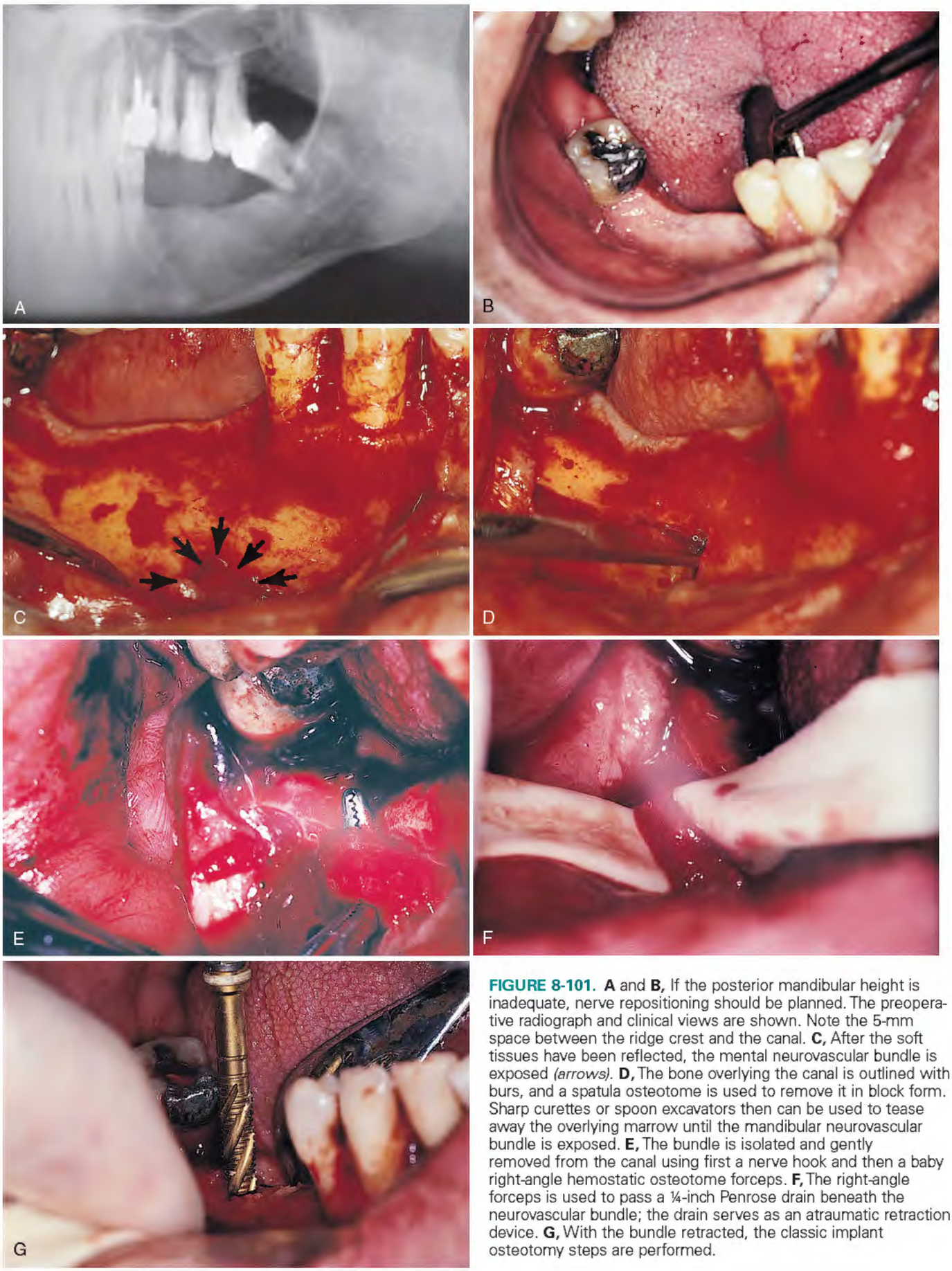


FIGURE 8-101. **A** and **B,** If the posterior mandibular height is inadequate, nerve repositioning should be planned. The preoperative radiograph and clinical views are shown. Note the 5-mm space between the ridge crest and the canal. **C,** After the soft tissues have been reflected, the mental neurovascular bundle is exposed *(arrows)*. **D,** The bone overlying the canal is outlined with burs, and a spatula osteotome is used to remove it in block form. Sharp curettes or spoon excavators then can be used to tease away the overlying marrow until the mandibular neurovascular bundle is exposed. **E,** The bundle is isolated and gently removed from the canal using first a nerve hook and then a baby right-angle hemostatic osteotome forceps. **F,** The right-angle forceps is used to pass a ¼-inch Penrose drain beneath the neurovascular bundle; the drain serves as an atraumatic retraction device. **G,** With the bundle retracted, the classic implant osteotomy steps are performed.

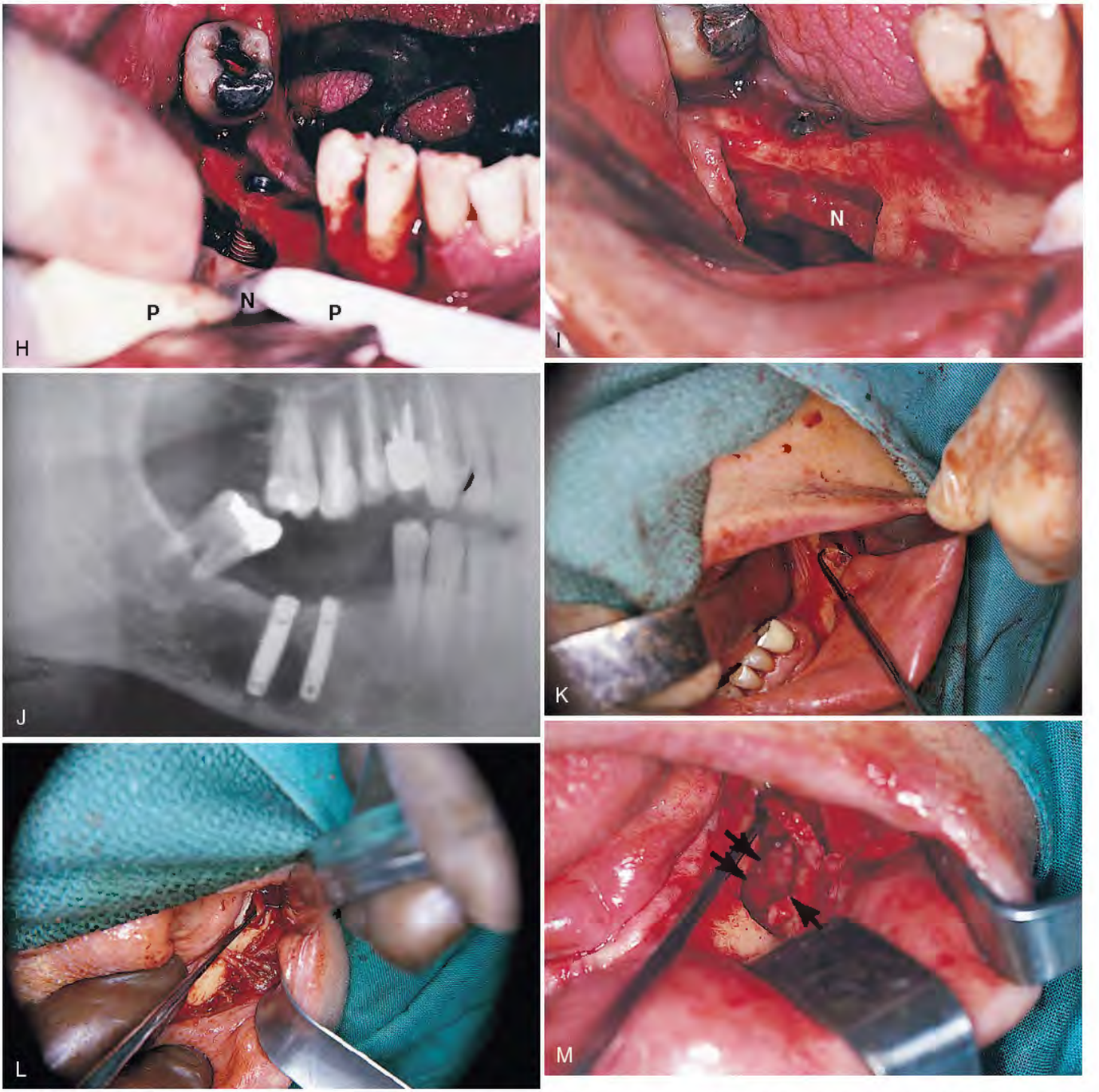


FIGURE 8-101, cont'd. **H,** With the neurovascular bundle *(N)* retracted by the Penrose drain *(P),* these Steri-Oss implants are placed almost to the inferior border of the mandible. **I,** After the requisite Colla-Cote has been placed to cushion the implant infrastructures, the neurovascular bundle is gently replaced; it is insulated with a moistened collagen sheet, and the wound is closed. **J,** The postoperative radiograph shows the extent to which an altered mandible may be used. **K,** As an alternative to removing the mandibular neurovascular bundle from the canal alone, which sometimes is physically restrictive, a mentomandibular bundle continuum may be mobilized. This is done by exposing the mental foramen and using it as a guide to locate and expose the contents of the canal. **L,** The round bur is used first, followed by the round diamond to extend the initial osteotomy anteriorly until the posterior osseous rim of the mental foramen is picked and curetted away. **M,** When the distal half of the foramen *(arrows)* and its canal are removed, the contiguous defects thus created allow comfortable retraction of the mentomandibular bundle, giving wider access to the potential implant host site.

A sponge is used to elevate the mucoperiosteum to the level of the mental foramen; this reveals the emerging neurovascular bundle (Fig. 8-101, *C*), which is protected with a periosteal elevator or other small retractor. Then, the surgeon uses a No. 8 round bur in a high-speed Impactair handpiece and, starting at a point 1 cm distal to the foramen, brushes the bone away from the mandibular cortex overlying the canal with gentle, light strokes. The procedure is continued posteriorly to a point at least 3 cm past the most distally planned implant site, until an oblong osteotomy has been outlined. This cortical block is removed by using a spatula osteotome as a lever (Fig. 8-101, *D*).

With careful effort and exquisite technique, using sharp spoon excavators or a slowly turning round bur in a straight handpiece, the surgeon exposes the neurovascular bundle lying in the canal. A Kerrison forceps enlarges the osteotomy until the full diameter of the canal is accessible. Then, a blunt nerve hook is used to lift the

bundle from its canal. The internal environment of the canal is lined with ossicles that cling tenaciously to the bundle; gentle teasing will release it.

The thin, fragile structure is best retracted with a length of ¼-inch Penrose drain, which can be passed readily with a baby right-angle hemostatic forceps (Fig. 8-101, *E* and *F*). A "nerveless" mandible has been created, which now is available for more aggressive implantation.

After the neuroplasty, the implants may be placed the full distance to the inferior border (Fig. 8-101, *G* and *H*). The displaced neurovascular bundle is laid gently into position over a tailored length of Colla-Cote shield, which is interposed between it and the implants (Fig. 8-101, *I*). A second strip of Colla-Cote is used to cover the bundle, a synthetic graft is placed to the level of lateral cortex, and the flaps are sutured for an anatomic closure (Fig. 8-101, *J*).

An alternative procedure, although more invasive and complicated, involves mobilizing the mental and mandibular bundles as a single unit by eliminating the entire distal half of the foramen. This may present significant difficulties because of the complex and labyrinthine course of the mental branch. However, it does afford far greater flexibility in retraction of the neurovascular bundle.

A sponge is used to evaluate the mucoperiosteum to the level of the mental foramen, revealing the emerging neurovascular bundle (Fig. 8-101, *K*). It is protected with a periosteal elevator or other small retractor. A No. 8 round bur is used in a high-speed Impactair handpiece to brush the bone away from the foramen's distal periphery with gentle, light strokes, directly through the lateral mandibular cortex. The procedure is continued posteriorly to a point at least 2 cm past the most distally planned implant site (Fig. 8-101, *L*). With careful, patient effort, the neurovascular bundle lying in the canal becomes completely visible. The osteotomy is enlarged until the full diameter of the canal is accessible. The bur is changed to a No. 6 round diamond, and while the mental bundle is protected, the distal or posterior half of the foramen is brushed away to an eggshell thickness. The remainder is removed with sharp spoon excavators. The combined mandibulomental bundle then is lifted from its crypt with a nerve hook (Fig. 8-101, *M*).

In surgical procedures of the palate, the greater palatine bundles are never cut when a flap is elevated. The integrity of these nerves and, particularly, the arteries must be maintained, or the flap will fail. The incisive bundle, however, may be sacrificed with small risk.

Anterior Maxillary Width Deficiencies

Monocortical Block Grafting

In addition to monocortical block grafting, which is performed in the maxilla using the same technique as for the mandible, the relatively elastic anterior maxillary ridge permits a number of more versatile and diverse techniques for width augmentation (Fig. 8-102).

Expansion by Longitudinal Splitting

A crestal incision is made, and the mucoperiosteum is reflected with care to avoid tearing it. The lower edge of the ridge is flattened and refined with a side-cutting rongeur and bone files to present a plateau sufficiently wide to allow entry of a No. ½-round and then a No. 699XXL high-speed bur (Fig. 8-103, *A* and *B*). This bur is used to make perforations to the full depth of its cutting surface (Fig. 8-103, *C*). If the bur holes are well aligned and oriented in a midcortical direction, they are connected into a groove. This groove is deepened to the depth of the planned implants, with great care taken to avoid perforating the labial or palatal plates (Fig. 8-103, *D*).

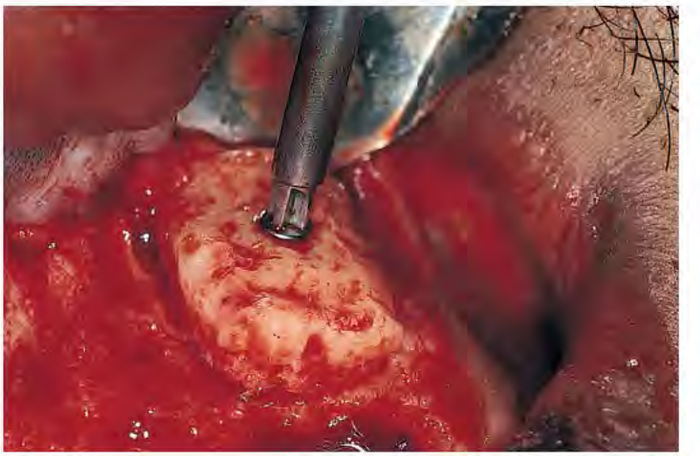


FIGURE 8-102. Anterior maxillary width deficiencies can be improved using the block grafting techniques described in Fig. 8-89, *G*. Here, a chin-derived monocortical onlay block graft has been fixed to the anterior maxilla with a single titanium lag screw.

Next, a spatula osteotome is placed in the osteotomy. It is tapped with a mallet to the planned depths in a stepwise, methodical pattern until an evenly created, full-length groove has been placed in the entire operative area. The osteotome is used as a lever to gently expand both the labial and palatal walls (Fig. 8-103, *E*). Skill and sensitivity are essential qualities in carrying out these expansion maneuvers, or cortical fracture can occur, possibly requiring withdrawal from the operative field. If the two bone plates can be expanded to the width of the proposed implants (minimally, 3.25 mm), and even better, some medullary bone remains as an internal lining, the implants can be placed with confidence. Using the Steri-Oss or similar osteotomes at each site, pushing and rotating directly upward with gentle finger pressure, offers additional assistance in achieving the requisite dimensions.

Because threaded implants have sharp flutes, bone microfractures may as the implants self-tap their pathways to the planned apical levels. When implants are to be placed in altered ridges, press-fit implants, such as the Calcitek (3.25 mm diameter) or IMZ (3.3 mm diameter) enter the osteotomies with fewer complications. In addition, these implants, as well as the Steri-Oss press-fit design, have smooth-sided metal try-in devices that further prepare such operative sites in a predictable manner. When the implants reach their full depth, there will be voids between them represented by the bone groove. These defects must be filled with particulate graft material, preferably autogenous bone or DFDB.

If placement of implants is contraindicated after expansion because of a lack of spongiosa or a fracture, the osteotomy (with widened ridge) is grafted within the cortical plates and allowed to mature for 6 months before implantation (Fig. 8-103, *F* to *J*).

Closure is done with 4-0 Vicryl or Polysorb suture material in a horizontal mattress configuration. Inadequate tissue coverage requires undermining and liberation of the labial mucosa from the underlying orbicularis oris muscle. A subsequent vestibuloplasty will have to be performed.

Osteotomes (Steri-Oss and Others)

Steri-Oss osteotomes are available in a set consisting of four diameters: 2, 2.7, 3.25, and 3.8 mm. The dramatic incremental change between 2 and 2.7 and 2.7 and 3.25 threatens the integrity of the bone. Consequently, two additional osteotomes were custom

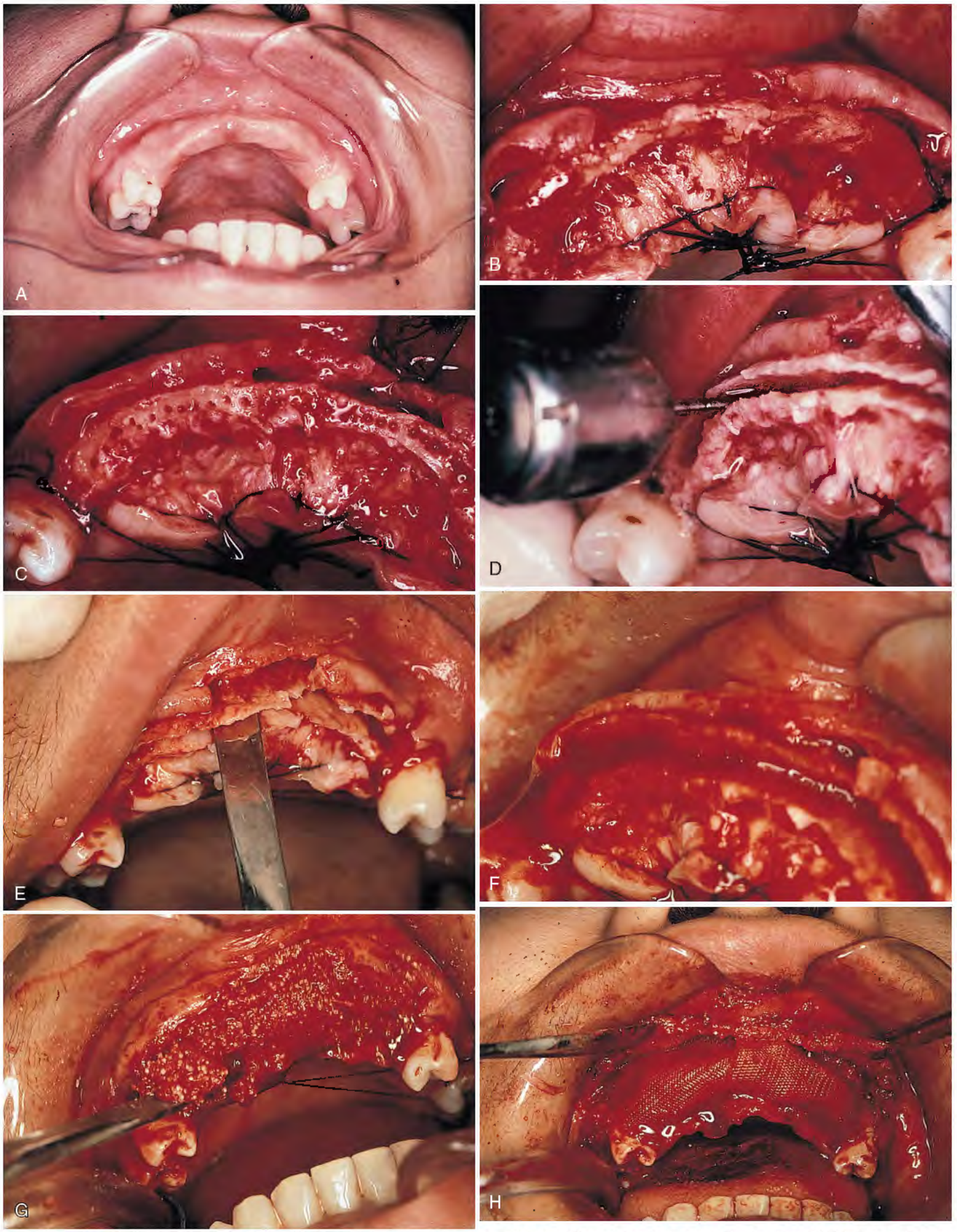


FIGURE 8-103. **A,** Preoperative appearance of an extremely narrow anterior maxillary ridge. The compliant nature of this bone allows dramatic expansion procedures. **B,** After mucoperiosteal reflection, the ridge is exposed. The palatal tissues are retracted by bundling with 3-0 silk suture. **C,** Bur dots are placed midcortically, tracing the outline of the ridge. **D,** A 699L fissure bur is used to connect the dots into a continuous osteotomy. **E,** A spatula osteotomy tapped with a mallet, makes the osteotomy regular in depth and then is used as a lever to create microfracture expansion that must be made to occur beneath attached periosteum. **F,** The separated labial and palatal plates demonstrate a significant enhancement of ridge width. **G** and **H,** Firmly tap particulate DFDB graft material, mixed with the patient's marrow derived from the iliac crest into the newly created osteotomy. Cover the area with Vicryl mesh, the margins of which have been tucked beneath the flaps.

Continued

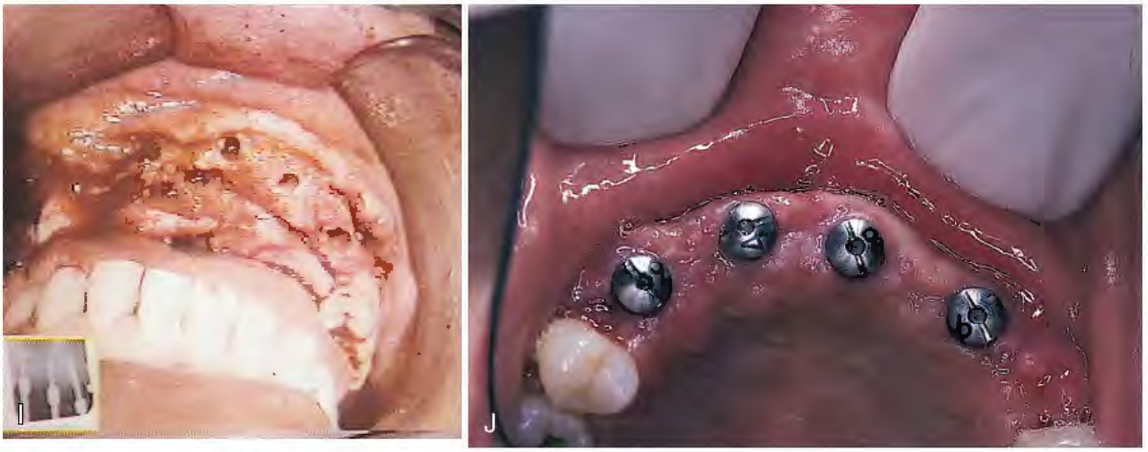


FIGURE 8-103, cont'd. **I,** Six months later, upon reexposure of the grafted area, its expanded dimensions are clearly evident. The new width permits comfortable preparation of implant osteotomies. **J,** An additional 6 months have elapsed, and these osseointegrated implants are now undergoing the restorative phases. Of note is the excellent level of gingival health and the presence of a functional, deep vestibule.

machined (at 2.35 and 3 mm) to make the gradients more moderate (Fig. 8-104, *A*). If other systems are chosen, the difference in diameters should never exceed 0.4 mm.

The osteotomes, which have blunted and smooth leading tips, may be used when the ridge is only slightly too narrow (i.e., 2.3 to 3.3 mm). In these cases, after the classic incision and reflection (Fig. 8-104, *B*), No. 2 round bur holes are placed at each projected implant site (following the generic technique described in Chapter 9), and each is enlarged and deepened with a Brasseler 1.6 × 11 mm internally irrigated drill. After radiographic verification of position and length, each osteotomy is enlarged to 2 mm. From this point on, the osteotomes are used for graduated expansion (Fig. 8-104, *C*). Firm hand pressure (rotating and forcing upward) or gentle mallet taps are used to push each of the six in the set in an apical direction to the planned depth. When each osteotome has reached its full depth, its handle is gently rocked in circular fashion to create slight additional expansion, as well as to facilitate smoother exit and entry of the next size. The exceptional compliance and elasticity of most anterior maxillae permit enlargement of the osteotomies to the final size before use of the try-in device for press-fit implants or the final sizing drill for threaded designs (Fig. 8-104, *D*). Total concentration must be devoted to visual and tactile observation of the labial and palatal plates to anticipate and avoid fracture. Threaded implants are used as self-tapping devices (Fig. 8-104, *E*). After placement of the implants, closure is performed without creating tension of the soft tissues. Undermining may be required.

Anterior Maxillary Height Deficiencies

Block Grafting

A block graft may be performed as described previously for width deficiencies. Block grafts make dramatic dimensional changes in ridges of inadequate height (Fig. 8-105, *A* to *C*). After the graft specimen is removed from the symphysis or another donor site selected by the surgeon, it is hollowed so that it is accurately accommodated by the residual ridge and fits atop it like a saddle. Depending on its width, a single lag screw can serve for fixation (Fig. 8-105, *D*). Combinations of height and width augmentation can be achieved in this fashion with the use of single contoured block grafts and added alloplastic particles (Fig. 8-105, *E*).

Elevation of the Nasal Floor

Height deficiencies can be corrected by grafting superiorly in the anterior maxillae. The pyriform apertures can be exposed through an intraoral approach. The floor of the nose, either unilaterally or bilaterally, may be grafted for up to 10 mm so that the apical extensions of implants of sufficient length can be enclosed in bone with only modest impingement on the nasal floor.

An incision is made at the crest of the ridge from one premolar area around to the other. A relieving incision is made at either end to allow elevation of the mucoperiosteum to the level of the anterior nasal spine. Continued elevation of the tissues presents less of a challenge because they are nonkeratinized. Lateral to the nasal spine, gentle manipulation of the periosteal elevator discloses the sharp cortical rims of the pyriform apertures (Fig. 8-106, *A*).

The direction of the elevator now is changed to horizontal, and hugging the nasal floor, it is used to lift the nasal mucosa (Fig. 8-106, *B*). Because the floor drops precipitously behind the rims, a Kerrison forceps is used to reduce the height of the rims so that direct access to the floor is possible.

With baby Parker retractors placed at each corner of the upper lip, aggressive elevation facilitates direct visualization of the nasal floor and allows observation of the preparation of each of the planned implant osteotomies from the crest of the ridge. The classic generic technique (Chapter 9) allows placement of each implant, none of which should be shorter than 15 mm. Bone blocks harvested from the chin are almost impossible for tapping threaded implants; because the blocks cannot be stabilized, the planned pathways of the implants through the maxilla and graft cannot be coordinated. Press-fit implants, however, allow this maneuver (Fig. 8-106, *C* and *D*). On entering the predrilled blocks, cylinders to pin them into position. Threaded implants, on the other hand, require the bone to be particulated and packed around their apices after the implants have been placed.

Despite the great variation in facial dimensions, most pyriform apertures are 9 to 11 mm wide. It can be predicted with consistency, then, that 8 mL of graft material will be required for each side.

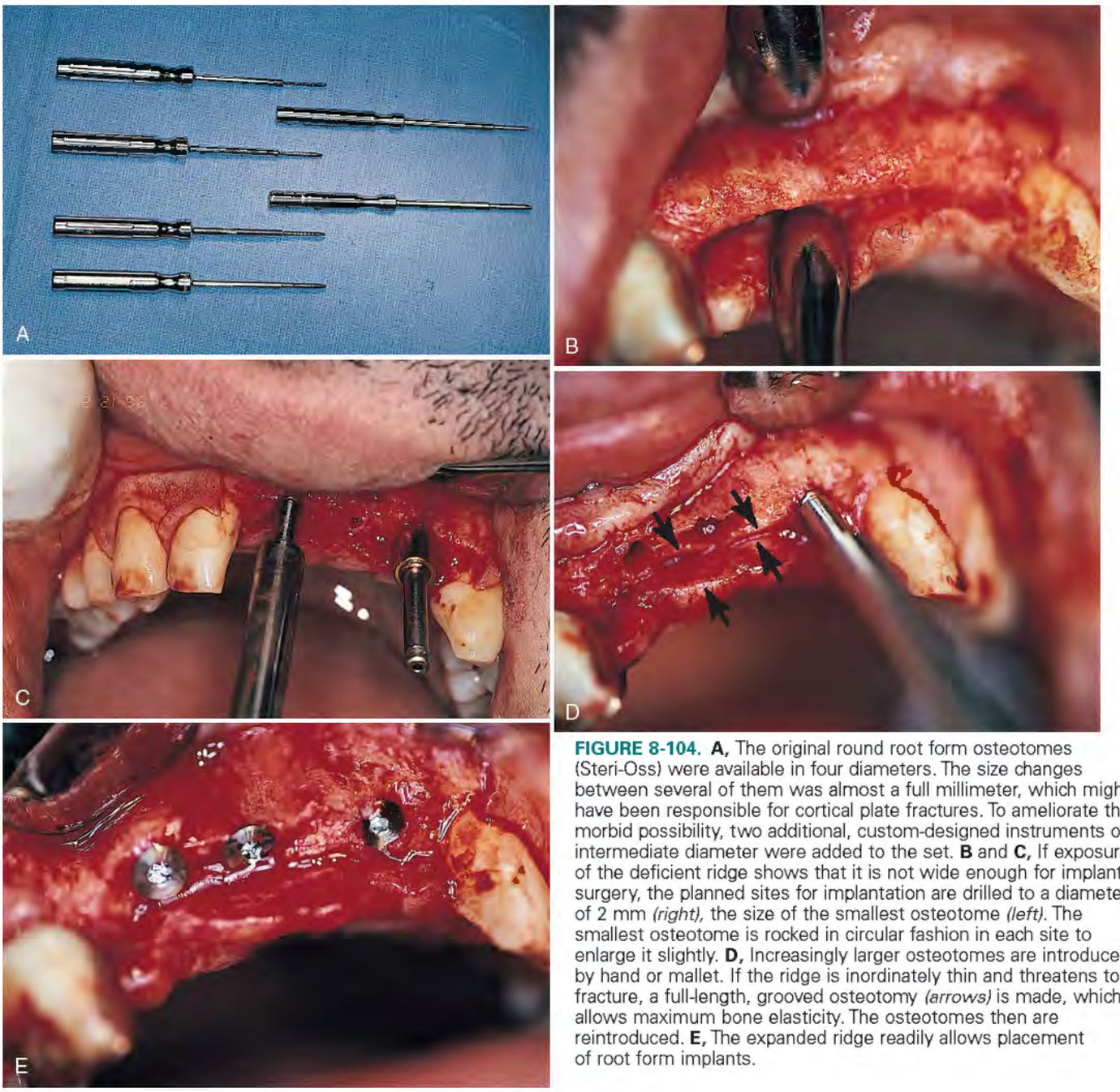


FIGURE 8-104. **A,** The original round root form osteotomes (Steri-Oss) were available in four diameters. The size changes between several of them was almost a full millimeter, which might have been responsible for cortical plate fractures. To ameliorate this morbid possibility, two additional, custom-designed instruments of intermediate diameter were added to the set. **B** and **C,** If exposure of the deficient ridge shows that it is not wide enough for implant surgery, the planned sites for implantation are drilled to a diameter of 2 mm *(right),* the size of the smallest osteotome *(left).* The smallest osteotome is rocked in circular fashion in each site to enlarge it slightly. **D,** Increasingly larger osteotomes are introduced by hand or mallet. If the ridge is inordinately thin and threatens to fracture, a full-length, grooved osteotomy *(arrows)* is made, which allows maximum bone elasticity. The osteotomes then are reintroduced. **E,** The expanded ridge readily allows placement of root form implants.

The donor site therefore must be able to yield 16 mL of bone. From a bilateral approach, the average symphysis yields 8 to 13 mL of material. Consequently, in most cases, bone expanders are required. To begin, the bone excised from the nasal rims increases the volume; this can be followed by the addition of DFDB particles.

After the graft slurry has been placed around the apices of the threaded implants, closure is not initiated until the incipient signs of graft stability, fostered by fibrin, are noted. A resorbable membrane may be required if the reliability of graft fixation is questionable.

Closure, which must include replacement of the nasal mucosa, does not present problems because the ridge was not subjected to dimensional change. Continuous horizontal mattress sutures of Biosyn or Vicryl complete the procedure. A period of 9 months is allowed for osseointegration and graft consolidation. Patients will not complain of a diminished airway.

Posterior Maxillary Width Deficiencies

Ridge Splitting

Ridge splitting and the use of osteotomies offer the same benefit to the posterior maxillary region as they do to the anterior maxilla.

Monocortical Block Grafting

Width deficiency, although less frequently found in posterior maxillae than in the other quadrants, profits by autogenous monocortical block grafting when needed. Such defects sometimes are caused

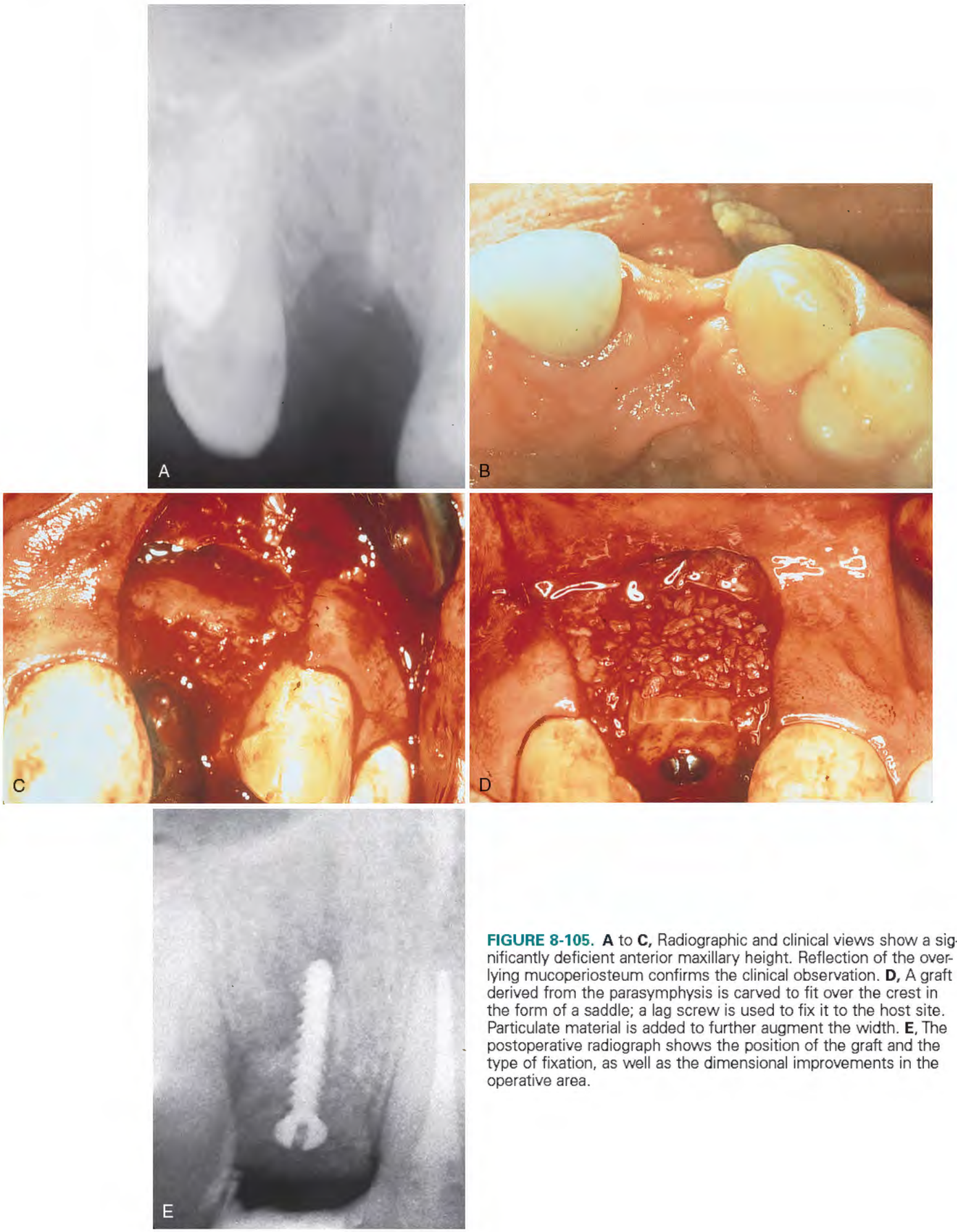


FIGURE 8-105. **A** to **C,** Radiographic and clinical views show a significantly deficient anterior maxillary height. Reflection of the overlying mucoperiosteum confirms the clinical observation. **D,** A graft derived from the parasymphysis is carved to fit over the crest in the form of a saddle; a lag screw is used to fix it to the host site. Particulate material is added to further augment the width. **E**, The postoperative radiograph shows the position of the graft and the type of fixation, as well as the dimensional improvements in the operative area.

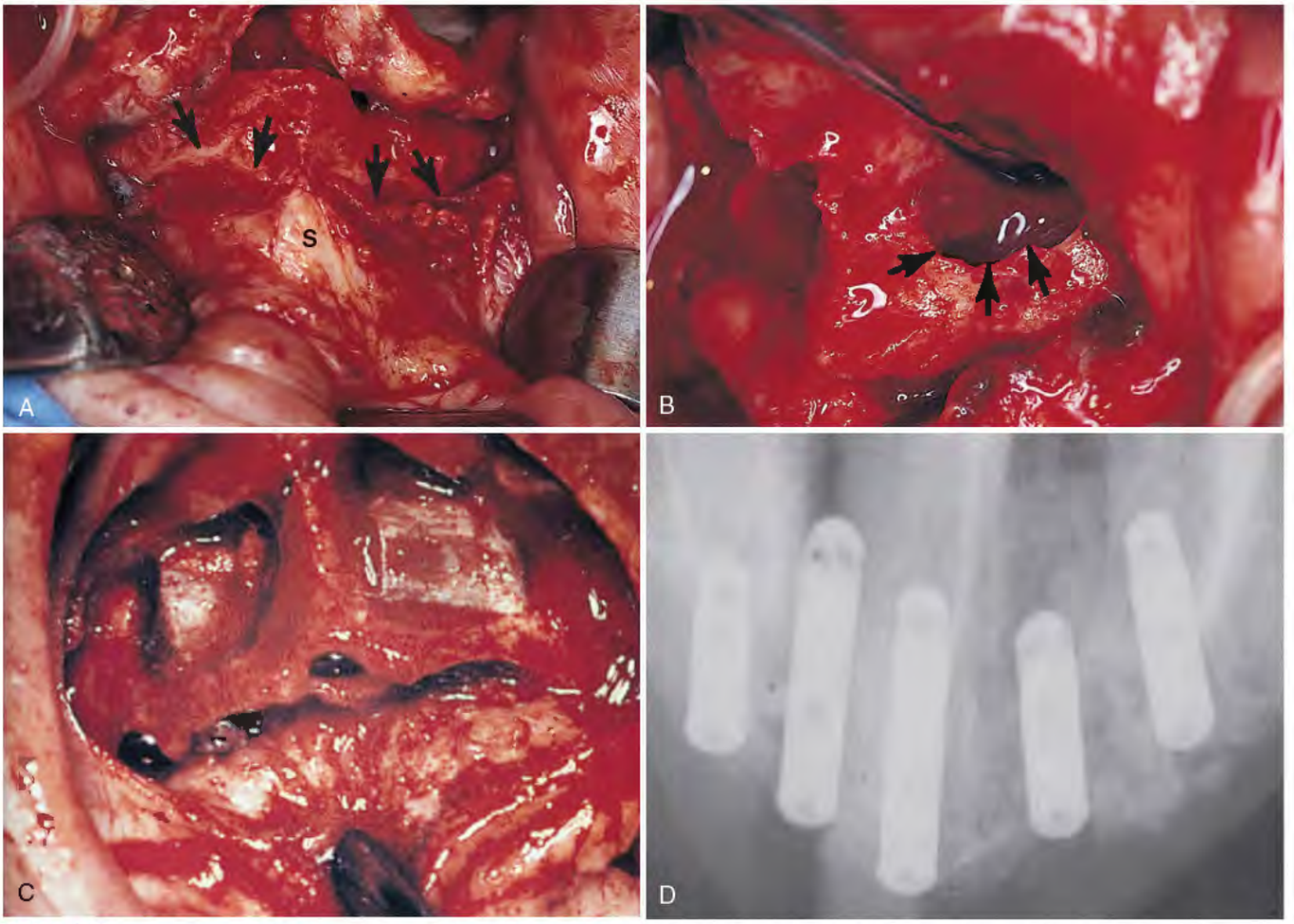


FIGURE 8-106. **A,** A crestal incision is made, and the tissue is elevated to reveal the inferior borders of the pyriform apertures *(arrows)* and the anterior nasal spine. **B,** Continued reflection with a Freer elevator reveals the nasal floors *(arrows)*. **C** and **D,** Bone grafts are taken from the chin and placed in the nasal floor bilaterally, which increases the depth for placement of the implants. The postoperative radiograph shows the extended implant positions and the locations of the bone grafts into which the implants protrude.

by failed plate form implants (Fig. 8-107). Some space limitation may exist in the posterior maxilla because of the proximity of the mandibular ramus, which might make fixation screw placement an awkward procedure. Offset screwdrivers are not effective in such cases.

Posterior Maxillary Height Deficiencies

Sinus Floor Elevation: Closed Techniques

Classic Method

Often when the posterior maxilla is evaluated for endosteal implants, the bone height is inadequate; this results from an enlarging maxillary sinus. As teeth are lost, pneumatization of the sinuses occurs, reducing the distance between the floor of the sinus and the crest of the maxillary alveolar ridge. If vertical bone height is insufficient for endosteal implants, placement of a subperiosteal implant should be considered. Even in these cases, it is strongly suggested that opposing sinus floors be augmented to discourage implant struts from settling into them. If root form endosteal implants are chosen, alveolar height is augmented using osteotome techniques or by performing a sinus floor elevation. This open operation requires grafting to the antral floor.

When bone height falls short of the surgeon's need by a few millimeters, the classic generic root form osteotomy technique may be completed up to but not through the bony floor. An implant is chosen that has a smooth, rounded apical end and that is up to 3 mm longer than the host site. Devices such as IMZ and Calcitek press-fit implants particularly satisfy this requirement. On completion of the preliminary operative steps, an implant try-in device is gently tapped into place, in-fracturing the floor of the antrum and, without lacerating it, elevating the membrane to within its elastic limits (Fig. 8-108).

Of course, use of this method offers only modest benefit, because the implant-support mechanism is restricted to the length of bone adjacent to its sides. However, it permits introduction of a longer implant, encourages secondary periapical bone formation, and avoids complex manipulation.

Summers Method

A second, more sophisticated, closed technique was developed by Dr. Robert Summers. Using the antroplasty methods described earlier, and wanting to embody the protruding implant apices in bone, he developed a system that encourages this osseous augmentation (Fig. 8-109).

Summers osteotomes can deal with several conditions. For all techniques, 4 to 5 mm of residual subantral bone is required.

The first technique uses a trephine 6 mm in diameter, which is malleted at selected sites, 6 mm apart, in ridges wide enough to accommodate it to its full depth. The plugs produced by the trephine are pushed up through the antral floor, elevating the sinus

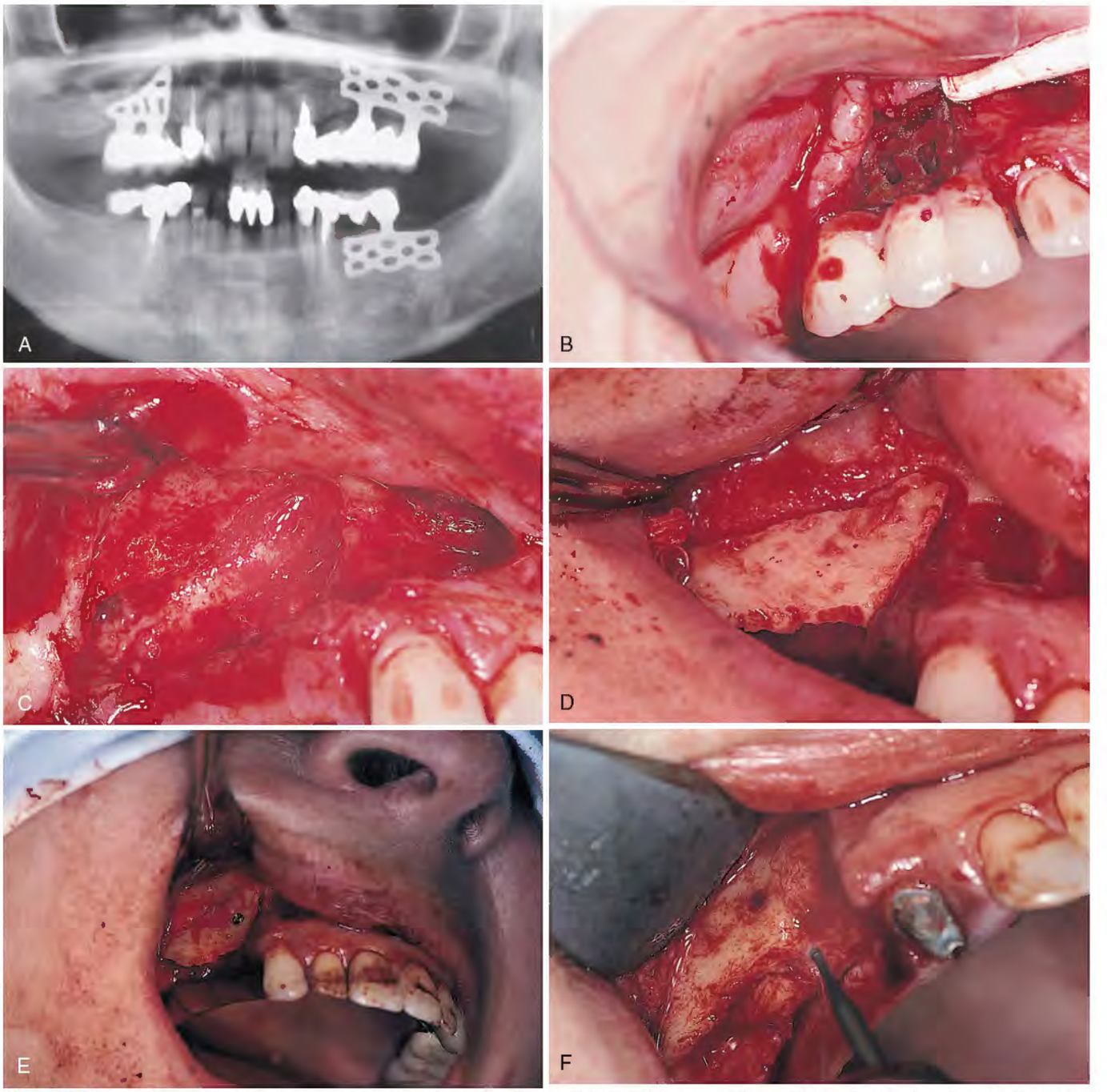


FIGURE 8-107. **A,** A panoramic radiograph shows a failed blade in the right maxilla. The obvious etiology is the violation of a basic tenet of blade superstructure construction: the prostheses must always be splinted to natural teeth. **B,** After overlying tissues have been reflected, the recently placed implant is picked out easily with a hemostatic forceps. **C,** After excision of the granulomas, the defect mimics the outline of the removed blade. **D,** An accurately shaped bone graft harvested from the mandibular parasymphysis is transferred to the deficient site using the lead foil template method of graft shape transfer (see Fig. 8-89). The remarkable similarity of the graft to the removed implant's infrastructure is a result of the accuracy of the lead foil template technique. **E,** A lag screw is used to fix the monocortical block to the deficient maxillary host site. Note the significant addition to dimension. **F,** The tissues are opened after 6 months of healing, and the screw is backed out, revealing firm consolidation of the graft. The initial steps for root form insertion in this generously augmented ridge are then undertaken.

membrane. If the bone is resistant to this pressure, tapping with a mallet works effectively. The graft material of choice is placed in the depressions made in the ridge before suturing. A period of 6 months is allowed before implants are placed.

Another technique allows immediate implant placement. An incision is made at the crest of the ridge, and a surgical template is used to mark each of the implant sites with a No. 2 round bur. In cases that offer soft, compliant bone, the floor elevation uses the osteotomes alone. Each, larger than its predecessor, has a concave tip. The established sites are entered with the smallest diameter first. The osteotomy so produced is completed 2 mm short of the antral floor. Each site is enlarged until its diameter is equal to the size of the intended implant. Then, small amounts of bone taken from adjacent sites (e.g., a tuberosity) are placed in the concave tip of the last osteotome that had been used, and further gentle tapping permits infracture of the antral floor (2 to 3 mm), elevation of the intact

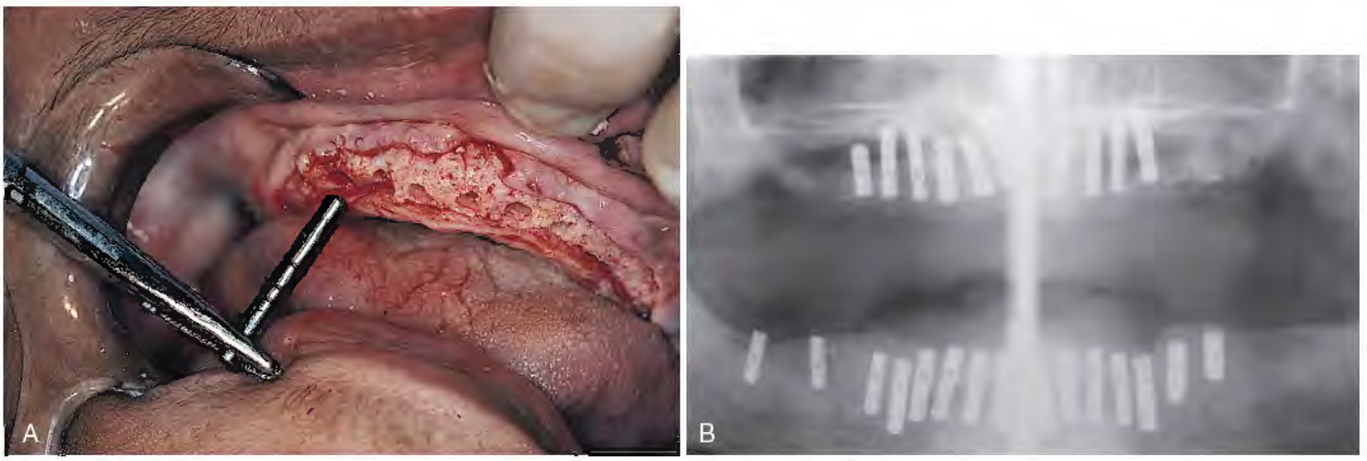


FIGURE 8-108. **A,** Gentle tapping of a press-fit implant try-in produces in-fracture of the antral floor and, because of the implant's rounded end, protects the membrane from injury. **B,** This method allows implants slightly longer than the available bone to be inserted without harming the maxillary sinus.

FIGURE 8-109. The Summers osteotomes increase in diameter and have sharpened, cupped ends that are designed to shave the bone and carry the bone through the antral floor and position the bone under the sinus membrane, which the osteotomes have elevated.

membrane, and introduction of the local bone with the addition of the autogenous graft. This process is continued during subsequent stages of the operation for up to three gentle bony additions. Placement of an implant again with bone propelled by its apex serves as the final osteotome before suturing (Fig. 8-110).

In some cases, the bone is too dense to yield to the simple use of the osteotomes. In these situations, each potential host site is created with a 1.6-mm diameter, internally irrigated bone drill carried to the level of the antral floor. Enlargement is continued with the Summers 3i osteotome set to enlarge each osteotomy to its requisite diameter. The primary purpose of these instruments is vested in their capability, when tapped, to in-fracture and expand the antral floor upward for distances up to 6 mm. The tips are sharp and concave, which allows them to carry small amounts of bone (retrieved from adjacent edentulous sites) and to transport shaved lateral bone into the newly made periapical concavities.

Implants, either threaded or press-fit, now may be introduced in the conventional manner to the newly increased depths. Routine closure completes these procedures.

Sinus Floor Elevation: Open Techniques

When a more dramatic improvement of subantral height is required, a considerable amount of graft material is required. This may be obtained from autogenous bone harvested from the ramus of the mandible, the symphysis, the anterior iliac crest, the tibial plateau, a rib, or the calvarium. Autogenous bone can be mixed with allogeneic material (50% autogenous bone with 50% DFDB by volume).

Some clinicians elevate the sinus floor only with synthetic graft materials. However, the chances for success are amplified if autogenous bone is added to the composite. The harvested bone is ground into fine particles with rongeur forceps. When less than the amount of autogenous bone needed is harvested, it is mixed with an acceptable expander (see Table 8-1) and stored in the patient's marrow-derived blood.

The antroplasty is performed by anesthetizing the area to be grafted from tuberosity to midline with infiltrations, infraorbital, posterosuperior alveolar, and greater palatine (second division) blocks (Fig. 8-111). A full-thickness incision is made along the crest of the maxillary ridge from behind the tuberosity forward to the canine area (Fig. 8-112). A vertical releasing incision at the anterior end is necessary. The flap is reflected with the periosteal elevator to allow access to the canine fossa just below the infraorbital foramen, to the buttress of the zygomatic arch, and to the lateral maxillary wall posterior to it. A No. 8 round diamond stone in a high-speed Impactair handpiece is used to make a horizontal line parallel to and at the level of the antral floor in the lateral cortex of the maxilla. The groove is created by gentle brushing of the bone so that it barely penetrates the cortical plate. Some experience is required before the surgeon's tactile skills allow this to be done without injuring the sinus membrane. The groove should run the full anteroposterior dimension of the antrum. A second line is placed parallel to the first one and 15 mm above it. Care must be taken to avoid injuring the infraorbital foramen or its contents. These two horizontal lines are connected with vertical ones at either end, again using the diamond in a gentle brushing motion. At this juncture, the outline of a rectangle is plainly visible. The two lower corners are rounded so that they do not tear the sinus membrane (Fig. 8-113).

After full bony perforation with the diamond drill, a mallet and the blunt end of an orangewood stick are used to gently mobilize

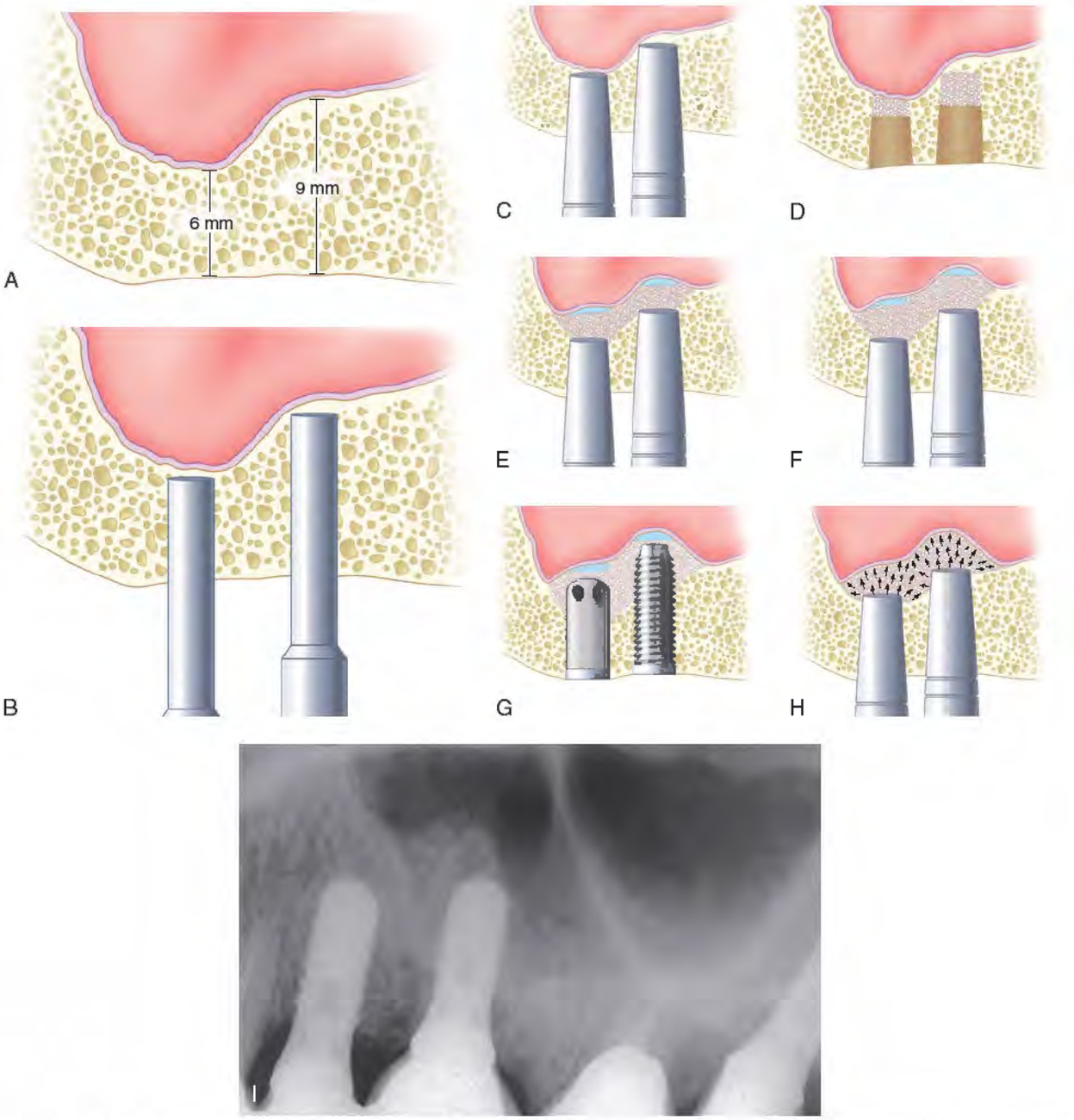


FIGURE 8-110. **A,** Preoperative bone dimensions beneath the sinus floor suitable for the Summers technique. A 6-mm site can be altered to support a 10-mm implant. A 9-mm location can be deepened to accept a 13-mm implant. **B,** In soft bone, a small-diameter osteotome (Summers osteotome No. 1) is inserted with hand pressure or light malleting to the sinus boundary. In harder bone, a drill is used with care to penetrate to this depth. The goal is to stay short of the membrane with the initial osteotomy. **C,** The osteotomy is widened with Summers osteotomes No. 2 and 3. The No. 3 instrument prepares a slightly undersized osteotomy for a 3.75-diameter implant. **D,** A prepared bone graft mix is inserted into the osteotomy with a sterile carrier before any attempt is made to elevate the sinus floor. The mix should contain 25% autogenous bone obtained from the tuberosity of the same quadrant. A variety of graft materials can be added to the autogenous particles. **E,** The largest osteotome used previously is reinserted into the sinus floor. Pressure from the instrument causes the added materials and trapped fluids to exert pressure on the sinus membrane. **F,** Small amounts of bone are added, and the osteotome is returned to the sinus floor. Each increment of material elevates the membrane by 1 to 1.5 mm. **G,** When the antral floor has been displaced, the graft moves freely, elevating the membrane without the osteotome entering the sinus. The implant becomes the final osteotome pushing up the membrane to its ultimate height. **H,** The concave osteotome tip traps bone and fluids as the instrument moves superiorly. Hydraulic force is created, exerting pressure in all directions (Pascal's law). This force elevates the membrane over an area wider than the osteotomy. **I,** A radiograph shows bone formation in the maxillary sinus graft region around the implant apices.

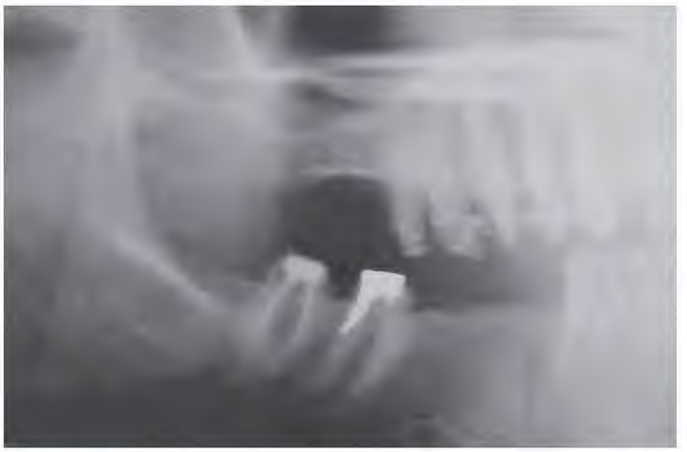


FIGURE 8-111. A panoramic radiograph shows a clear sinus, free of septa. The bone available is inadequate for the placement of implants. In this case, the sinus floor should be elevated with ramus bone and synthetic grafting materials.

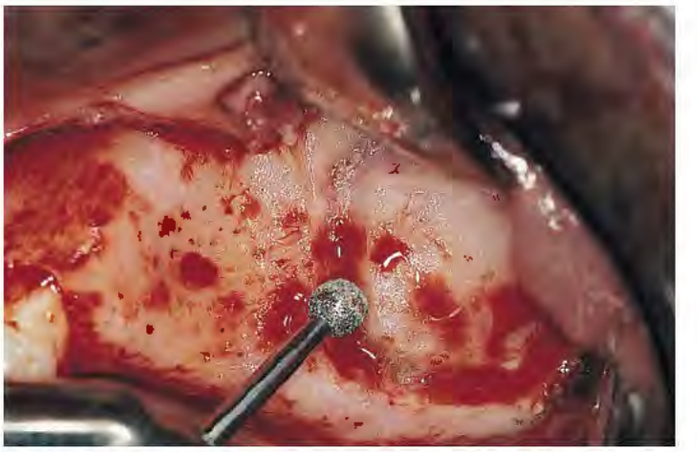


FIGURE 8-113. After reflection of the mucoperiosteum, the lateral maxillary wall is exposed almost to the level of the infraorbital foramen. A No. 8 diamond round bur is used to create an oblong window with an inferior perimeter at the level of the antral floor.

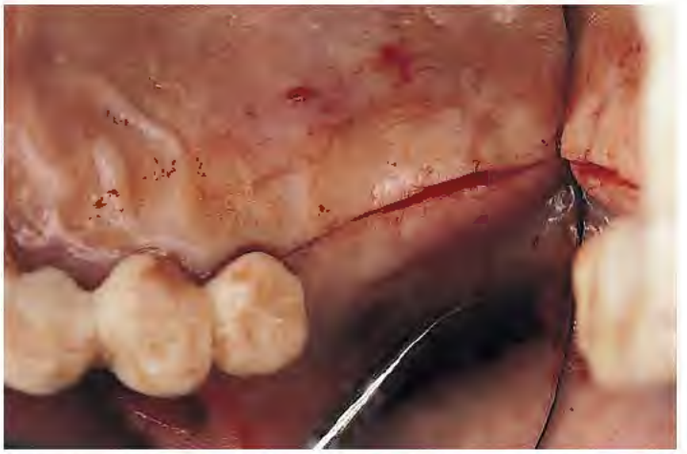


FIGURE 8-112. A crestal incision provides access to the sinus.

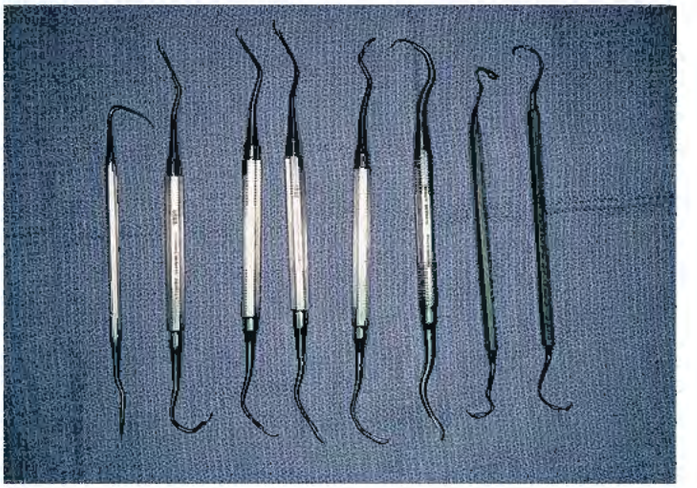


FIGURE 8-114. Tatum membrane elevators, which are available in a variety of sizes and angulations, are used to tease the sinus lining from the floor.

the plate of bone inward. As this is done, the superior line with its remaining attachment to the flap becomes a hinge. Care must be taken not to pierce the membrane during any of the steps in this procedure. After the door is pressed inward for 4 to 5 mm, the membrane is reflected from the bony floor of the sinus with the backs of Tatum's elevating instruments (Fig. 8-114). The lining ahead of the bone trapdoor is elevated as it is moved further inward. In such a manner, the rotated maxillary wall, when elevated to a horizontal position, becomes the new floor of the sinus, and the antral membrane is advanced in folds above it (Fig. 8-115). If the antral floor has septa (which may be seen on the preoperative Panorex film), contiguous membrane elevation is not possible. Under such circumstances, attempts should be made to remove septa with a thin, curved osteotome or a Kerrison forceps. If that effort fails, the elevations are performed in sections, and the membrane is gently teased from the thin bony partitions as if they were separate sinuses.

Membrane lacerations occur on occasion. In such instances, the membrane is repaired with 4-0 Vicryl suture on an SH tapered needle. An extremely effective technique is to make tiny No. 2 round bur holes in the bony wall just above the trapdoor hinge. The sinus membrane, which is plentiful because it was elevated in folds, may be sutured to the bone using these bur holes as sites of fixation. This effectively ablates any lacerations (Fig. 8-116). If suturing is not undertaken, Colla tape, which acts as an adhesive when moistened with blood, can serve as a repair device. Healing is not affected because of the abundance of overfolded, accordion-like tissues and the rapidity of epithelial proliferation.

If less than 4 mm of original crestal bone height is present, implants should be placed only if they are offered a transitional support mechanism, such as a miniplate. A description of this technique is found in the last section of this chapter.

On the other hand, if 5 mm or more of bone height exists, root form implants are placed in routine fashion at the time of antroplasty. However, because primary retention of root form implants is necessary, threaded rather than press-fit submergible designs are best (Fig. 8-117). An implant system is selected that has the greatest number of threads near the cervix, because this is where the bone is found, rather than implants with a wide zone of polished collar. Nobelcare, Steri-Oss, 3i, Lifecore, and Swede-Vent are good choices.

Regardless of whether implants have been placed, the next step is to fill the floor with the graft material (prepared with antibiotics, saline, and/or blood) to the upper level of the fenestration. This

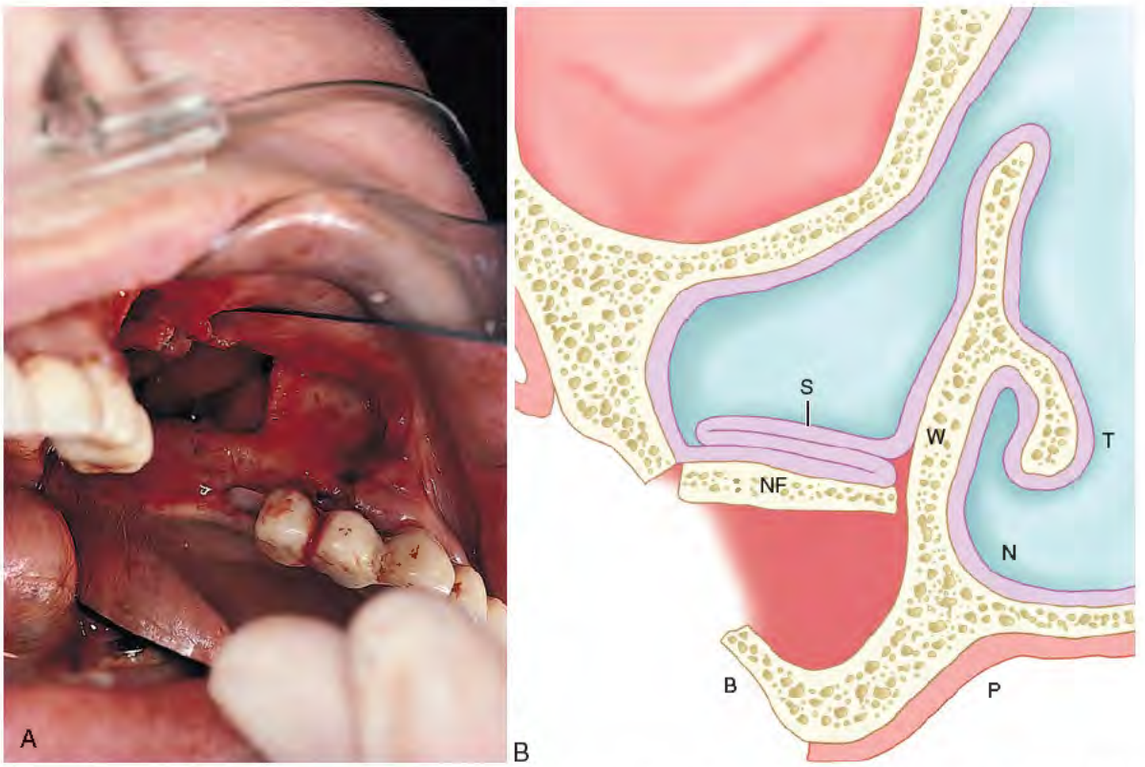


FIGURE 8-115. **A, B** Gentle tapping causes a medial translation of the bony window. The window is rotated upward and inward into a horizontal posture with the folded membrane gathered above it. *B,* Buccal surface of the ridge; *M,* elevated buccal mucosa; *N,* nasal cavity; *NF,* new antral floor; *P,* palate, *S,* folded sinus membrane; *T,* turbinate; *W,* medial sinus wall.

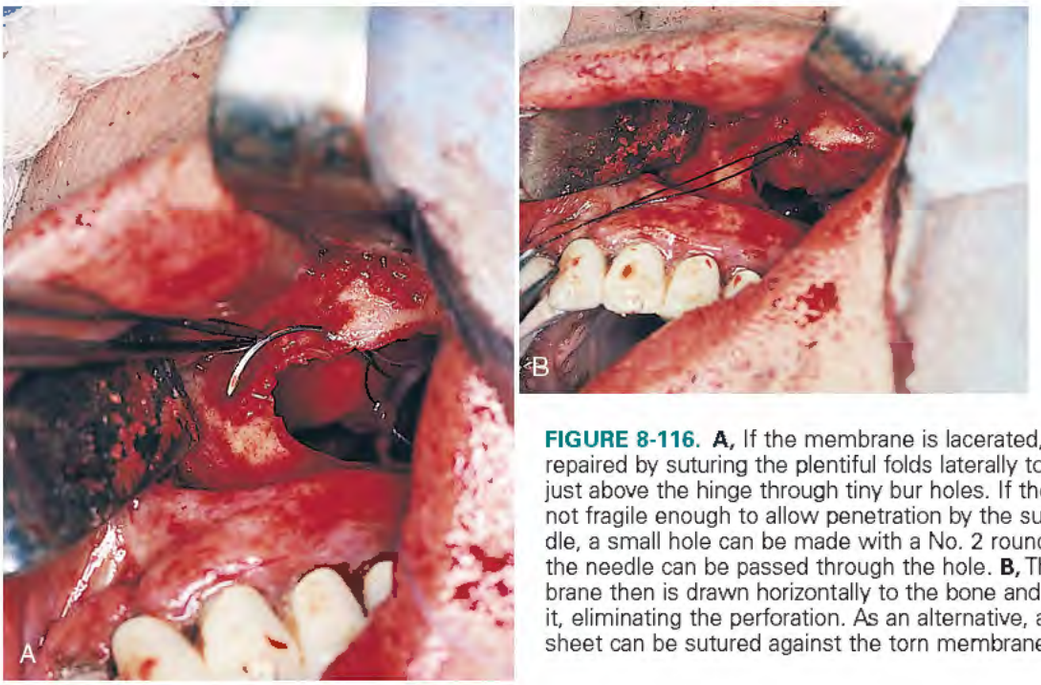


FIGURE 8-116. **A,** If the membrane is lacerated, it is repaired by suturing the plentiful folds laterally to the bone just above the hinge through tiny bur holes. If the cortex is not fragile enough to allow penetration by the suture needle, a small hole can be made with a No. 2 round bur, and the needle can be passed through the hole. **B,** The membrane then is drawn horizontally to the bone and sutured to it, eliminating the perforation. As an alternative, a collagen sheet can be sutured against the torn membrane.

stabilizes the trapdoor in its new horizontal position (Fig. 8-118). The antral membrane is gently pushed upward ahead of and above it so that its integrity remains protected (Fig. 8-119). When the floor is filled completely, with graft material totally surrounding the implants (if placed), a resorbable membrane is tucked superiorly beneath the mucosal flap and brought down to cover the antral window and graft completely; it then crosses over the crest of the ridge. Finally, it is wedged beneath the residual palatal mucoperiosteum, which is elevated to receive it. The buccal flap is returned to its original presurgical position and closed with a continuous horizontal mattress suture.

The patient should be instructed not to blow the nose for 2 weeks after this procedure. The standard sinus regimen must be prescribed (see Appendix G). Expectations of moderate swelling,

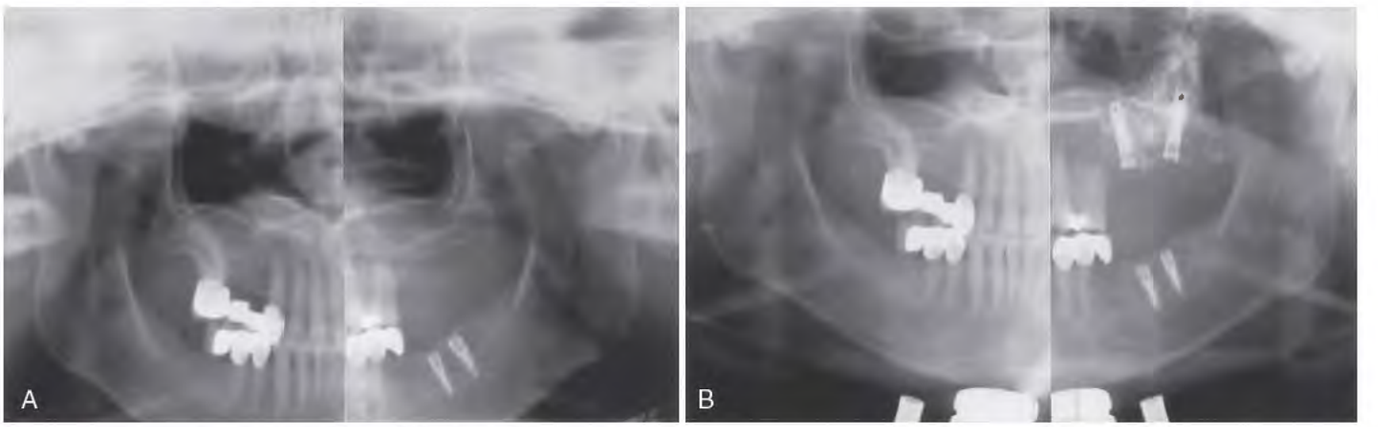


FIGURE 8-117. **A,** A radiograph shows a sufficient amount of bone to allow placement of endosteal implants at the time of grafting. **B,** A postoperative Panorex film shows the acceptance of a combination of autogenous and synthetic graft materials, which have embodied two 15-mm long Steri-Oss implants.

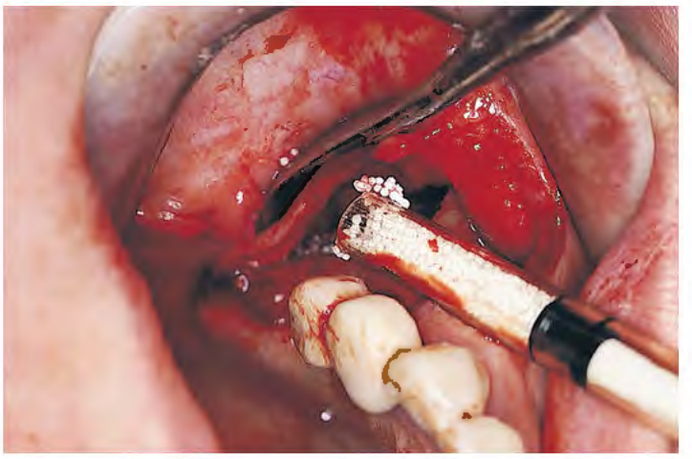
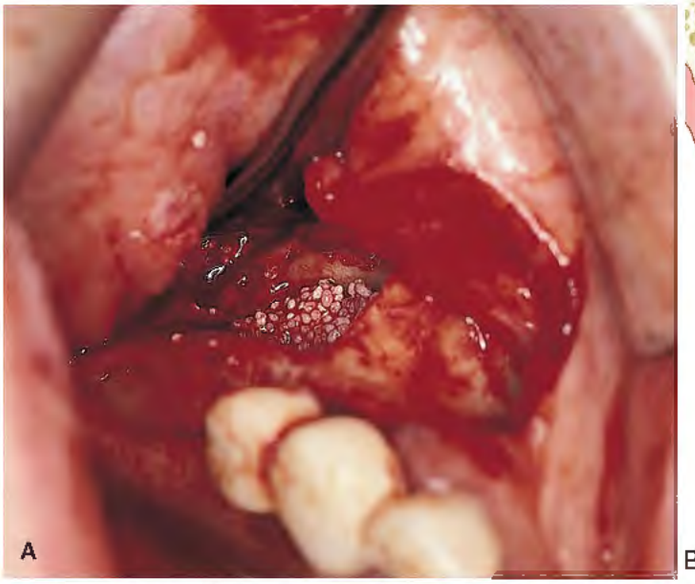


FIGURE 8-118. After the antral floor has been made available for grafting, a syringe is used to deliver the graft complex.

pain, and ecchymosis, which are found mostly at the donor site in the mandibular symphysis, should be emphasized. In addition, some nasal bleeding may occur during the first day. After the standard postoperative visits, the patient should be evaluated at 9 months. At this point, a clinical determination is made, using radiographs, whether the area has matured sufficiently to allow classic root form endosteal implantation. If implants have already been placed, the patient is evaluated to see whether the person is ready for exposure and healing collar placement (Figs. 8-120 through 8-122). Earlier or even immediate surgery can be performed after antroplasty if a subperiosteal implant is the treatment choice.



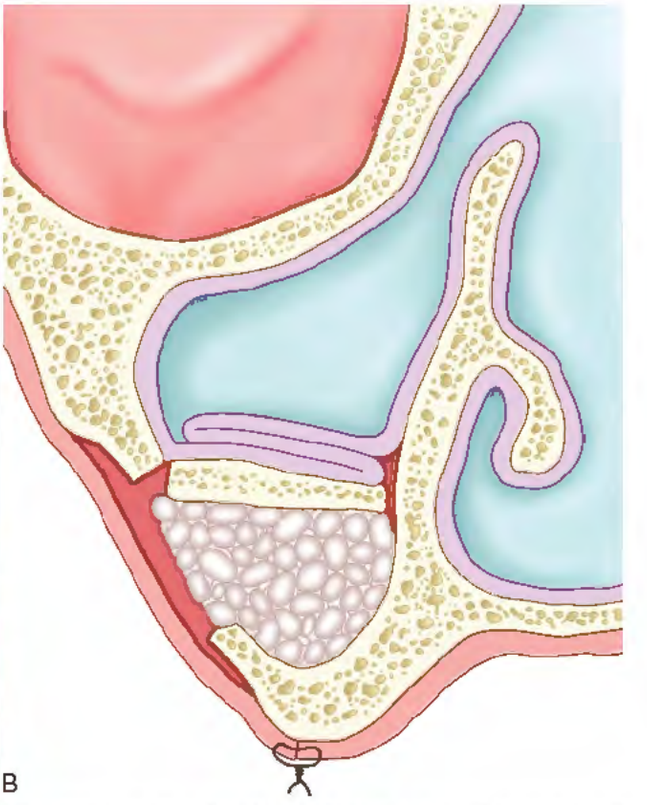


FIGURE 8-119. **A,** A sufficient amount of the particulate graft material (moistened in an antibiotic-blood slurry) is used to fill the antrum to the level of the horizontal window. This supports the newly repositioned antral floor and serves as a matrix for osteogenesis. **B,** Closure is performed at the crest of the ridge, after a large square of Vicryl mesh membrane has been placed, using a continuous horizontal mattress suture.

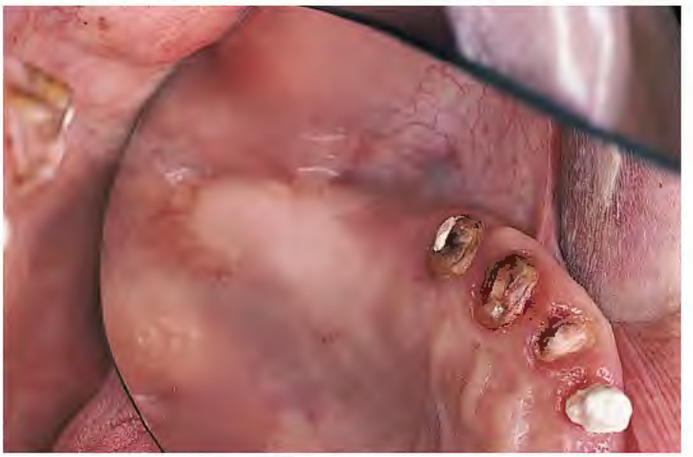


FIGURE 8-120. Six months after antroplasty, healing at the alveolar site has been completed.

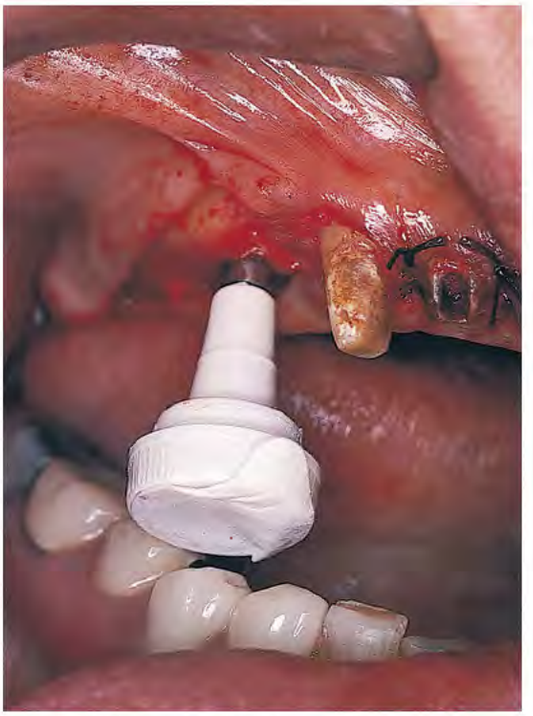


FIGURE 8-121. Classic implant placement procedures may be undertaken after maturation of the sinus floor.

FIGURE 8-122. Radiograph showing that the newly ossified antral floor has accommodated two Steri-Oss root form implants.

Posterior Maxillary Deficiency and Use of a Miniplate

Generally, the absence of adequate alveolar bone (4 mm or less) beneath the maxillary sinus prevents placement of endosteal root form implants at the same time as antroplasty. A technique has been devised that allows implantation simultaneously with sinus floor elevation. This has been made possible by the use of titanium fracture miniplates, which serve as transitional fixation devices until mineralization of the graft material creates implant osseointegration.

This technique uses a miniplate; self-tapping screws (2 mm in diameter); 3.8 × 16 mm threaded root form implants (i.e., Steri-Oss or ScrewVents); the armamentarium to place them; and titanium healing screws with heads 3.8 mm in diameter. In addition, the classic antroplasty instruments are required. The patient is managed by means of regional anesthesia; infraorbital, posterosuperior alveolar, and second division blocks with or without sedation; or general anesthesia.

An incision is made at the crest of the alveolar ridge, with relieving incisions extending distally from the base of the tuberosity and mesially in a vertical-oblique direction to the midline. The mucoperiosteum is reflected to the base of the ridge palatally and to a region just below the infraorbital foramen on the buccal side.

The assistant surgeon must protect the identified infraorbital neurovascular bundle while reflecting the investing tissues so that the lateral antral wall can be exposed aggressively.

A No. 8 round diamond in a high-speed, water-cooled Impactair handpiece is used to sketch the outlines of a fenestration designed to enter the antral environment. It should be oblong, with its inferior border at the level of the antral floor, the superior outline 4 mm beneath the infraorbital foramen, and the anterior and posterior vertical components at the most practicable accessible locations but certainly more mesial and more distal than the planned zone of implantation in precisely the same manner as described earlier. The well-irrigated diamond is used with gentle brushing motions until the antral membrane is seen at all of the osteotomies. The blue, translucent appearance of the membrane is appreciated as the maxillary cortex dissipates beneath the diamond.

At this juncture, the window can be in-fractured by tapping it with an orangewood stick and elevated inward by using a periosteal elevator as a lever. Medial retraction allows separation of the membrane from the inferior, internal surface of the sinus with the Tatum curettes. As the membrane is lifted away from the floor and inferior walls, the trapdoor is pushed farther inward by gentle pressure or tapping and is lifted on its membrane hinge to a horizontal posture. The membrane curettes are used to complete the separation of the membrane from the bony floor and lateral walls and to lift it in an upward direction above the trapdoor.

At this juncture, a sponge that has been moistened in saline is placed beneath the elevated window with the gathered membrane maintained above it.

Attention is turned to the alveolar crest. A strip of Synthes, Osteomed, or similar titanium CP miniplate with holes 2 mm in diameter is selected and cut. It is bent to fit the length and configuration of the ridge from a point just distal to the last tooth in position and extending posteriorly to the tuberosity (Fig. 8-123).

While the assistant surgeon keeps the plate in position, a fine tapered diamond in the high-speed handpiece is used to tap holes at two appropriate screw sites, and short (4 mm) self-tapping screws 1.5 mm in diameter are placed, fastening the device in position (Fig. 8-124).

FIGURE 8-123. Synthes titanium miniplates are available in curved and straight designs. Their countersunk holes accept Zimmer's Screw-Vent screw heads with precision. These plates can be cut and bent to conform to the shape of the ridge crest.

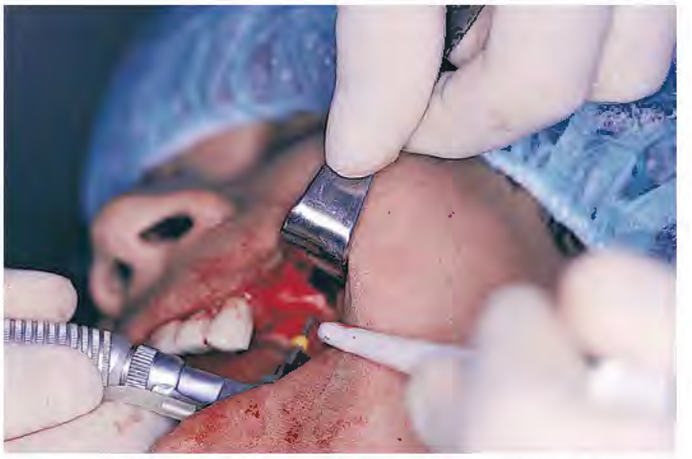


FIGURE 8-125. After the ridge has been marked through the miniplate holes at each planned implant site, the plate is removed and the osteotomies are completed to a diameter of 3.5 mm.

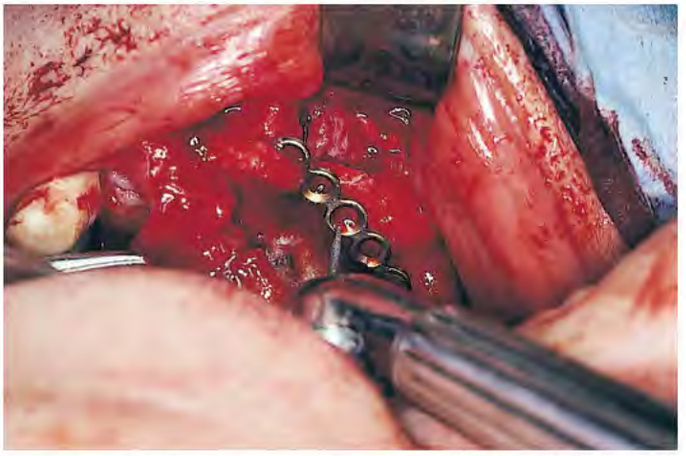


FIGURE 8-124. After bone tapping, the miniplate is fixed to the crest of the ridge with 4-mm long titanium screws. The screws are placed in holes that will not be used as implant sites.

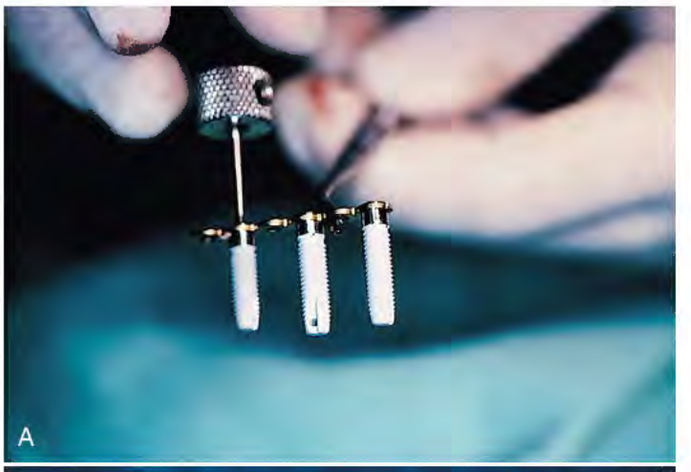


FIGURE 8-126. **A,** When the osteotomies have been completed, the healing screws are used to fix each 16-mm long, 3.8-mm diameter, threaded implant to its corresponding site in the miniplate. **B,** Note the perfect relationship between the screw heads and the plate.

The bone sites selected for implantation are scored with a No. 2 round bur in the centers of the selected holes in the miniplate; the plate is then removed by backing out the short fixation screws.

Using the generic technique described in Chapter 9, the surgeon develops and enlarges each osteotomy to a diameter of 3.5 mm (Fig. 8-125). Then, Steri-Oss threaded implants 16 mm long and 3.8 mm in diameter (or similarly compatible designs) are affixed to the matching holes of the plate by their large-head healing screws (Fig. 8-126). The plate-implant assembly is carried to the bone, the apical ends of the implants are guided into their respective osteotomies, and the complex is seated by gentle mallet tapping with an orangewood stick (Fig. 8-127). When the plate comes to rest at the ridge crest, wider (2-mm-diameter) plate-holding bone screws that are 6 mm long are inserted into the original fixation sites in the ridge (Fig. 8-128).

With the implants now securely affixed to the ridge and protruding into the antrum, the sponge is removed and the grafting of synthetic and autogenous bone to the sinus floor and around the implant is completed. HA and DFDB mixed with the patient's own parasymphyseal bone and consolidated with blood and gentamicin (80 mg) are reliable combinations (Fig. 8-129).

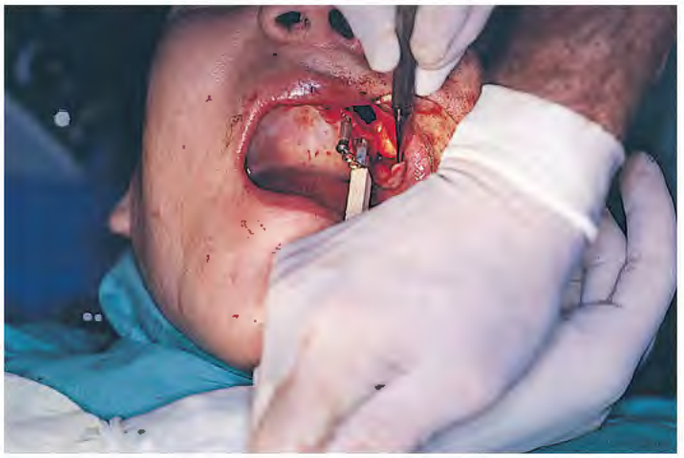


FIGURE 8-127. The miniplate-implant complex is guided into the osteotomies, and an orangewood stick and mallet are used to tap it into place.

Upon complete filling (usually about 16 mL) of the newly occupied implant zone with the window in a horizontal posture and the antral membrane pushed and gathered above it in loose folds, a square of resorbable Vicryl mesh or laminar bone is placed beneath the periosteum on the bone rim above the fenestration and brought down over the mass of graft material. From this point, the GTRM is curved down over the ridge and then carried across the crest, thereby covering the implants and their stabilizing plate; it finally is wedged beneath the palatal flap (Fig. 8-130).

Radiographs are taken to affirm the position of the implants and the location and density of the graft material (Fig. 8-131). The flaps (with buccal undermining when necessary) are then brought together and closed with 4-0 polyglactic acid continuous horizontal mattress suture (Fig. 8-132).

When only a portion of the floor is thin and the remainder is thick enough to require use of a conventional osteotomy technique with a bone-tapping drill, vertical seating of a threaded implant

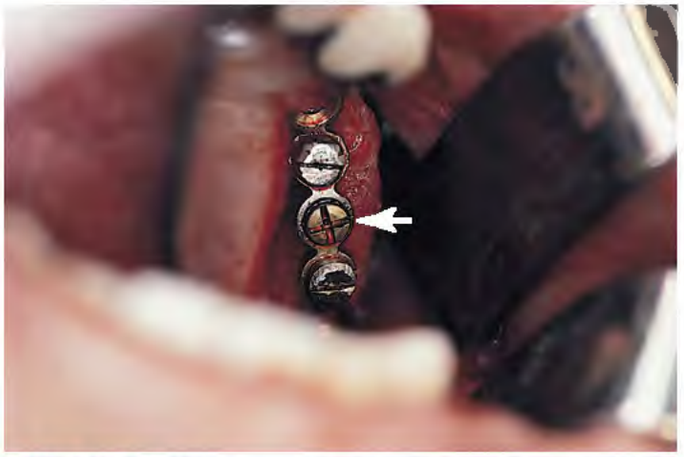


FIGURE 8-128. The miniplate, which is bracing the implants in the extremely shallow bone, is stabilized with 6-mm, short, compatible titanium screws, each placed in one of the original 4-mm fixation sites *(arrow)*.

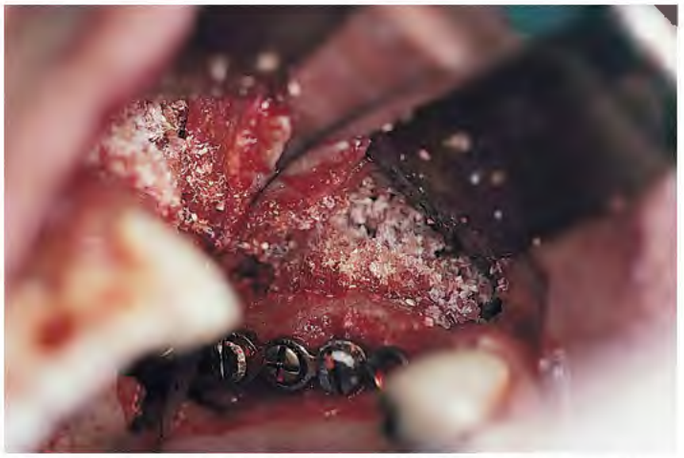


FIGURE 8-129. After firm stabilization of the plate, the position of the protruding 16-mm long implants should be assessed, and the posture of the bone trapdoor and the overlying folded sinus lining is affirmed. This is followed by placement of the graft material, which consists of parasymphyseal autogenous bone expanded with TCP and DFDB.

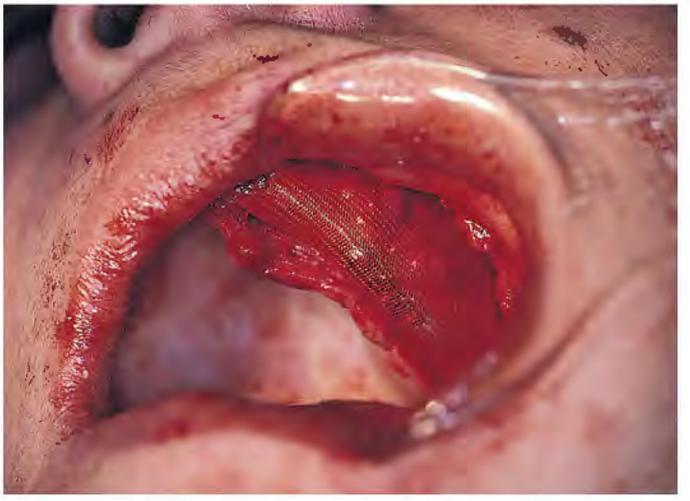


FIGURE 8-130. Vicryl mesh is trimmed to fit over the entire osseous wound. It should be wider than the antrostomy, so that it rests on cortical bone mesially and distally. The mesh is tucked beneath the flap just below the infraorbital foramen, brought down over the graft, contoured across the ridge crest and miniplate, and then tucked beneath the palatal flap. Closure follows, completing the procedure.

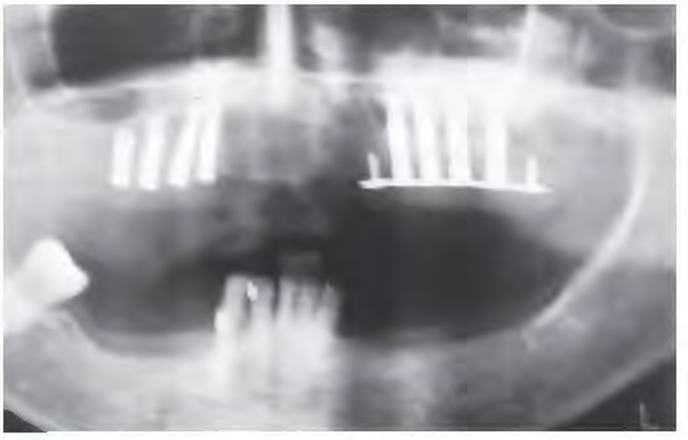


FIGURE 8-131. A postoperative Panorex film demonstrates a well-placed miniplate with its fixation screws and the implants inserted into a grafted antral floor. Note the 6-mm long fixation screws at either end.

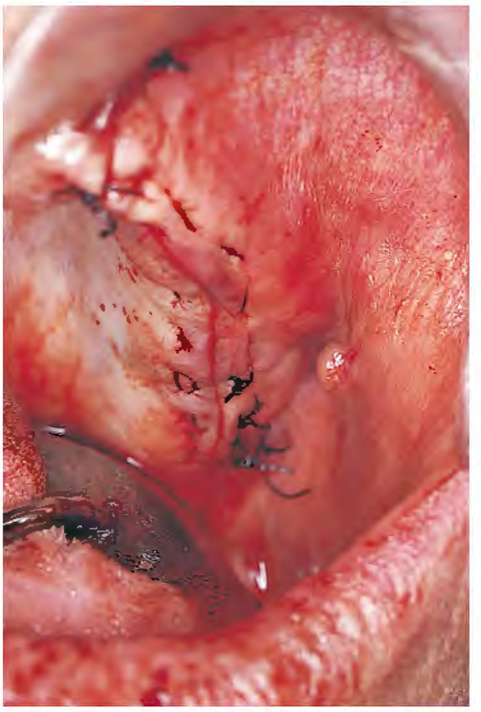


FIGURE 8-132. Violet-dyed Vicryl sutures are used to create a tight, continuous horizontal mattress closure.

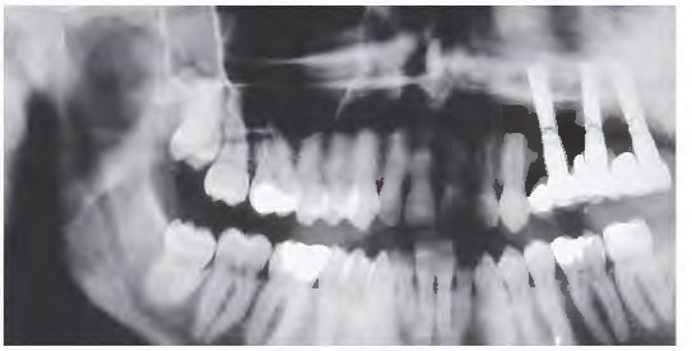


FIGURE 8-133. Radiograph showing the satisfactory results of a restoration in the left maxilla supported by implants, which are supported by a miniplate placed in a grafted sinus floor.

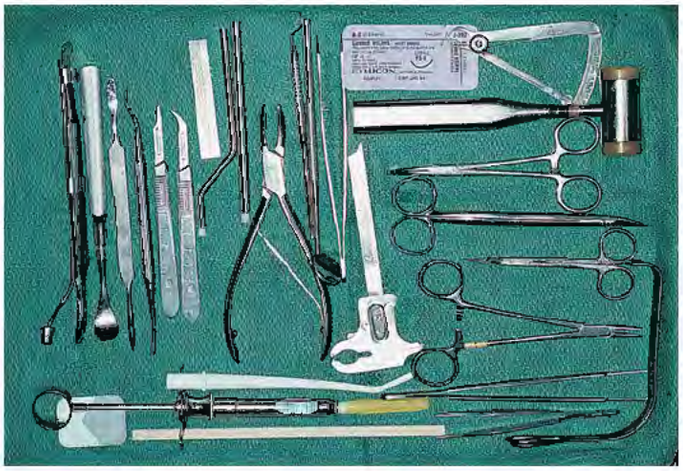
assembled to the plate is impossible, because that implant could not be turned. In such cases, a press-fit implant is substituted to allow seating of the entire complex by tapping (see Fig. 8-126).

As an alternative, the plate can be shortened, allowing seating of a conventional threaded implant before the plate is placed. After the graft has matured for 9 months, the healing and fixation screws are backed out at second-stage surgery, the miniplate is removed, and the requisite prosthetic steps are undertaken and completed (Fig. 8-133).

Root Form Implant Surgery: Generic

9
CHAPTER

ARMAMENTARIUM



Boley gauge
Bougies: whalebone, olive-tipped, or lacrimal probes
Bur extender: mandrel (internal irrigation; to be used when adjacent teeth prevent direct access to bone)
Calipers
Colla- Cote
Colla-Plug
Console, motor, and handpiece
Depth gauge
Disposable bur length markers, Disposaboots (yellow)
Implant system of choice with bone taps (if implant is not self-tapping), countersink (if required), final sizing drills, and try-ins
Millimeter ruler: 15 mm or longer periodontal probe
Paralleling pins (double-ended): small and large (Brasseler/Cranin)
Pilot drill (1.6 × 11 mm) with internal irrigation (Brasseler/Cranin): 1.6, 2, 2.5, 3, and 3.5 mm, bispade drills, 16 mm long, each with internal irrigation (Brasseler/Cranin)
All drills over 3.5 mm in diameter should be selected in relation to the specific system selected
Starter burs: No. 2 round
Surgical instrument set
Surgical template (guide for implant placement)
Standard set of instruments (in addition to calipers, gauge, mallet, and implant-seating devices)

Before undertaking the placement of any type of root form implant, the practitioner should read this section in its entirety. It lists the introductory techniques of insertion for all types of root forms. In addition, recommendations are found in the tables of Chapter 4 for the selection of a wide variety of implant designs. The techniques for placement of the specific proprietary designs are presented in chapters 10 and 11.

This chapter first presents the generic, step-by-step technique for insertion of root form implants. The illustrations and explanatory notes demonstrate the procedure in a sequence that starts with gingival incision and ends at a point that satisfies the introductory requirements for all systems. The final osteotomies and techniques for specific implant insertions are described in the following sections. If the instructions in this chapter are followed, a "generic" root form implant can be inserted and uncovered. That is, these steps are identical for most root form systems.

After acquiring an understanding of each maneuver, the reader should refer to Chapter 4. Its charts describe most of today's implant varieties, their general grouping, material and design characteristics, surface finishes, methods of primary retention (during the integration period), and basic restorative options. Several systems offer implants with diameters of 3, 3.25, and 3.3 mm (small diameter). Especially in the maxillae, such implants often may be inserted after a 3-mm diameter drill is used without the formality of tapping, enlarging, or countersinking.

The diameters of drills should be increased in increments of 0.5 mm only (Brookdale Generic System). Bone density is a determining factor, as are internal irrigation, drill speed, torque, and bur sharpness. The smaller each graduation of bur size, the less heat and trauma are generated to the host site and the more accurate the osteotomy.

Not all systems supply all drill sizes. Different manufacturers supply a variety of sizes that may be selected to complete an entire generic set. For example, Nobel Biocare does not manufacture burs or a console that supplies internal irrigation; Calcitek recommends a round starter bur (the rosette); and Brasseler supplies graduated-diameter, internally irrigated spade drills.

Unless a computed tomography (CT) scan is available, the actual bone dimensions are known only at the time of flap reflection, and they dictate where the implants can be placed and what sizes should be chosen. However, the surgeon will find it significantly beneficial to use a surgical guide or template, so that the ideal locations for all implants are presented clearly where bone dimensions can accommodate them.

CAVEATS

In all endosteal implant procedures, the dental surgeon must take care not to impair vital structures. The use of infiltration anesthesia in the mandible helps guide drilling depths when the mandibular canal is approached, because the patient will report lip tingling. Slow drilling keeps intraosseous temperatures at safe levels. Saline irrigants can be chilled preoperatively to aid temperature control.

Implant placement must be planned with impeccable care; drills must be directed accurately, which can be aided by the use of paralleling pins and intraoperative radiographs.

Perforations of the cortical plates must be avoided. Systems that supply backup (or larger) implant diameters are valuable in case an oversized osteotomy is made (see Chapter 28 for specifics).

Burs and drills should be marked with the number of times used and discarded when they become dull.

Bone drills should be pumped vertically, rather than in an arc, to introduce copious irrigant and to encourage straight osteotomies.

Pressure should not be used when osteotomies are prepared; rather the drills should be allowed to find their own way. In systems that require bone tapping, use of a ratchet wrench by hand is preferable. Avoid this step completely if the bone is compliant enough to allow the implant to tap itself to place (e.g., Nobel Biocare, Biomet-3i, Zimmer). This level of pliability is found most frequently in the maxillae.

In the planning stages, a surgical template should be prepared for implant placement (see Chapter 4 and this chapter). However, the surgeon should keep in mind that sometimes, even the most careful planning does not yield satisfactory results because the bony ridge is not found directly below the soft tissues. The surgeon must be versatile enough to alter the positions and angles of the implants at the time of surgery.

Root form selection procedures (see Chapter 4) should be reviewed for the manufacturers' recommended drilling speeds for different implant systems.

Particularly in the maxillae, but also in less dense mandibles, some of the preparatory steps may be eliminated (i.e., tapping, or threading, the bone and use of the final sizing drill and the countersink drill). In this less dense bone, the implant can seat itself and thread and countersink the host site bone.

SURGICAL TEMPLATES

As surgeons gain more experience, they will find that the same template may be used for radiographic diagnosis (Chapter 4), for surgical placement, and even for uncovering the implants. Fabrication of the surgical template is a necessary step in the planning and placement of implants. Its design is based on the anatomic, prosthetic, and esthetic considerations. If (as discussed in Chapter 4) a diagnostic, 5-mm, ball-imbedded Omnivac template is available and each ball has been processed at a potential implant site, simply removing the balls allows the device to be used as an implant site locator. However, a template can be fabricated to be used specifically for intraoperative guidance.

A surgical template also can be fabricated with computer-aided design and manufacturing (CAD/CAM) using computed and cone beam volumetric tomography (CT/CBVT) virtual implant planning (i.e., Nobelguide from Nobel Biocare, and Sicat's Siroguide from GalaxisImplant). The latter requires some proficiency in computer-guided surgery, and the related fabrication costs are much higher than the traditional Omnivac template.

Three types of templates can be made using either the Omnivac or CAD/CAM process: a template for single tooth replacement or edentulous spans between natural teeth; a free-end saddle template for edentulous areas; and a template for completely edentulous sites.

Template for Single Tooth Replacement or Edentulous Spans Between Natural Teeth

The process of single tooth replacement begins with marking a cast at the ideal location for the implant. A denture tooth then is fixed in place with sticky wax. Next, an Omnivac shell is created using 0.02-inch clear material. After the material has cooled, the plastic is trimmed to include at least two teeth on either side of the operative area. In the edentulous area, the parts of the appliance that extend buccally and lingually beyond the points of flap retraction (approximately 6 mm) should be shortened. The denture tooth is removed, and the occlusal and lingual surfaces of the denture teeth area are snipped away with a fine shears. The device should be cold sterilized and placed into position over the bone after flap retraction. It is stabilized by the teeth on either side of the host site, and it serves as an efficient surgical guide (Fig. 9-1).

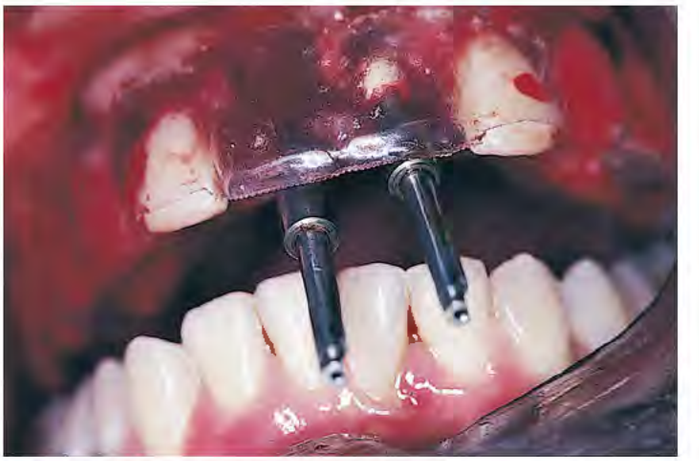


FIGURE 9-1. A simple Omnivac guidance device is used when implants are placed as pier abutments.

Free-End Saddle Template for Edentulous Areas

A free-end saddle template is made in the same way as the single tooth design, with minor changes. Four or more teeth anterior to the edentulous area are included in the Omnivac, and the shell margin is extended posteriorly past the anticipated distal extent of the incision line. In this way, the device is stabilized by a large number of anterior teeth and by its position on the soft tissues posteriorly, which are not to be elevated (e.g., tuberosity retromolar pad) even after flap reflection.

Template for Completely Edentulous Sites

For completely edentulous sites, a new denture is fabricated at least to the wax try-in stage. If an existing removable denture is being converted or an original full denture is to be used, it is relined with a chairside material, such as Viscogel. Next, the denture is flasked using Kentosil in a denture duplicator with petroleum jelly as a lubricant. The denture is removed, and clear acrylic resin is poured into its place. The flask is closed, and the acrylic resin is allowed to polymerize. When it is removed from the elastomer, it is a duplicate of the original denture in clear acrylic. The borders are trimmed and polished.

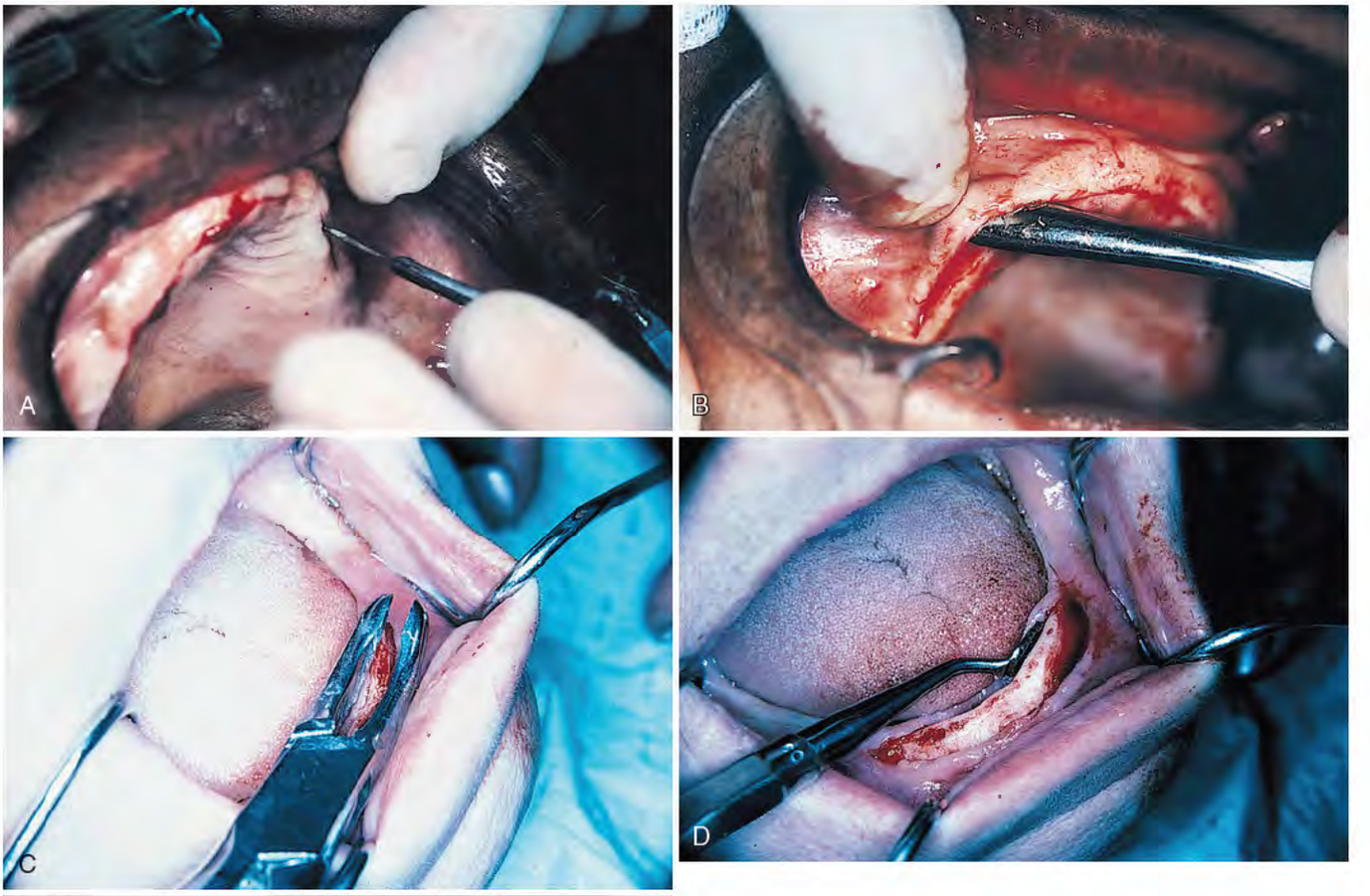
In the areas to be implanted, the lingual and occlusal aspects of the teeth are cut away with a bur in the form of a U-shaped trough; the incisal and facial surfaces are left intact. The fenestrated area denotes the sites where the implants are to be placed to satisfy the reconstructive and aesthetic needs of the case. Individual holes can be made, although this may prove too restrictive. The clear labial surfaces allow direct viewing during the preparation for osteotomies (Fig. 9-2). This not only ensures proper angulations, but also shows that the transepithelial abutments (TEAs) emerge from optimal areas, such as the cingula of incisors and the occlusal surfaces of molars.

These templates subsequently can be used to point out the site of each implant at the time of uncovering, which makes major reflection of the overlying gingivae unnecessary.

SURGICAL TECHNIQUES

An infiltration technique is used to anesthetize the patient. A crestal incision then is made directly to bone, with adequate relief at either end, and the mucoperiosteum is reflected, exposing the bony operative site (Fig. 9-3, *A* and *B*). At this point, the bone

FIGURE 9-2. The occlusal surface and lingual flange of the processed acrylic resin surgical template are opened, and the proposed implant sites are exposed. The labial tooth surfaces remain as guides to the surgeon.



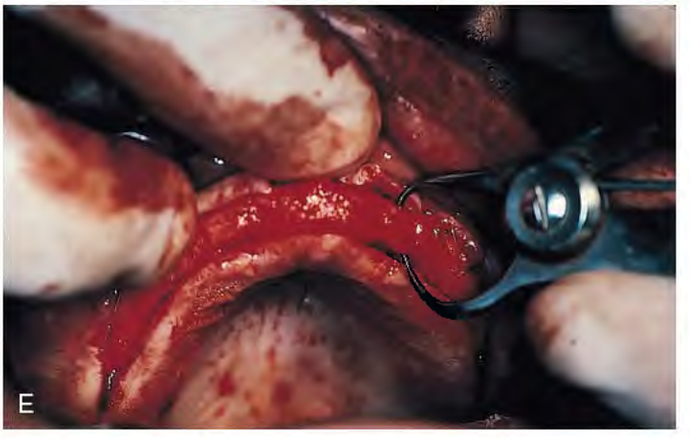


FIGURE 9-3. **A,** Incisions are made at the crest of the ridge. Relieving incisions may be required. **B,** Reflection of the mucoperiosteal flaps permits good visibility of the ridge crest. **C,** Rongeur forceps or a bur may be used to flatten (and widen) a knife-edged ridge. **D,** The final osteoplasty is performed with a bone file. **E,** Calipers are used to verify the ridge width.

is assessed. If the ridge is too narrow (i.e., knife edged), the surgeon must determine whether it can be flattened to an acceptable width and still have sufficient depth to accommodate an implant. If so, side-cutting rongeur forceps are used, and then a small, round vulcanite bur or a fissure type with irrigation (Fig. 9-3, *C*). Final smoothing is done with a bone file (Fig. 9-3, *D*). If the narrow ridge cannot be corrected but is deep enough, the surgeon should consider ridge augmentation (see Chapter 8) or placement of a blade implant (see Chapter 12).

After the ridge has been prepared and measurements indicate that the width is adequate (i.e., at least 5.25 mm) (Fig. 9-3, *E*), the osteotomies are made. As an alternative, ridge-widening procedures may be undertaken (see Chapter 8). (The surgeon must keep in mind that implants must be spaced one full width apart.) A colored sleeve is placed on the shaft of each drill at the level of the planned depth of each osteotomy (yellow Disposaboots currently are used) (Fig. 9-4). The drill tip pierces the rounded end, and the sleeve is slid up the shaft to mark the proper length.

The sterilized, clear acrylic, Omnivac surgical template is placed in the patient's mouth. The flanges are trimmed so that they will nestle comfortably beneath the reflected flaps of tissue; in this position, the flanges keep the flaps reflected. The template is stabilized with the host bone that appears directly beneath the U-shaped window. The starter bur (No. 2 round) is set in the center of each proposed implant site and rotated only into the cortex. Copious coolant is used, even though most starter burs are not equipped for internal irrigation. For each planned implant, a similar starter hole is made and then deepened just through the cortex (Fig. 9-5, *A*).

After the starter bur, the pilot drill is used. This drill, which is 1.6 mm in diameter and internally irrigated, is drilled to its full depth of 11 mm, unless a shorter implant length is planned (Fig. 9-5, *B*). If so, a colored sleeve is placed on the drill shank to mark the appropriate length. The proper angulation must be achieved in the first osteotomy. It is imperative to check the accuracy of dimension and location by taking an intraoperative radiograph of the first pilot drill in position (Fig. 9-5, *C* to *E*). If the dimension and location are satisfactory, another bur or a 1.6-mm diameter paralleling pin is placed in the first osteotomy as a directional guide. If the pin visually appears to have the proper orientation, it is left in position. Then, with the guidance of the template, the pilot drill is used to make the osteotomy for the second implant, which should be parallel to the first. A second bur or paralleling pin is placed in this hole (Fig. 9-5, *F*). In this fashion, all the osteotomies are made with 1.6-mm diameters to the 11-mm (or appropriate) depth; the surgeon must strive for continued parallelism and acceptable angulation. Using this system, which includes internal irrigation throughout, the entire series of pilot holes is completed and verified by placement of a paralleling pin into each hole. The template is used throughout to verify the location and accuracy of each site (Fig. 9-6).

FIGURE 9-4. Internally irrigated Brasseler bispade drills with colored depth markers (1.6 × 11 mm; 1.6 × 16 mm; 2 × 16 mm; 2.5 × 16 mm; 3 × 16 mm; 3.5 × 16 mm).

Each osteotomy may require deepening. This is done by removing the first bur (which was being used as a guide pin) and using a 1.6-mm hollow core, 16-mm long spade drill (with a yellow Disposaboot depth marker on its shank, if necessary). The spade drill is attached to the internal or external irrigation supply and rotated at the lowest speed that allows it to cut. This step must be performed with special care, because it is still remotely possible to deviate from the direction of the starter osteotomies. The bone is entered with the drill already turning. Requisite speeds vary, depending on the torque of the motor, the bone density, the sharpness of the flutes or spades, and the pressure applied by the surgeon's hand. Parallelism to the remaining pins is maintained.

The spade drill is driven to the full depth of the planned implant. For drilling, the surgeon uses a gentle, vertical pumping action to allow maximum coolant effect and to cause minimal bone trauma. However, the wrist should not move in an arc, although surgeons have a natural tendency to do this early in their experience. Each gentle application of force must be strictly vertical. The wrist is kept rigid, and movements are generated from the elbow. Drills are withdrawn from the bone while rotating, not after they have stopped.

When the planned number of osteotomies has been completed, each parallel to the others and all deepened to the proper depth with the 1.6-mm drill, the cycle is repeated in exactly the same manner using the 2-, 2.5-, and 3-mm drills. Paralleling pins are used at each step for continued verification.

Some systems suggest the use of guide drills (Biomet-3i, Nobel BioCare, and Zimmer). These types of drills have protruding, 2-mm diameter guide pins that discourage deviation from the starting angulation (Fig. 9-7, *A*). If used at the 2-mm osteotomy size, the smooth end of the drill enters flawlessly and guides the drill's direction, allowing its cutting portion to enlarge the superficial half of the osteotomy to a diameter of 3 mm. This is followed with a full-length 3-mm drill, which quite naturally finds its path to the full depth. However, this incremental change exceeds the safe increase of 0.5 mm, therefore its use is discouraged. If the surgeon moves from a starter drill of 1.6 mm to the larger diameters in 0.5-mm increments (Fig. 9-7, *B*), deviation from the direction of the pilot hole is virtually impossible, and the counterbore is not necessary. In addition to this safety feature, small increments cause less bone damage and maintain bur sharpness for longer periods.

For systems with larger diameter implants, the steps just described should continue to 3.5- and 4-mm diameter generic drills. The final diameter of the planned implants determines the largest diameter drills used (Fig. 9-8, *A*). The drills should be 0.25 to 0.5 mm smaller than the implants so that the final proprietary sizing drill for the selected implant can be used to complete the osteotomy. The drills for the standard generic set are available from companies such as Brasseler and Salvin Dental. The diameter is marked on the shank of most of these drills. However, a sterile Boley gauge should always be used to verify the measurement of each drill before it is used; this ensures that an oversized cut is not made inadvertently (Fig. 9-8, *B*).

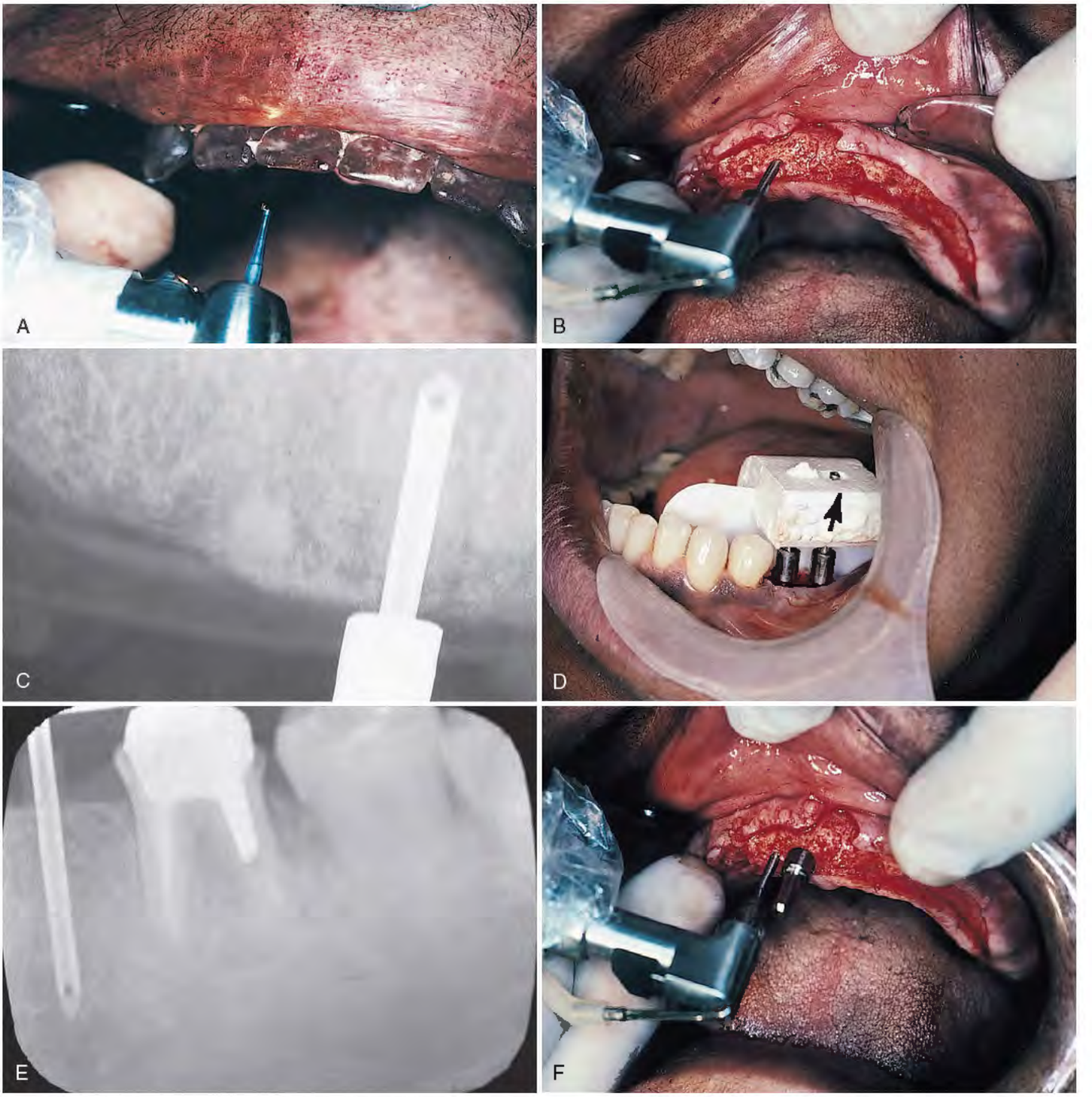


FIGURE 9-5. **A,** The surgical template is put in position. It both retracts the flaps and guides the placement of the starter osteotomy, just through the cortex. **B,** The second step is made with the 1.6-mm pilot drill, at the proper angulation and site, for distances of up to 11 mm. **C,** An intraoperative radiograph is taken to confirm the length and location of the pilot drill. **D,** Intraoperative radiographs are always used when nerves are near the host sites. A simple technique, which maintains sterility and keeps the patient's hand out of the field, involves a gas-sterilized Styrofoam film holder, which is held in position by paralleling pins or burs that pierce its soft block *(arrow)*. **E,** The resulting film shows safe progress during the operation, as well as accuracy of distances, parallelism, and positioning. The first 1.6-mm diameter drill, if satisfactory, facilitates a simple, flawless operation. **F,** Pins are placed in each osteotomy to preserve continuing parallelism of adjacent bone cuts.

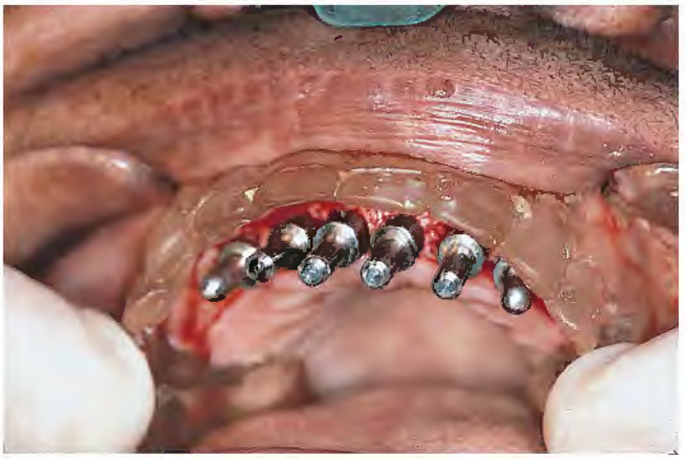


FIGURE 9-6. The final positioning of the 1.6-mm diameter osteotomies is determined by the placement of the pins, all of which should lie within the confines of the template.

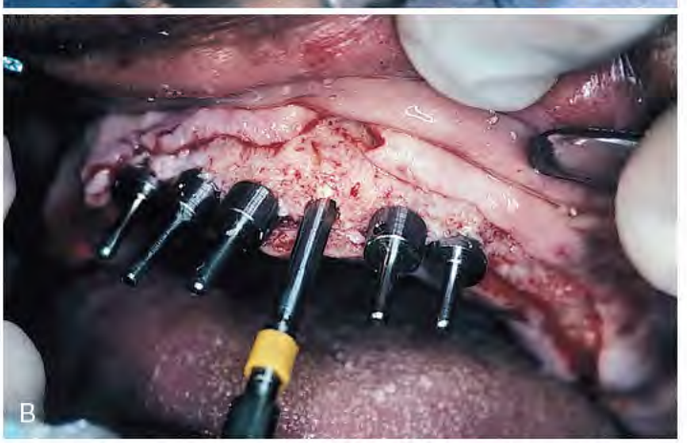
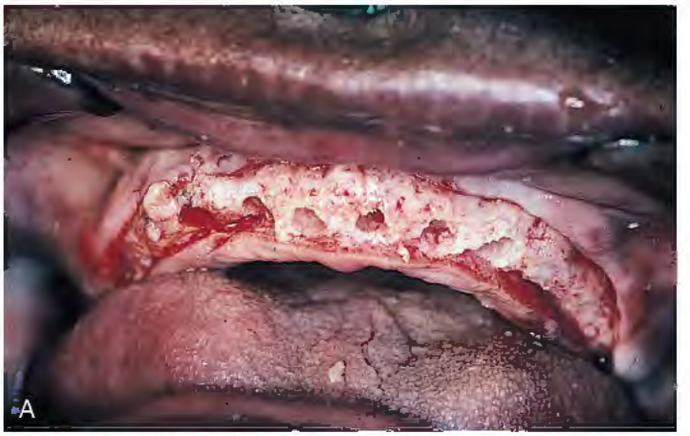


FIGURE 9-7. **A,** The guide drill has a smooth end that allows atraumatic entry into the 1.6-mm diameter osteotomy and a fail-safe enlargement to 2 mm. Note the bone *(arrow)* embedded in the drill flute; this debris, when saved, is a source of osteogenic graft material. **B,** The use of increments of 0.5-mm diameter spade drills at each step preserves accuracy and enlarges the bone slowly and safely.

At this point, the specific steps for seating of one of the three major types of root form implants are initiated. Chapters 10 and 11 describe the specific steps required to place the various implants, starting with the first step after use of the generic system.



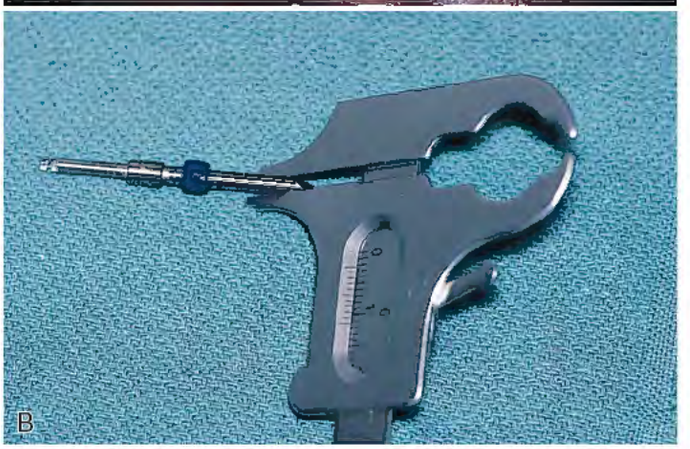


FIGURE 9-8. **A,** The last generic step before the manufacturer-specific osteotomy is created is completion of 3- or 3.5-mm diameter implant sites of the appropriate depth. **B,** Drill diameters should be double-checked with a Boley gauge.

Threaded Pretapping Implants

Threaded pretapping implant systems (e.g., Zimmer, Nobel Biocare, Biomet-3i, Lifecore) supply taps or threaders; if the bone is hard, these should be used once and then discarded. After using a generic drill of a diameter 0.25 to 0.5 mm less than the planned implant, the surgeon inserts the tap into the osteotomy and rotates it, when possible, with a handheld ratchet, wheel, or wrench (Fig. 9-9, *A*). If the progress becomes too difficult, an ultra-low-speed tapping motor drive (i.e., 5 to 10 rpm) is used (Fig. 9-9, *B*). Conversely, if the progress appears to be too easy, the tap should be removed and the implant itself substituted as its own bone tap. The same rule applies for the countersink drill (Fig. 9-9, *C*). If the bone is compliant, the countersink is not used. Instead, the implant is allowed to seat itself fully (Fig. 9-9, *D*).

After threading is complete, the tap is backed out with great care. Hand pressure should be minimal. The hand is used only to guide the direction of unthreading of the bone tap. The pitch of the threads should be depended on to influence its removal from the bone. Placement of the implant follows, and again the handheld ratchet or ultra-low-speed motor with irrigation is used (Fig. 9-9, *E*).

Some of the more finely threaded systems require the development of an even greater skilled tactile sense, which requires experience. Early efforts may result in stripping of the bone threads. The surgical team must be prepared with larger threaded sizes or press-fit implants to serve as backups. A wise course is to start bone tapping using handheld wheels and, if resistance is met, ratchet wrenches with lever arms. The wheel handle transmits to the surgeon's fingers a much greater sense of the feel

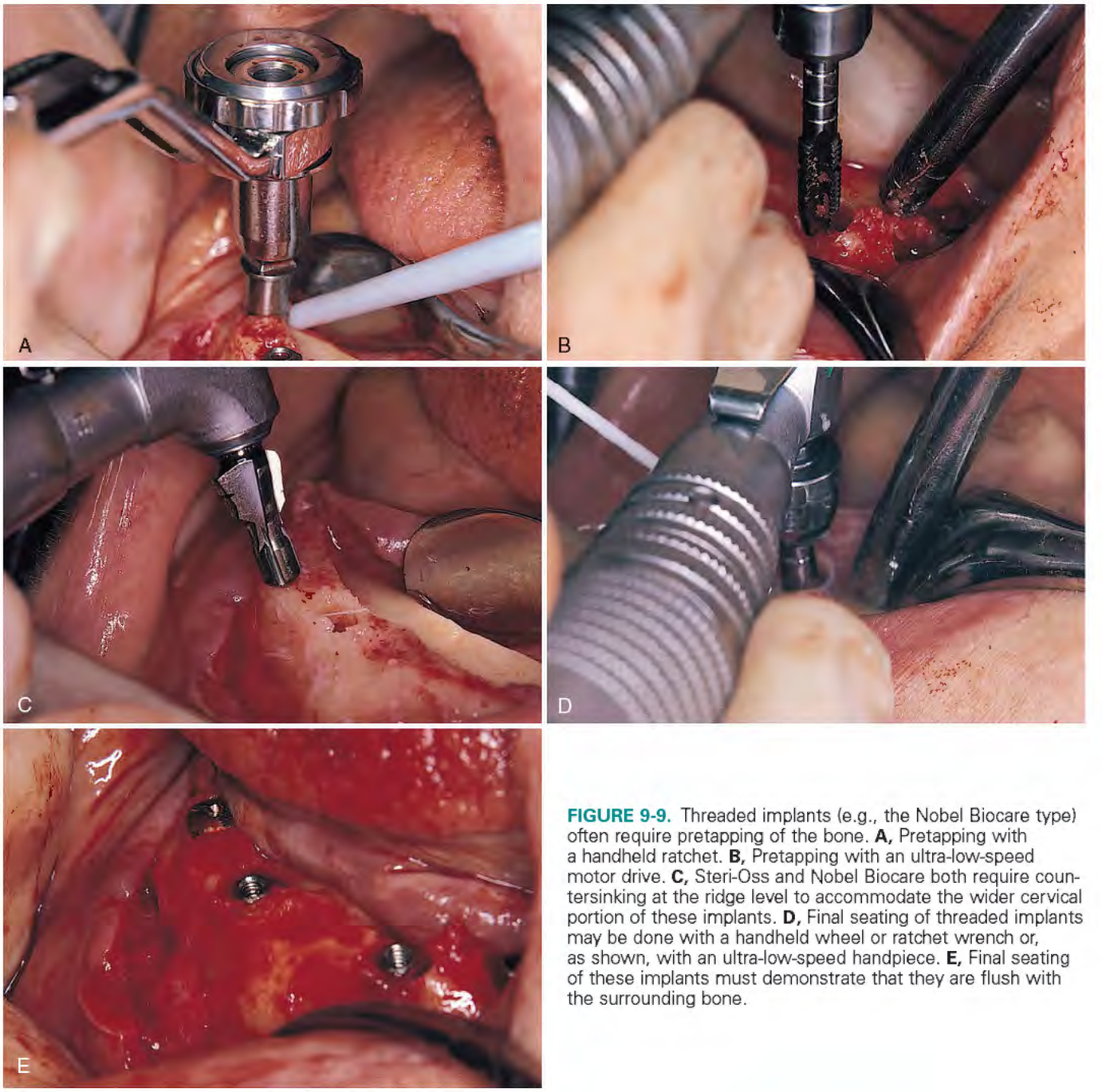


FIGURE 9-9. Threaded implants (e.g., the Nobel Biocare type) often require pretapping of the bone. **A,** Pretapping with a handheld ratchet. **B,** Pretapping with an ultra-low-speed motor drive. **C,** Steri-Oss and Nobel Biocare both require countersinking at the ridge level to accommodate the wider cervical portion of these implants. **D,** Final seating of threaded implants may be done with a handheld wheel or ratchet wrench or, as shown, with an ultra-low-speed handpiece. **E,** Final seating of these implants must demonstrate that they are flush with the surrounding bone.

of the procedure than does the ratchet wrench. Even less is perceived with the motor and handpiece.

Threaded Self-Tapping Implants

Threaded self-tapping implant systems (e.g., Zimmer and Nobel Biocare self-tap) are simpler to place than implants that require pretapping. After using the final bone drill, 0.5 mm smaller in diameter than the implant itself, the surgeon taps the implant into the unthreaded osteotomy with a handheld ratchet wrench (Fig. 9-10). As an antitorque influence, the forefinger of the other hand is used to exert firm pressure in an apical direction. Threaded self-tapping implants offer a more satisfactory tactile experience to the less experienced practitioner and are recommended for those just entering the field. If the threads become stripped, a number of companies make backup sizes of larger diameters.

Nonthreaded Press-Fit Implants

Several systems of nonthreaded, press-fit implants are available (e.g., Zimmer and Camlog). The technique is easier and no threading is required, but in some cases the final sizing drill is just slightly too large. Whenever possible, the try-in implant (a stainless steel replica) should be tapped into place with a mallet after the next-to-final drill is used (Fig. 9-11, *A*). If the try-in goes to place, eliminate the last manufacturer-recommended step and use light mallet taps to seat the implant itself (Fig. 9-11, *B* and *C*). (See chapters 10 and 11 for the final osteotomy steps required for each system before final implantation [Fig. 9-11, *D*]). As each step is completed, accuracy is verified with the depth gauge and paralleling pins. After the implants have been fully seated, healing screws, which are either smooth or threaded, are placed in the implant chambers (Fig. 9-12). Some implants are available with healing screws already inserted; these often require

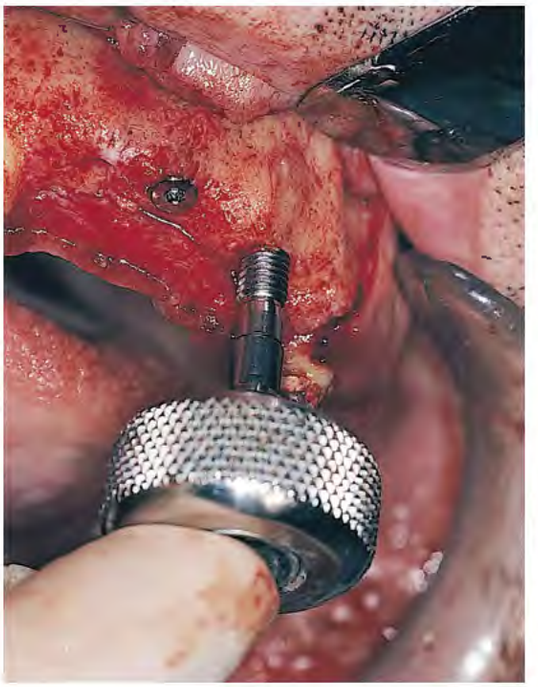
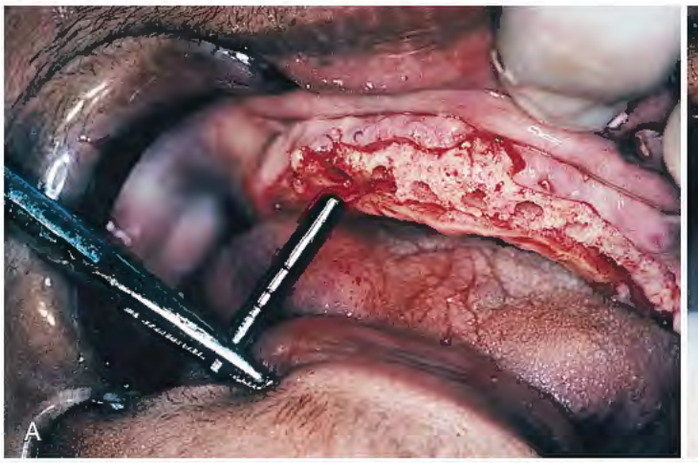
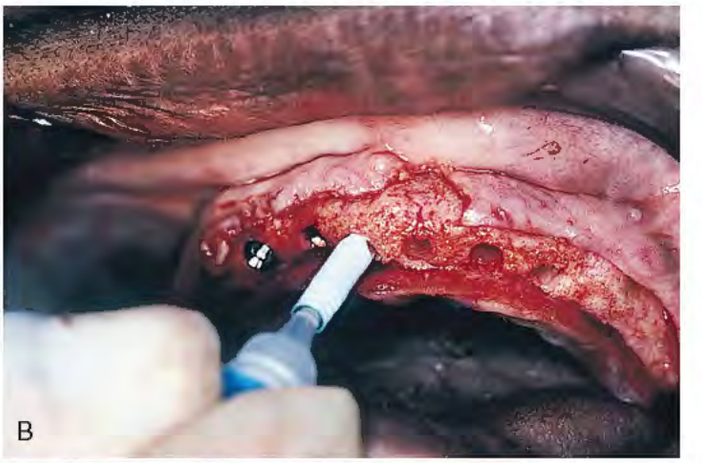
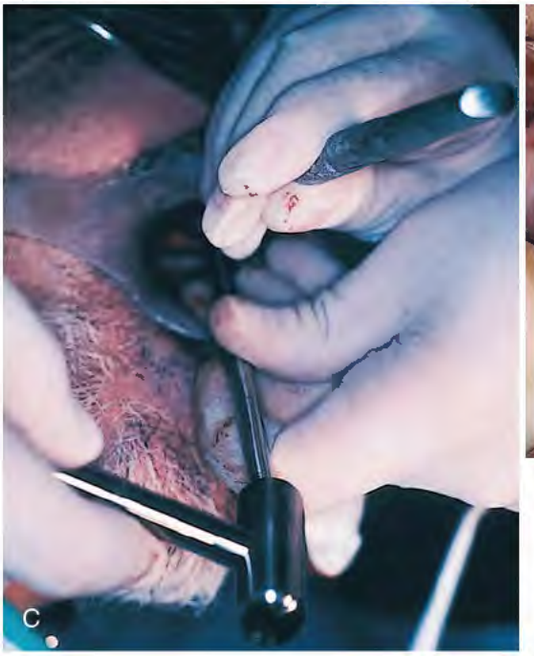


FIGURE 9-10. Self-tapping implants, such as this Paragon Screw-Vent, find their own way into the bone when a handheld ratchet is used to tighten them.







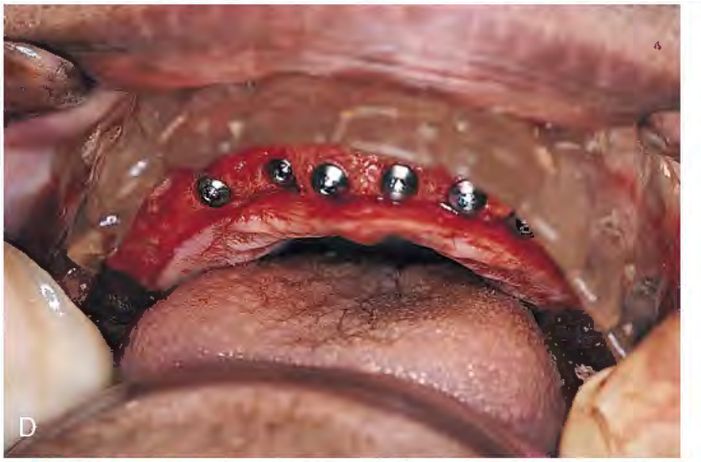


FIGURE 9-11. **A,** Press-fit implants (e.g., IMZ, Bio-Vent, and Integral) make stainless steel try-ins available. When these are tapped into slightly undersized osteotomies, they create very accurate host sites for a firm frictional fit. **B,** Some press-fit implants may be removed from their packages by the cover, which also serves as an insertion handle. **C,** After a press-fit implant can be introduced no farther with finger pressure, tapping can be used to insert it more deeply. **D,** These implants are in position, and the template serves as an indicator of accurate placement. Healing caps have been placed into the three on the patient's left side.

FIGURE 9-12. Assorted healing caps and screws made of titanium and polyethylene. Some are threaded, and others snap into position.

tightening with an Allen wrench. Other manufacturers supply the screws in the hollow caps used to cover the containers in which the implants are delivered. Still others offer them in separate sterile packages.

A valuable maneuver when placing implants in the maxillae and softer mandibular areas is to eliminate the final step in the osteotomy preparation recommended by the manufacturers. In less dense bone, use of the final sizing drill, thread tapper, or countersink not only is not necessary, it often creates an oversized osteotomy; the result is an unstable implant or the need to use the next largest diameter (or backup size) implant. It is imperative to have good frictional fit after the implant is seated fully. Several companies make larger diameter implants in case an implant is loose because of an oversized osteotomy.

Also, for cases in which threads become stripped, most manufacturers make larger backup implants. Nobel Biocare and Biomet-3i make 4-mm diameter implants for the 3.75-mm implant (Fig. 9-13, *A*), and Zimmer makes a press-fit implant for the same osteotomy as their threaded (3.9-mm diameter) implant (Fig. 9-13, *B*). Most root form systems supply implants of varying diameters to serve this emergency function (Fig. 9-13, *C*). Larger implants should be used if bone dimensions permit it.

When a surgeon selects a root form implant, the benefits of a backup system must be taken into serious consideration. If a particular system does not supply this feature, the surgeon should find a compatible system to serve as a backup (see Table 4-2). For stripped bony threads, a larger threaded implant or a press-fit implant is used to fit the osteotomy. A loose press-fit implant should be replaced with a larger press-fit or larger threaded implant. Closures are best performed in the continuous horizontal mattress suture configuration. Patients must be instructed in the proper postoperative care (see Appendix H).

When molars are to be replaced with implants, the ideal goal is to place a long, thin implant for each mandibular root and, when feasible, one for each maxillary buccal root. Although the space often is limited, and impression making may present the problems of fitting closely placed copings, the force distribution is improved when multiple implants are used (Fig. 9-13, *D* and *E*). Single implants in such sites present cervical diameters that, even at 6 mm, fall far short of the dimensions of the molar being replaced. The resulting problems include concentrated occlusal forces, exceptionally large and annoying embrasures, and unacceptable esthetics. Even the extra-large esthetic abutments cannot satisfy the anatomic demands of the molar operative site.

Immediate Placement of Root Form Implants into Extraction Sites or Former Implant Sites

Endosteal irnplants usually are implanted into well-healed, adequately contoured ridges. However, if extractions are part of the process, placing the implants in the alveoli immediately after the extraction (Fig. 9-14) offers a number of benefits:

- Combining integration of the implant with mineralization of the socket shortens healing time.
- Preservation of ridge morphology and dimension is encouraged by the presence of an implant.
- Positioning and angulation of the implant is simpler, because the recently removed tooth indicates this geometry, and the walls of the alveolus serve as guides in directing the osteotomy.

Certain precautions must be observed with this approach. The location and angulation of the tooth to be replaced must be correct. Altering the direction of a socket is difficult because of its generally thin cortical plates. However, such an alteration can be done, even if a buccal or labial cortical plate is perforated. If part of the implant protrudes through the fenestration, a particulate bone substitute material may be added and covered with a guided tissue regeneration membrane (GTRM). Techniques using membranes and grafting materials are found in Chapter 8.

The socket must be completely free of soft tissue, granulomas, and other infectious debris. A No. 15 BP blade, sharp curettes, and small, curved mosquito hemostats are used for this purpose. The scalpel blade is used to make a 360-degree incision through the periodontal gingivae down to the alveolar bone margins. Curettes then are used to undermine the granulomatous lining of the socket, and with the traction supplied by a mosquito hemostat, the soft tissue mass comes away cleanly. The overlying soft tissues are closed primarily, and the adequacy of the flaps is verified before the implants are placed. When necessary, the surgeon must create the appropriate environment for a primary closure in advance. Undermining of the labiobuccal flap from its muscle bed is the best option. As an alternative, the facial and lingual papillae can be interdigitated (see Chapter 8).

Adequate apical bone must be present to allow primary retention for at least 40% of the implant length. This means that at least 3 to 4 mm of a 10-mm implant must reside in newly cut bone. This 40% relationship can be developed from bone beyond the apex or from narrow bone within the extraction site that requires enlargement to accommodate the implants. If the socket is wide, wider implants should be chosen. If room is available apically, the coronal portions of the alveolus that do not approximate the implant are removed; this allows deeper penetration into virgin bone and elimination of the less predictable, more fragile, and poorly vascularized alveolar margins. It also reduces the diameter of the socket so that a more intimate primary interfacial relationship is encouraged. However, it increases the final crown-to-root ratio (Fig. 9-15).

Surgical Technique

For implant surgery, the method of choice for anesthesia is infiltration of a local anesthetic with small amounts of epinephrine. The extractions are performed as atraumatically as possible (Fig. 9-16, *A*), which contributes to preservation of the maximum amount of alveolar bone. When the availability of adequate soft tissues for closure has been determined and the socket is completely free of granulomas, the osteotomies are performed. An internally irrigated, 24-mm long,

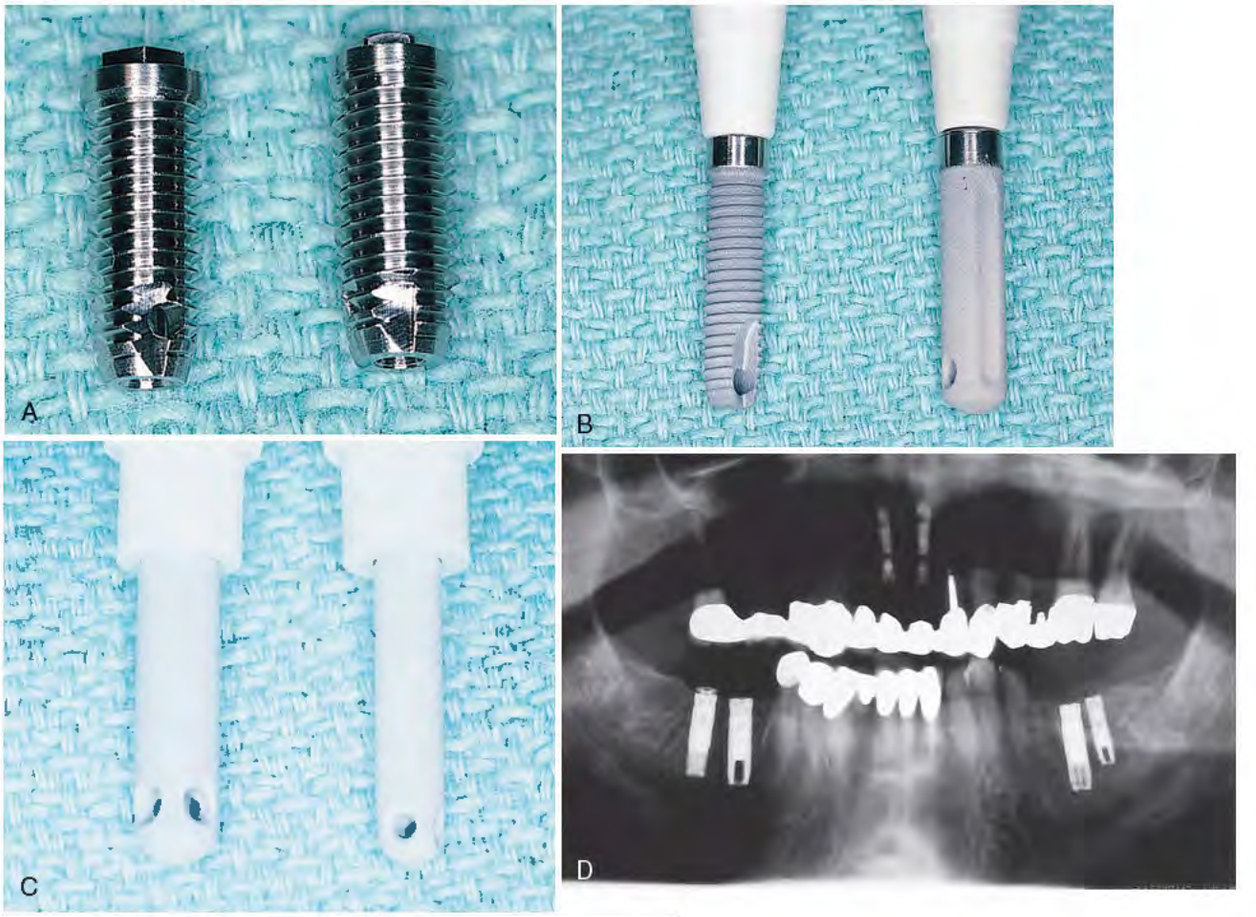


FIGURE 9-13. The surgeon is well advised to use implant systems that can supply larger "backups." **A,** Nobel Biocare 3.75- and 4-mm threaded implants. **B,** Camlog 3.8-mm threaded and press-fit implants. **C,** Calcitek press-fit implants; 3.25- and 4-mm diameters. **D,** The placement of two narrow root forms at molar sites (either immediate or delayed), as seen here, is preferred over placement of a single large-diameter implant. If the root forms are too close together, a custom abutment may be cast as a single component with extensions into each implant. **E,** If separate abutments are used, the final restoration can be a single, fixed-detachable, molar-type crown cast over both of them.

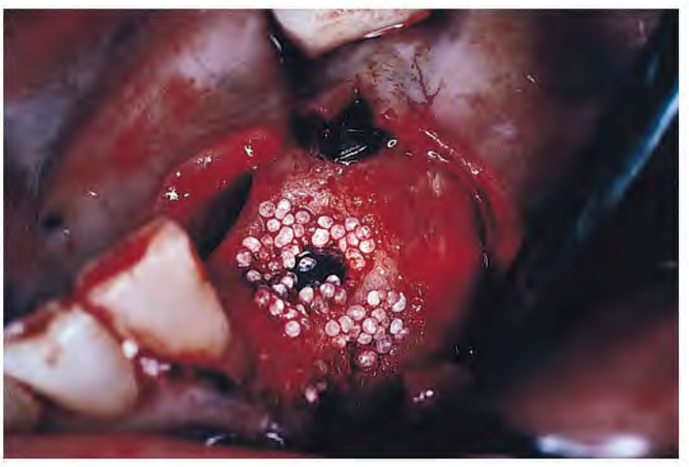


FIGURE 9-14. Implants may be placed immediately into extraction sockets, but defects must be augmented with grafting materials and often require coverage with guided tissue membranes.

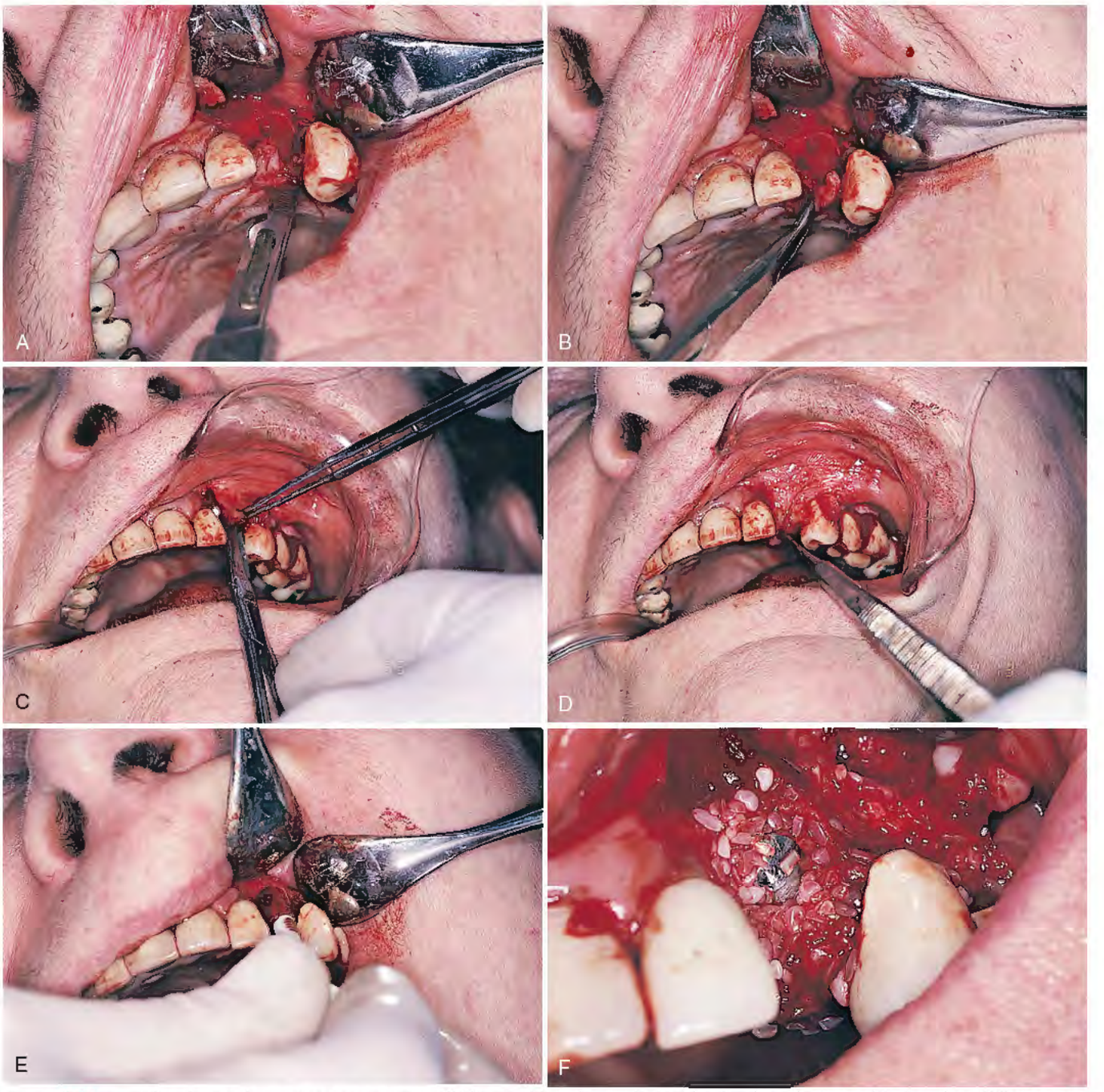


FIGURE 9-15. **A,** After the tooth has been removed, a BP No. 15 blade is used to excise the invaginated epithelium in a 360-degree incision down to the bone margins. **B,** After the back of a small curette is used to elevate the granulomatous lining of the socket, a mosquito hemostat is used for traction and to assist in total soft tissue removal. **C,** To create tissue sufficient to permit primary closure, the facial mucoperiosteal flap is undermined and lifted away from its underlying muscle bed. **D,** The flap is brought across the defect to test its ability to cover the site without tension. **E,** After the host site has been prepared, the implant is placed into at least 40% newly cut bone. **F,** Graft material is used to fill the peri-implant space before the pedicle flap is sutured over the graft.

1.6-mm diameter Brasseler spade drill should be marked with a yellow boot (this is followed by drills of increasing size, as described earlier). Often a bur extender mandrel is required, particularly if adjacent teeth are present (Fig. 9-16, *B*). Finally, the widest and longest implant that can be accommodated is inserted (Fig. 9-16, *C*). In some cases, implantation after extraction of a tooth offers less satisfactory interfacial relationships than when the implant is placed in healed alveoli.

A 20-mesh particulate bone substitute material, such as hydroxyapatite (HA) or demineralized freeze-dried bone (DFDB), is placed around the implant to serve as an osteoconductive or inductive medium and encourage a more intimate final osseous interface.

When a multirooted tooth has been extracted, if implants cannot be inserted into each socket, the surgeon must decide which socket to use for the implant or whether the interseptal bone should be removed. A factor that influences the selection of site is the required angulation of the implant. This can be determined by inserting a paralleling pin or implant analog (try-in). Once the appropriate socket has been chosen, the osteotomy is completed and the implant is placed. The operative and adjacent alveoli are filled

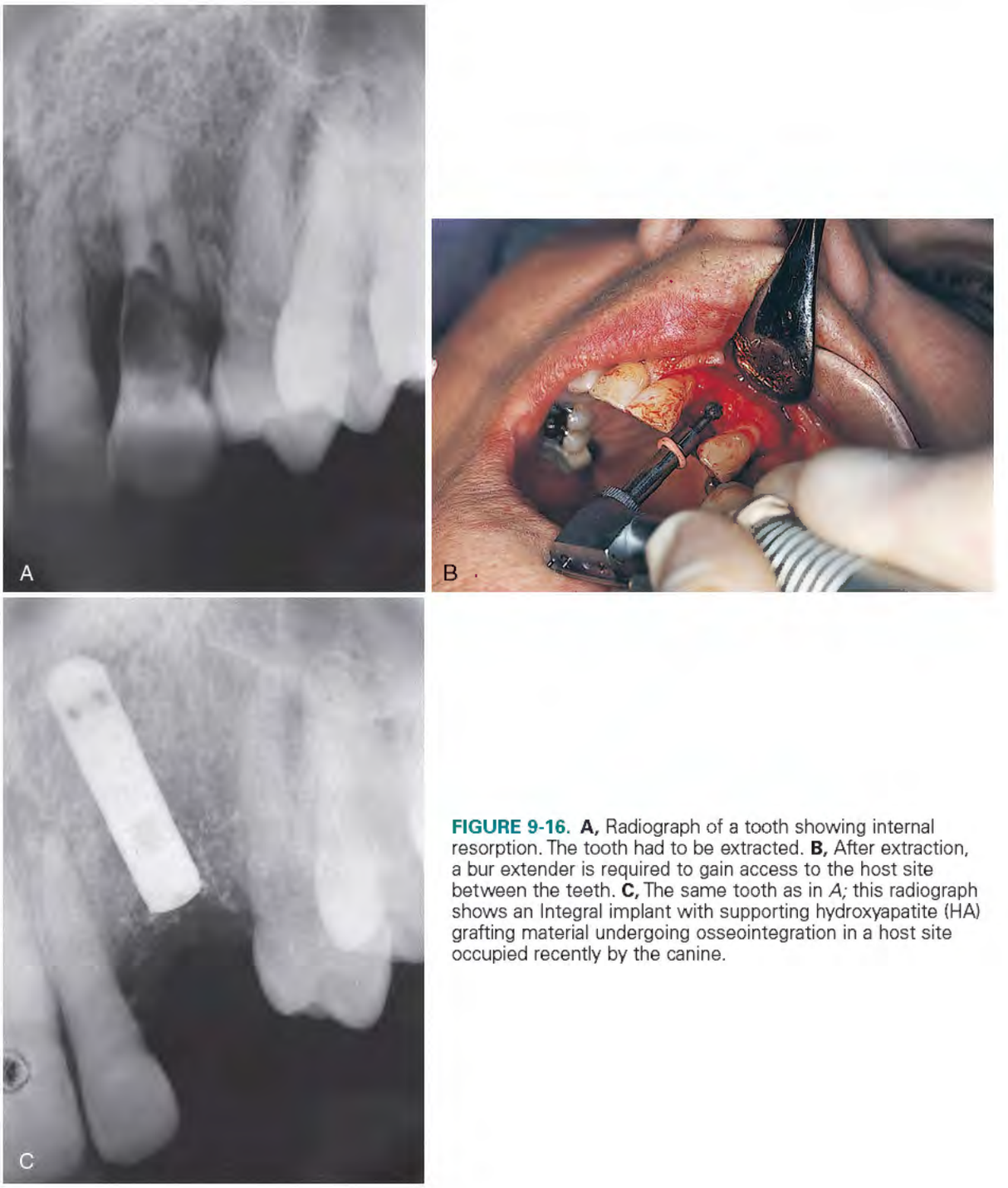


FIGURE 9-16. **A,** Radiograph of a tooth showing internal resorption. The tooth had to be extracted. **B,** After extraction, a bur extender is required to gain access to the host site between the teeth. **C,** The same tooth as in *A;* this radiograph shows an Integral implant with supporting hydroxyapatite (HA) grafting material undergoing osseointegration in a host site occupied recently by the canine.

with a bone substitute material as required, a GTRM is fastened into position, and closure is completed.

If the separate alveoli are too small to accommodate individual implants, a second factor must govern the management of the host site. One or several septa must be removed and the newly enlarged area used for implant placement. As described previously, a particulate bone substitute material is valuable for complementing the portions of the osteotomy that do not have contact with the implant. If the altered host site dimensions are greater than the selected implant, and primary retention depends on the several millimeters of subapical bone into which the osteotomy was extended, a threaded implant should be considered. An implant with threads extending to the apical end offers greater primary retention and a more favorable prognosis. Vital structures must be avoided and perforations of the cortical plates create hazards that must be treated with grafting materials and membranes.

The benefits of immediate implantation are considerable, and the operative procedures often are simpler because of the guidance offered by the existing extraction socket. Bone grafting materials are generally required (see Chapter 8).

If a single tooth is being replaced by an implant and adjacent teeth are present, maintenance of alveolar height and gingival contour are of great aesthetic importance. In such cases, if inadequate gingiva presents a problem for primary closure and undermining (see Chapter 7), a GTRM can be used. The material is tailored to a size that allows it to extend at least 2 mm beyond the extraction

site and onto the surrounding bone in all directions. The membrane is secured in position using a crisscross suture pattern over the operative site. This presents a barrier that discourages epithelial down-growth. The complex is then covered with a periodontal pack. These implants are allowed to integrate for at least 6 months before the second-stage surgery is performed.

Uncovering Submergible Implants

When the implants have become integrated (3 to 6 months), they are ready for the uncovering, or second-stage procedure. First, however, the sites are examined radiographically. This examination should consist of panoramic and standardized periapical films. The radiographs should show that the bone has healed immediately adjacent to the implants, with no intervening radiolucent areas (Fig. 9-17). Once healing appears to be complete, the appointment for uncovering is scheduled. Before performing the surgery, if the surgeon did not perform the first-stage procedures, he or she should gather information about the type and number of implants placed, the location of each, the kinds of healing caps or screws used, the bone augmentation materials and/or GTRMs used, and any operative complications that had been encountered at the time of placement. A well-kept chart offers this information.

The prosthetic treatment plan is reviewed so that the proper pregingival temporary healing collars are available, as well as the final TEAs. The appropriate final abutments may be placed at the time of uncovering, but it generally is recommended that temporary collars be used until the soft tissues mature and can be properly measured for final abutment sizes. Healing collars are available in several designs and lengths per implant type. They are inexpensive and often are interchangeable from system to system (Fig. 9-18). They can be used repeatedly and simply require ultrasonic cleaning and autoclaving. Their best feature, however, is that some are designed to assist in the creation of a neat, geometric gingival cuff. When a collar of the proper shape and length is used, the correct emergence profile can be established for the final restoration.

Different healing screws require different screwdriver types (i.e., Allen, hex, hooded, modified Phillips). Also, certain abutments require special instruments for seating, countertorquing, and bending. Some gingival punches are also system specific.

Before anesthetizing the area, the surgeon should attempt to visualize the location of the implants. Sometimes the gingivae take on the appearance of small, raised, blue-gray circles at each site. When such demarcated areas are noted for each implant and

FIGURE 9-17. Before root form implants are uncovered, a periapical radiograph is taken so that the state of mineralization of the host bone can be determined.

FIGURE 9-18. Healing collars *(center and right)* are not available for all systems. Nobel Biocare recommends immediate placement of their final transepithelial abutment *(left)* in nonesthetic areas.

these areas are in attached gingiva, the punch technique can be used. If the sites are not identifiable, the sterilized original surgical template may be seated over the intact tissues. It often indicates the location of the implants. These areas are anesthetized with buccal and lingual infiltrations, and the specific punch for the implant system is pressed through the tissues and rotated firmly directly over the site (Fig. 9-19, *A* and *B*). After one or two full rotations of the instrument to its full depth, the punch is removed. A circle of soft tissue sometimes comes away in the lumen of the instrument. If it does not lift out fully with the punch, it may be grasped with a mosquito hemostat and gently dissected free with a BP No. 12 blade in a scalpel handle. These segments of epithelium should not be discarded, because if necessary, they can be used as free grafts to create zones of fixed gingiva adjacent to the newly exposed implants. This can be done simply by pushing the abutting alveolar tissues apically 3 to 4 mm, placing the round free gingival graft over the residual periosteum, and stabilizing it with two crisscross sutures.

In a similar manner, the surgeon can perform an anterior mandibular vestibuloplasty at the time of the second-stage uncovering with a free palatal graft, using a pushback operation or (as described in Chapter 7) a split-thickness, labial mucosa pedicle graft. The opening so created is inspected to make sure the entire surface of each cover screw can be seen, along with the full circumference of the implant head (Fig. 9-19, *C*). More soft tissue may need to be removed with the scalpel at this point. Also, if bone is growing over the implant margins, a small, sharp osteotome or a saline-cooled No. 2 round bur should be used to remove it gently. Some systems (e.g., Nobel Biocare) make a cover screw mill specifically for this purpose.

Finally, the cover or surgical healing screw is removed with a screwdriver (Fig. 9-19, *D*). At this point, the entire superior aspect of the implant should be visible. The area is irrigated gently with sterile saline or a 50:50 mixture of povidone-iodine and saline. The surgeon must confirm that the implants have become integrated. Integration is assured if bone has grown up to and around the implants' most superficial aspects. In addition, a tap on each implant with the back end of a metal mirror handle should produce a solid, resounding sound, much like that made when an ankylosed tooth is tapped. Implant rigidity is verified by placing a sterile prosthetic insert into the implant and testing for mobility with the Siemens Periotest. Finally, the healing collar is placed (Fig. 9-19, *E*).

If no indication is seen of the exact location of any or all of the implants, they must be exposed through a crestal incision. Anesthesia is administered by infiltration in the same manner as described previously. Then, using a BP No. 15 blade, the surgeon makes a crestal incision directly down to bone and extends it 5 mm mesially and distally to the anticipated implant locations. Next, a carefully reflected, full-thickness, soft tissue flap is created facially and lingually until all of the implants have been fully exposed (Fig. 9-20). Any tissue from around the implants is removed with a hemostat or toothed Adson forceps and scalpel. The healing screws are backed

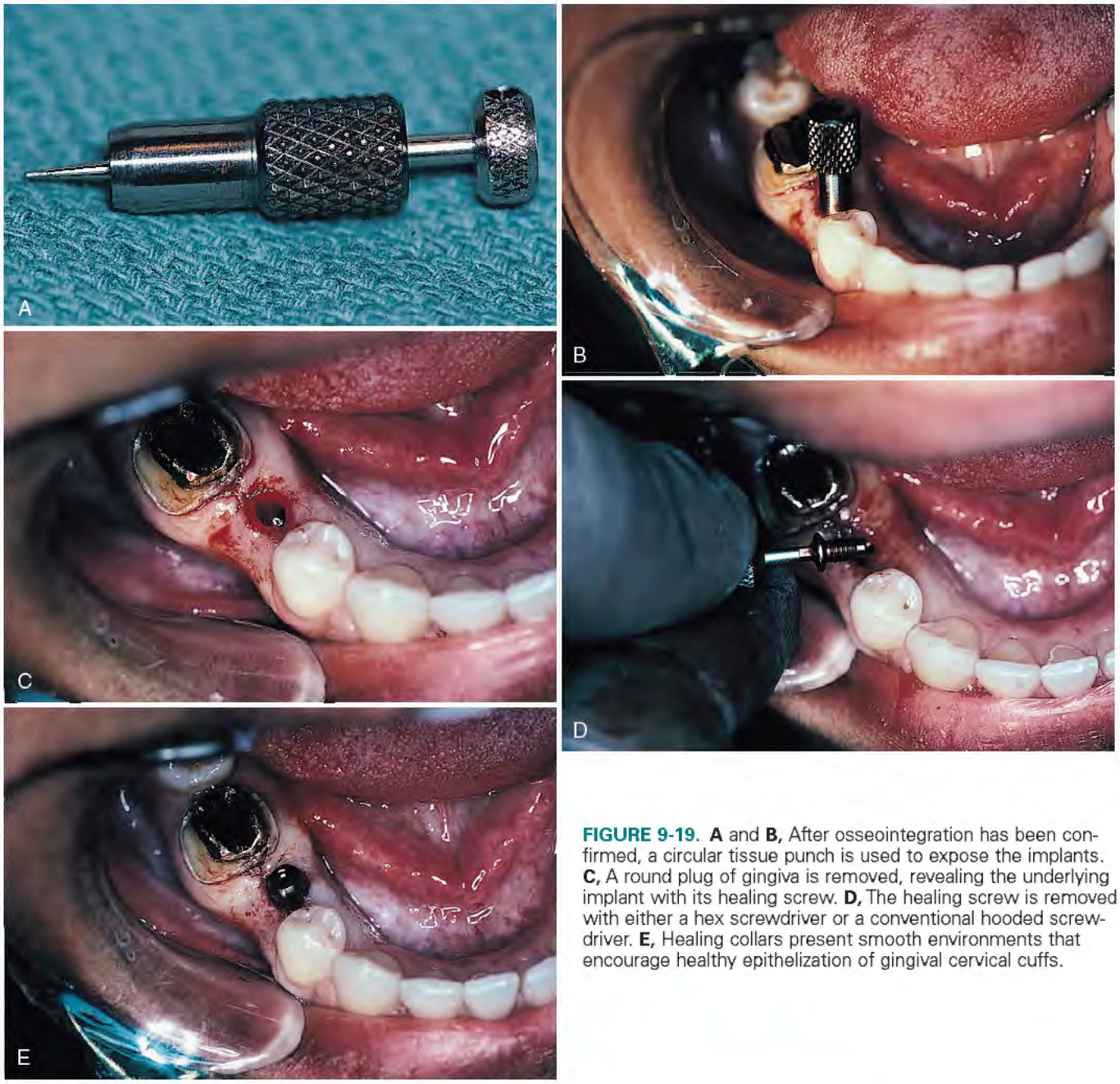


FIGURE 9-19. **A** and **B,** After osseointegration has been confirmed, a circular tissue punch is used to expose the implants. **C,** A round plug of gingiva is removed, revealing the underlying implant with its healing screw. **D,** The healing screw is removed with either a hex screwdriver or a conventional hooded screwdriver. **E,** Healing collars present smooth environments that encourage healthy epithelization of gingival cervical cuffs.

out, and any osseous tissues over the superior aspects of the implants are moved with a bur or mill.

The area is irrigated, and integration of each implant is verified. After the implants have been fully uncovered, a periodontal probe is used to measure the soft tissue thickness for each implant. Some systems offer specialized tissue measuring devices that can be used to determine final cuff heights. In nonesthetic areas, a height that extends 1.5 to 2 mm above the gum is proper. The healing collar components are seated completely; this must be confirmed radiographically if clinical evidence is uncertain (Fig. 9-21, *A*). The tissues are contoured to fit around the cervices of the collars, and closure is performed using interrupted or mattress sutures (Fig. 9-21, *B*). The existing interim prosthesis is radically relieved and lined with a soft material, such as Viscogel or Coe Soft. The soft tissue measurements made influence the selection of the final TEAs, which can be placed approximately 2 weeks later. Anesthesia generally is not required for this step. Re-epithelization of the pericervical gingival cuffs should be complete at that time.

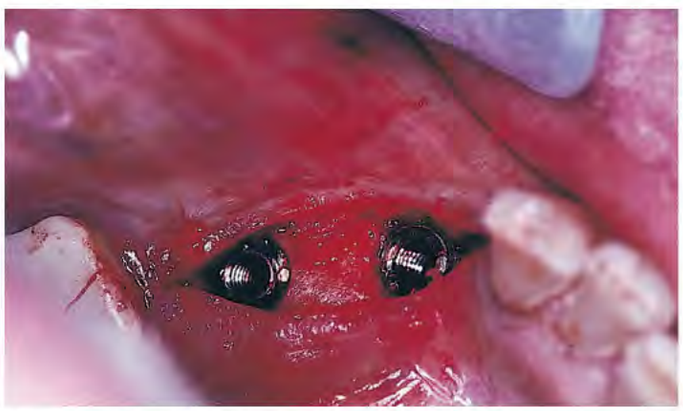


FIGURE 9-20. When tissue punches are not practical, implants can be safely exposed by crestal incision.

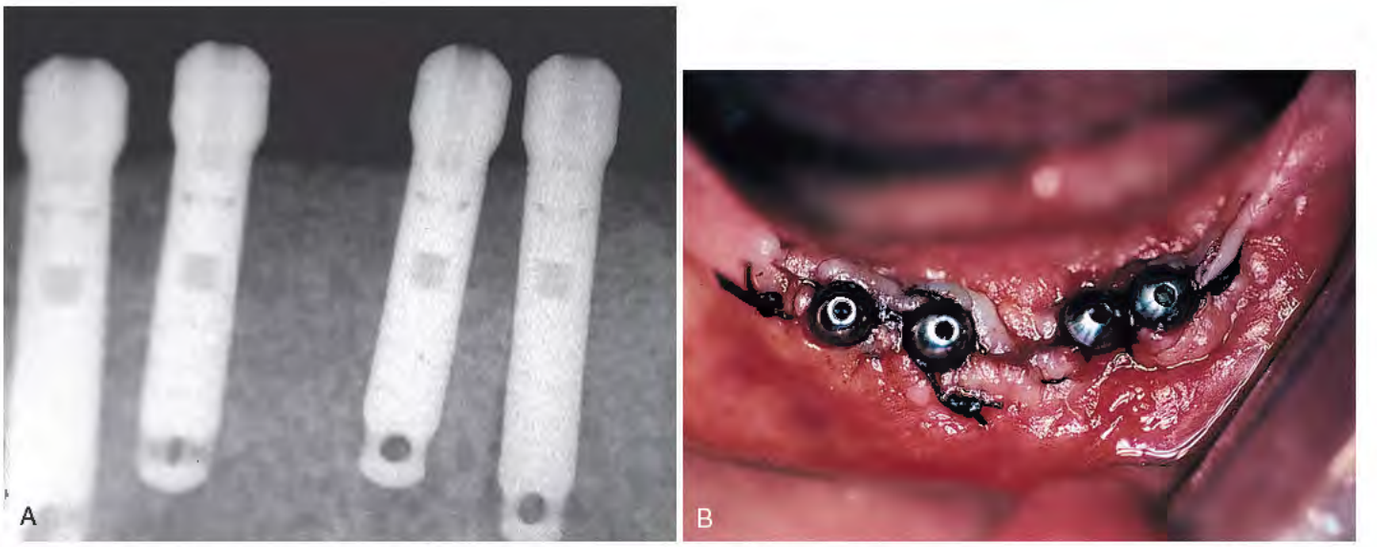


FIGURE 9-21. **A,** After healing collars have been are placed, complete seating is verified with a periapical radiograph. **B,** When the position of the collars is assured, the flaps are scalloped to accommodate the implants and then sutured closed.

Root Form Implant Surgery: Proprietary I

10 CHAPTER

The generic steps leading to the definitive procedures described in this section can be found in Chapter 9. Not all the systems described in this chapter begin after the use of the 3-mm spade drill. For example, for small-diameter implants, the sequence must stop at the 2.5- or 2.7-mm drill. If the surgeon uses the 3-mm spade drill for these systems, the host sites will be too wide. Therefore, the dental surgeon must read each section carefully before beginning.

Although this chapter may not mention all the implant sizes available, Table 4-2 lists dimensions for each type and style. For the practitioner who does not want to use the generic system, as described in Chapter 9, to begin the osteotomy for the chosen implant system, the illustrations begin their instructive patterns with the full spectrum of drills, starting with the smallest diameter offered by the specific manufacturer.

EXTERNAL HEX, THREADED IMPLANTS

The abutments for external hex, threaded implants have an antirotational design in the form of an external hexagon that protrudes from the top of the device (Fig. 10-1, *A*).

Manufacturer	System
BioHorizons	External system
Imtec	Hexed-Head
Keystone	Restore
Nobel Biocare	Mk III, Mk IV, Brånemark system, NobelSpeedy Groovy, NobelSpeedy Shorty
Osteomed	Hextrac
Zimmer Dental	Swede-Vent
Park Dental Research	Star/Vent
Sargon	Immediate load implant
Biomet-3i	Standard system, Microminiplant, Miniplant

INTERNAL HEX THREADED IMPLANTS (Fig. 10-1, B)

Manufacturer	System
Zimmer Dental	Screw-Vent, Micro-Vent
Friatec	Frialit (two step)
Nobel Biocare	NobelSpeedy Replace

PRESS-FIT IMPLANTS

Manufacturer	System
Zimmer Dental	Spline-Cylinder
Innova	Endopore
Lifecore	Restore

SPLINE AND SIMILAR IMPLANTS

Manufacturer	System
Zimmer Dental	Spline
Park Dental Research	Star★Lock

MORSE TAPER

Manufacturer	System
Astra Tech	Implant with screw fixation
ITI	Implant with screw fixation, Standard Plus
Bicon	Implant with screw fixation

NOBEL BIOCARE

Although most implant systems are quite similar, they are packaged differently. For example, Noble Biocare is available in a scored glass tube that snaps in half on finger pressure. Biomet-3i comes in a blister pack that includes the surgical cover screw. Some of the designs are manufactured as self-tapping implants in wide and small diameters. Various coatings (e.g., hydroxyapatite [HA], titanium oxide [TiO_2], and titanium plasma spray [TPS]) also are available for some implants. The directions for placement are similar for each system (e.g., Osteotite, NobelActive, Advent), but the instruments have different names. In the directions that follow, Nobel Biocare's Brånemark instrument names are used. These implants are available in diameters ranging from 3.25 to 6 mm and in varying lengths (5.5 to 18 mm) for most applications, even up to a 52.5-mm length, which is used as an extraoral implant to be inserted into the Zygoma. Insertion techniques vary slightly according to the size of the implant.

Joining the Procedure in Progress

The generic process (see Chapter 9) will have been performed up to this point; that is, the 3-mm twist drill will have been used to its final depth. The procedure then follows these steps.

1. For dense bone, the 3.15-mm twist drill is used next. The surgeon must proceed with care, particularly if internal cooling is not available.
2. The compatible (3 mm) end of a paralleling pin is placed in the osteotomy to verify the angulation of the preparation.
3. The appropriate countersink is used at the top of the osteotomy. The short countersink is recommended for implants 10 mm long or shorter; the long countersink is used for implants longer than 10 mm.
4. The osteotomy is measured with the depth gauge, and any necessary corrections are made.
5. The handpiece connector is attached to the ultra-low-speed handpiece, and the console is set to its lowest speed.
6. Unless self-tapping implants are used or the bone is compliant, bone tapping is performed. The appropriate bone tap is snapped into the handpiece connector while it is stabilized in the fixture rack with the titanium-tipped hemostat. The bone taps and implants should not be handled with fingers, gloved or otherwise. The rack and forceps are used for mounting and removal. Some manufacturers (e.g., Camlog) prepare each implant with its own handpiece connector. Others (e.g., Straumann) prepare some of their implants with a handpiece connector and some require attachment of a connector at the time of surgery.
7. The low-speed handpiece (8 to 18 rpm) is used (along with copious saline irrigant) in a forward or clockwise direction to tap the bone.
8. When the tap arrives at a point 3 mm short of the full depth, the motor is stopped, and the tapping is completed with the handheld wheel or handheld ratchet wrench.

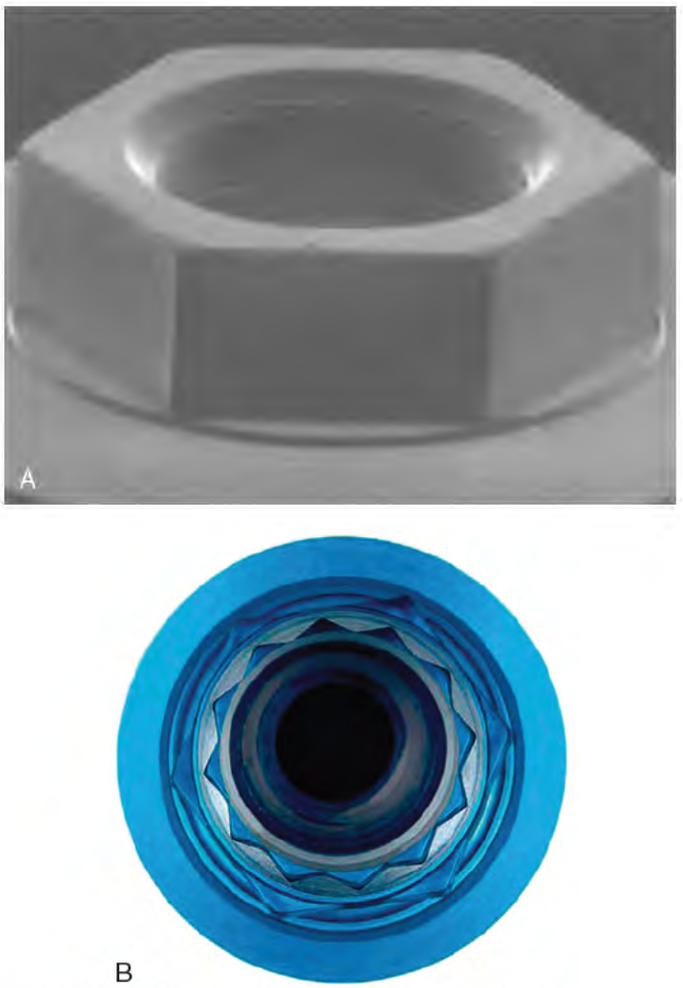


FIGURE 10-1. **A,** The external hexagon is the second most commonly used form of antirotational design. **B,** The internal hexagon is the most frequently used antirotational design.

9. The bone tap is removed by turning the handheld wheel or ratchet wrench counterclockwise (reverse mode).
10. The outer container of the chosen implant is opened, and the implant is allowed to fall gently into the small, sterile, square container marked "T" (for titanium). Alternatively, titanium-tipped forceps can be used to transfer the implant to the proper-diameter hole in the surgical tray and, if the handpiece connector is not already attached, the screwdriver is used to attach it to the implant. If the handpiece connector has already been attached to the implant, the implant is carried to the proper hole in the surgical tray and stabilized with the notched-beak, curved hemostat forceps.
11. The ultra-low-speed handpiece rotates the implant into its prepared site at less than 20 rpm until the implant is 3 mm short of full seating. Although most motors usually stop when the implant is fully seated, the risk of stripping the bone threads does exist. For this reason, the safest method is to use the handheld wheel or, if necessary, the ratchet device to seat the implant for the last 3 mm. The handpiece is detached from the handpiece connector, leaving it attached to the implant. The ratchet handle is held as close to the implant as possible to enhance tactile sensitivity and to minimize excessive distracting movements, which the long handle can cause.
12. Tightening with the wheel or ratchet wrench ensures the implant's stability. If the operative site has stripped internal bony threads, most systems offer backup implants of commensurate lengths. The backup implant should be introduced into the site directly, without pretapping.
13. The screwdriver backs off the fixation screw while the open-ended wrench is used to provide countertorque to the implant.
14. The wounds are irrigated, and the cover screw is then placed. A throat pack should always be in place when small instruments and fittings, such as cover screws, are used. Techniques for placing the cap screw include the following:
    - A special cover screw screwdriver can be used. This screwdriver is mounted in a low-speed handpiece; the speed should not exceed 15 rpm, and the lowest torque (10 Ncm) should be used. Final tightening always should be done by hand with either the short or long screwdriver (Fig. 10-2).
    - The flat-top cover screw can be seated with the hexagonal screwdriver.
15. The flap may now be sutured (see Chapter 6).

The uncovering procedure is described in Chapter 9. The appropriate healing collar or cuff or an abutment is placed, depending on the thickness of the tissue and its esthetic needs. Healing cuffs should protrude approximately 2 mm above the free gingival margin. Special abutments are used that are similar in contour and diameter to the anticipated restoration. These abutments are kept in position until the tissues have matured sufficiently to allow the impression procedures. Generally, this takes 2 weeks.

Brånemark System

Mk III TiUnite and Mk IV TiUnite

The Mk III TiUnite and Mk IV TiUnite are the original Brånemark designs. A 1.5-mm external hex is part of the restorative platform design.

TiUnite is Brånemark's patented, enhanced titanium oxide (TiO_2) layer. As are other TiO_2 surfaces, it is osteoconductive, and its texture and porosity are ideal for bone apposition and for creating an enhanced environment for bone formation. The enlarged surface area and structure, which absorb blood proteins and aid in bone growth, are very similar to human cancellous bone.

Mk III (Narrow Platform, Regular Platform, and Wide Platform)

The Mk III implant is a universal, self-tapping implant that can be used for all conditions in which sufficient bone volume is available for an implant. (Refer to Chapters 2, 4, and 7 for bone volume criteria for root form implants.) Mk III implants are available in three diameters: narrow platform (NP), 3.3 mm; regular platform (RP), 3.75 and 4 mm; and wide platform (WP), 5 mm. Seven lengths are available: 7, 8.5, 10, 11.5, 13, 15, and 18 mm. The line also includes a 5.5-mm long implant (i.e., the NobelSpeedy Shorty), which has been approved for immediate function. The osteotomy sequence and protocol for this implant are similar to those for the NobelSpeedy Groovy implant.

The Mk III 3.3-mm NP implant is used when interproximal space is limited or minimal alveolar bone width is available to accommodate an RP implant. Narrow-diameter implants have less mechanical strength; therefore the surgeon must carefully evaluate the expected loads and the support the planned restoration will require to function.

The Mk III 3.75- and 4-mm diameter RP implants are used for the widest range of conditions. RP implants have an extensive selection of implant restorative components.

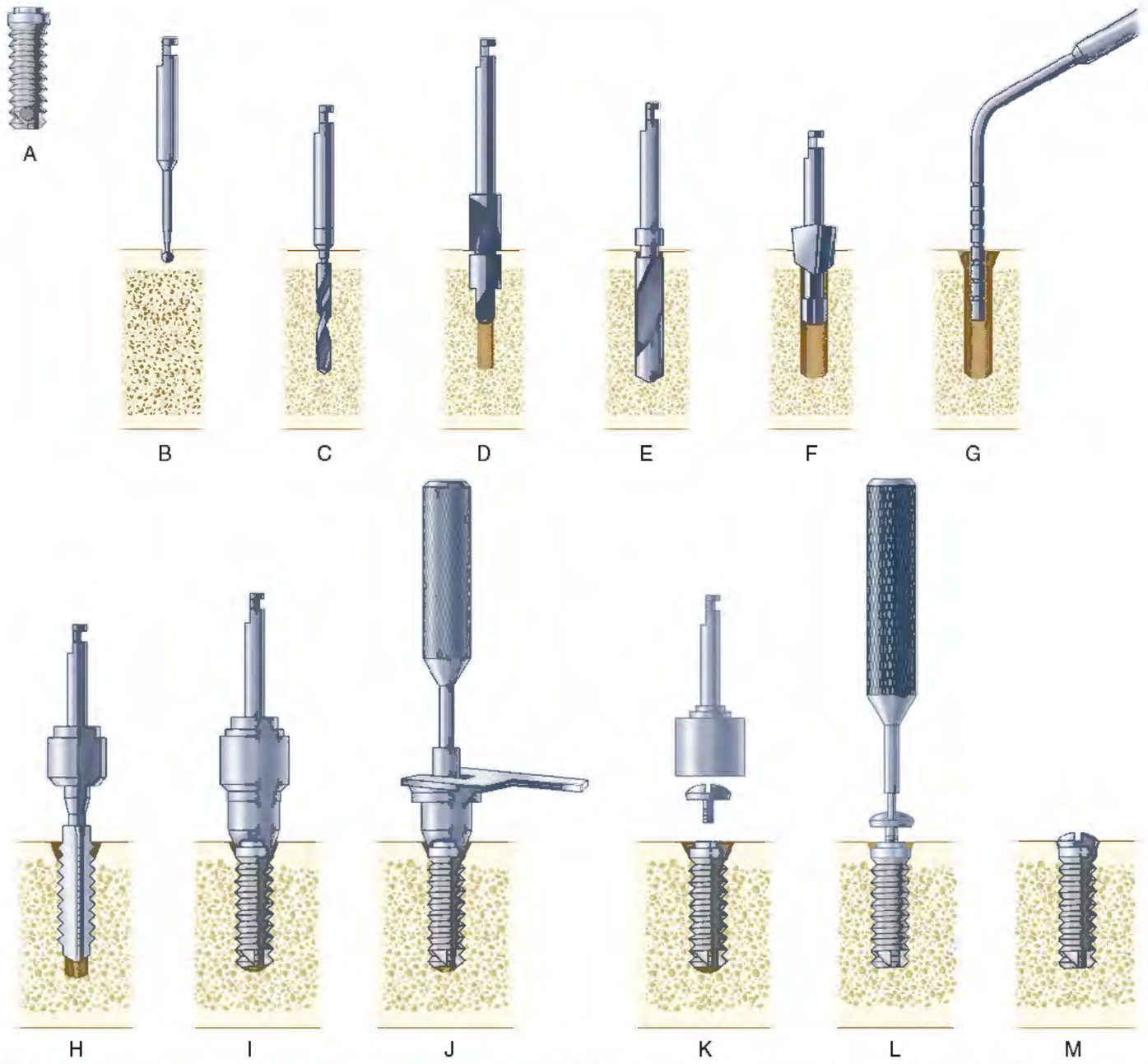


FIGURE 10-2. **A,** Nobel Biocare implant. **B,** According to the manufacturer's recommended procedure, the surgeon begins by using the guide drill to half its diameter to penetrate the cortical plate at the proposed implant site. **C,** The 2-mm twist drill is used to the final implant depth. **D,** The counterbore is used to enlarge the coronal portion of the osteotomy in preparation for the 3.5-mm twist drill **(E).** **F,** Countersink drill. **G,** Depth gauge. **H,** Screw tap. **I,** The implant is inserted attached to the handpiece connector. **J,** The open-ended wrench stabilizes the handpiece connector while the fixation screw is removed from the implant. **K,** Cover screw inserter. **L,** Placement of the cover screw with the small hexagon screwdriver. **M,** The Nobel Biocare implant is seated so that its cover screw is flush with the crest of bone.

WP implants are used when the potential functional loads of the restoration and the available anatomy justify the use of a wider implant. Although the mechanical strength of implants has been improved considerably, bone quality and quantity remain patient-dependent variables. Both the amount and quality of bone can be limiting factors when the higher occlusal loads found in the posterior regions of the jaws are factors in the treatment.

Mk IV (Regular Platform and Wide Platform)

The Mk IV implant is a tapered implant intended for use in soft bone. The tapered design and double threads achieve and enhance initial implant stability in soft trabecular bone. The RP implants have a 4-mm diameter, and the WP implants have a 5-mm diameter. As with the Mk III implants, seven lengths are available (7, 8.5, 10, 11.5, 13, 15, and 18 mm). All drills and components are marked so that the implantologist can prepare the implant site to the correct depth and create a secure, predictable implant position. Twist drill preparation is deeper than the final position of an implant apex. Depending on the diameter of the twist drill, the apical part of the drill deepens the site about 1 mm.

NOTE

The graduations on the twist drills and depth gauge represent the height of the implant plus a cover screw (Fig. 10-3).

FIGURE 10-3. Straight-walled external hex. Sequence of the osteotomy from initial pilot twist drill to the cover screw. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Osteotomy Procedure

Mk III ∅ 3.3-mm NP Implant

Fig. 10-4 presents the osteotomy sequence for a narrow-platform implant.

Mk III ∅ 4-mm RP Implant

A 4-mm diameter RP implant can be used in soft bone or when initial stability cannot be achieved with a 3.75-mm diameter RP implant. In very dense bone, a Mk III Screw Tap may also be required. Drills of different diameters can be used, depending on the bone quality and implant diameter.

Mk III ∅ 3.75- and 4-mm RP Implants

The crestal preparation drill and final shaping drill for an RP implant are shown in Fig. 10-5.

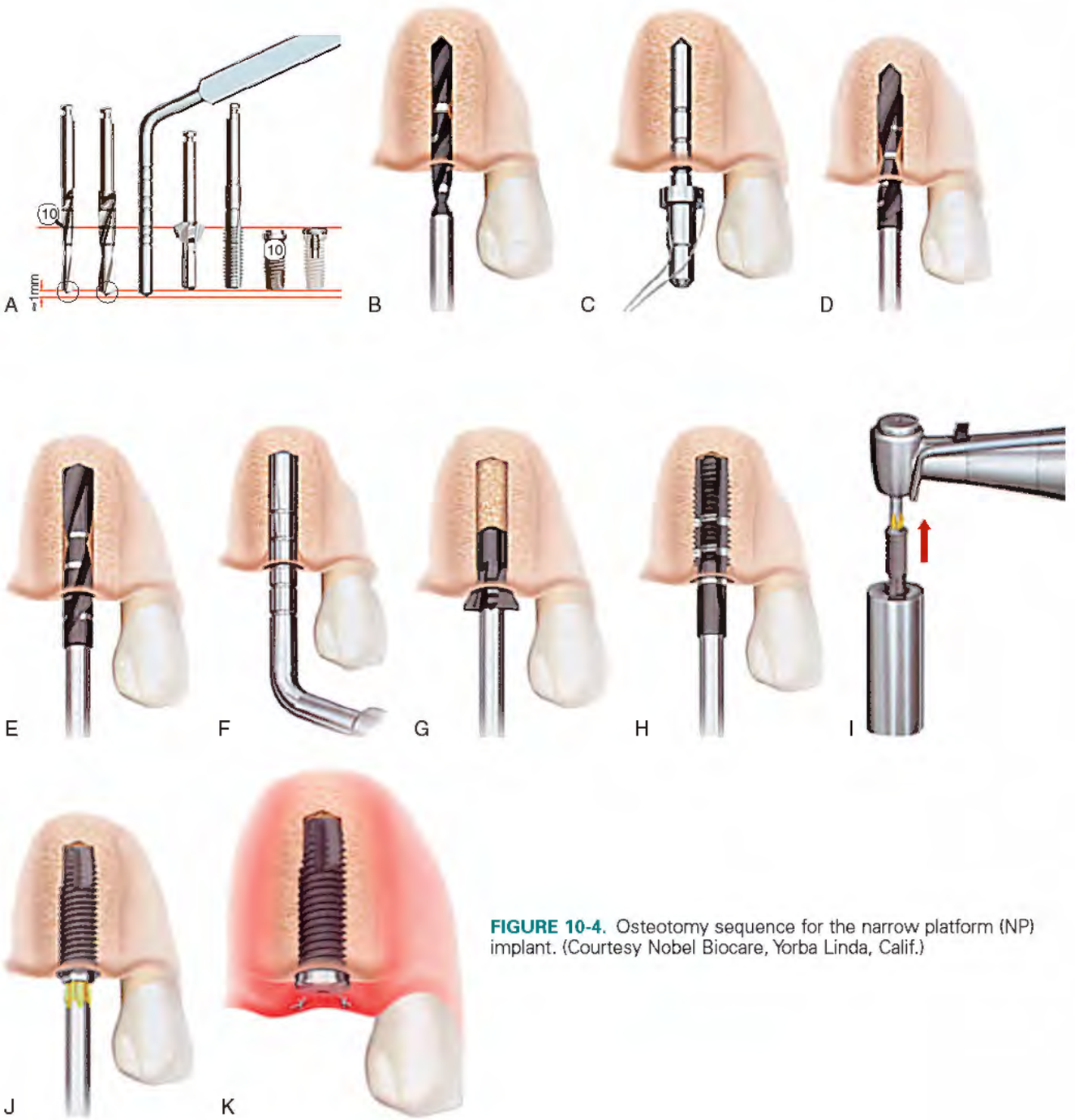


FIGURE 10-4. Osteotomy sequence for the narrow platform (NP) implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

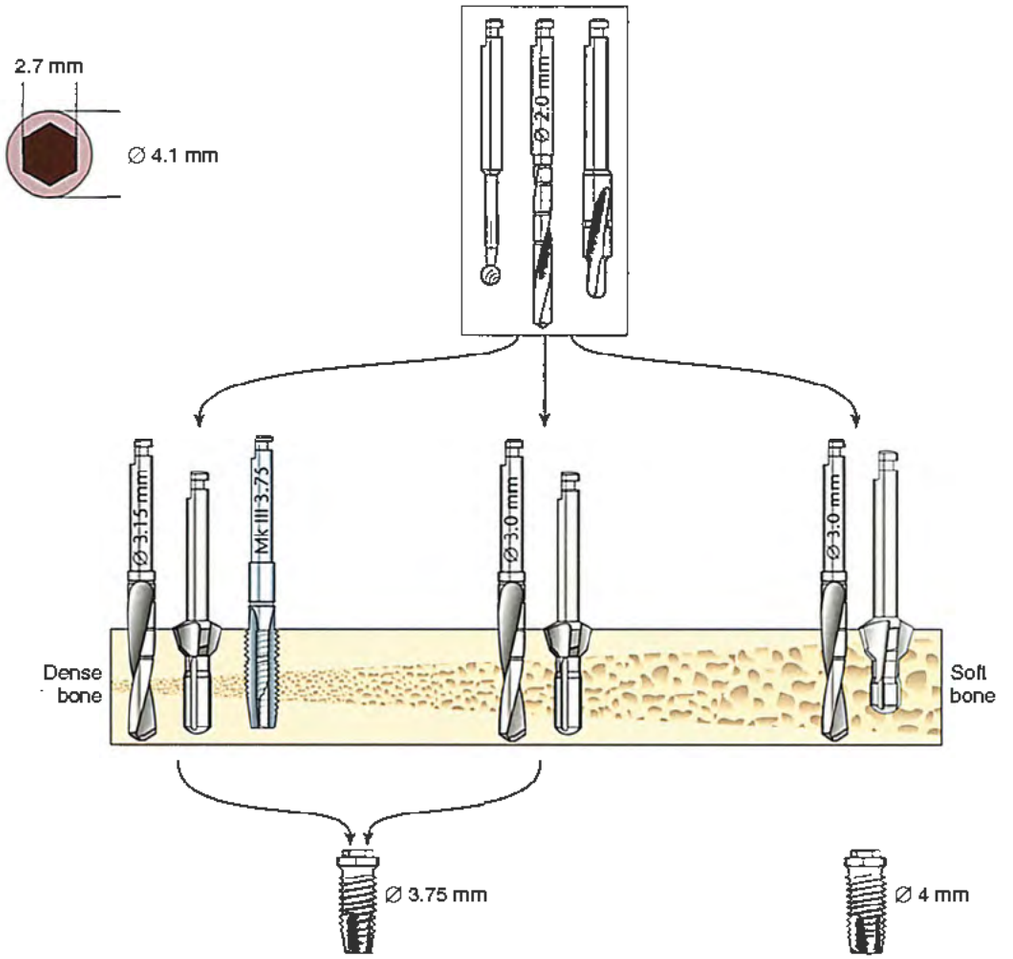


FIGURE 10-5. Crestal preparation drill and final shaping drill for a regular platform (RP) implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Mk III ∅ 5-mm WP Implant

The crestal preparation drill and final shaping drill for a WP implant are shown in Fig. 10-6.

Drilling Procedure

Mk IV ∅ 4-mm RP Implant. The Mk IV implant is recommended for use in predominantly soft bone (classes III and IV). The surgeon must pay particular attention to bone quality. Optimum results depend on selection of the appropriate drill diameter after the bone quality at each site has been evaluated. In principle, the osteotomy sequences are the same as for placement of a Mk III implant (Fig. 10-7).

Class IV (Very Soft) Bone. The process for drilling in very soft bone is as follows:

1. A standard drill kit is used.
2. In very soft bone, the implant is placed directly after the 2/3-mm pilot drill is used.
3. In the posterior maxilla, where a wider preparation is needed, a 3-mm drill is used. To improve apical implant stabilization in soft bone, the surgeon may elect not to extend the full length with the 3-mm twist drill.
4. Traditional countersinking should be avoided in very soft bone, so that better use can be made of the available thin crestal cortex.

NOTE

The implant platform may be left to the level of the alveolar crest for maximum compression and initial stability.

5. If the bone topography is irregular and/or of a different density around the implant head, the Mk IV RP counterbore can be used for access shaping to allow easier future abutment connection. If a good-quality cortex layer is available, the Mk IV RP counterbore should be used according to the standard protocol, at either high or low speed. The reference line on the Mk IV RP counterbore indicates the seating level of the implant platform.
6. If the osteotomy equipment has the capability, the implant should be inserted using progressively increasing insertion torque. Torque levels are based on bone quality and the resistance encountered, so that the bone threads are protected from stripping. In soft bone, the torque level should begin at 20 Ncm. The last turn is carefully hand-tightened to obtain a precise platform level position and to ensure that the resistance to insertion is positive and increasing.

Class III (Soft to Moderately Soft) Bone. The process for drilling in soft to moderately soft bone is as follows:

1. A standard drill kit is used.
2. The sites are prepared for use of the 3.15-mm twist drill.

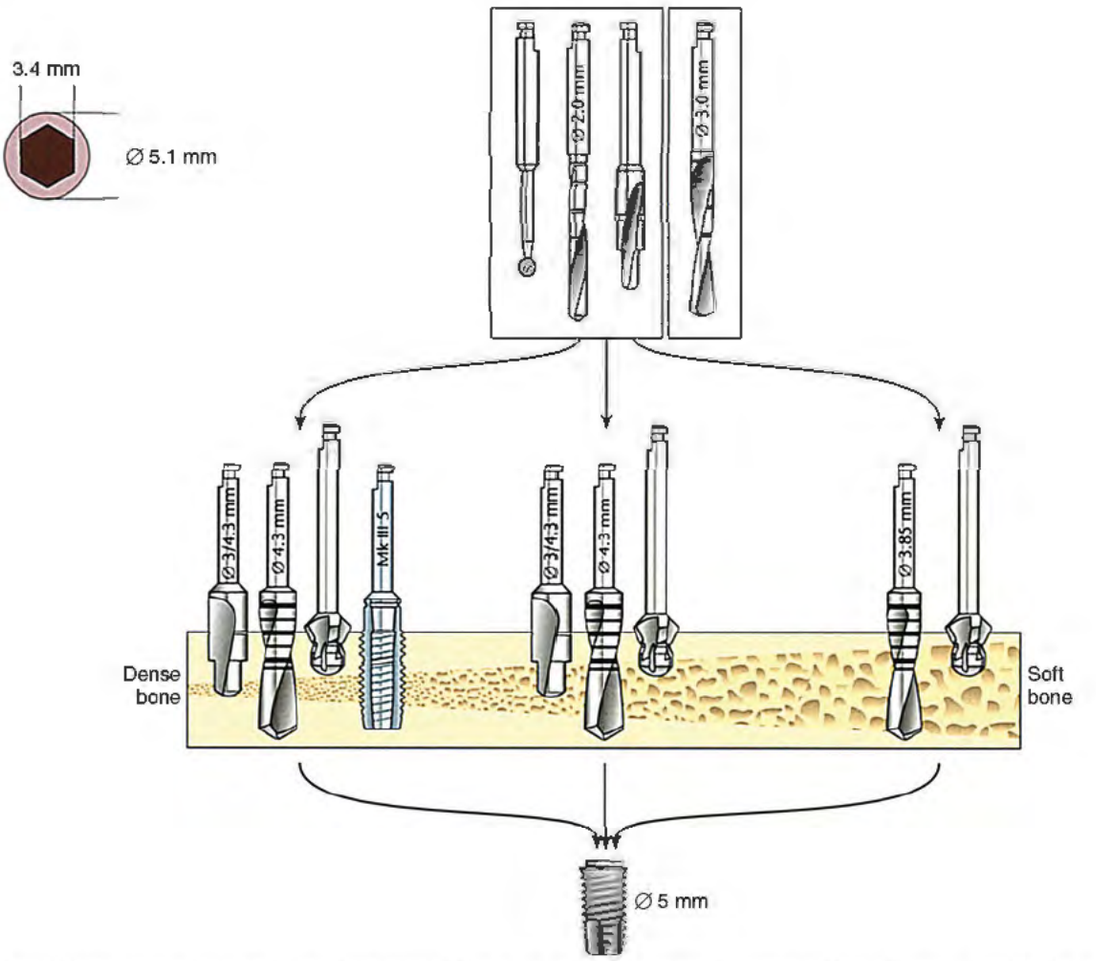


FIGURE 10-6. Crestal preparation drill and final shaping drill for a wide body implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

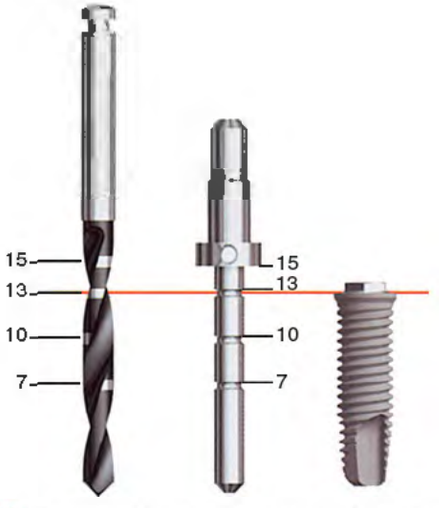


FIGURE 10-7. Because of the softer quality of the bone, a bone-tapping drill is not required. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

3. The Mk IV RP counterbore is used to prepare the cortical bone for the implant flange. The reference line on the Mk IV RP counterbore matches the seating level of the implant platform.
4. If the osteotomy equipment has the capability, the implant is inserted using progressively increasing insertion torque. Torque levels are based on bone quality and the resistance encountered, to further protect bone threads from stripping. The last turn is carefully hand-tightened to obtain a precise platform level position and to ensure that the resistance to insertion is positive and increasing.
5. If the implant does not seat completely, the insertion torque is increased to a maximum of 40 to 50 Ncm.

NOTE

Insertion with the hand wrench above 50 Ncm of torque is not recommended. Instead, the implant should be backed out and the site should be pretapped at low speed with the Mk IV Screw Tap, accompanied by copious irrigation. The implant then can be reinserted into the pretapped site.

Class I and Class II (Cortical) Bone. The Mk IV implant is not recommended for use when predominantly dense cortical bone is present. In some patients, 2 to 3 mm of dense cortical bone is found in the posterior mandible, with loose trabecular bone underneath. Even if the rest of the bone in the area is soft, seating the Mk IV implant may be difficult because the implant cannot compress the thick layer of cortical bone. In such cases, the Mk IV Screw Tap can be used through the cortical layer (Fig. 10-8).

Mk IV 5-mm WP Implant

The Mk IV 5-mm WP implant is inserted as shown in Fig. 10-9.

FIGURE 10-8. Bone-tapping drill for dense cortical bone. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

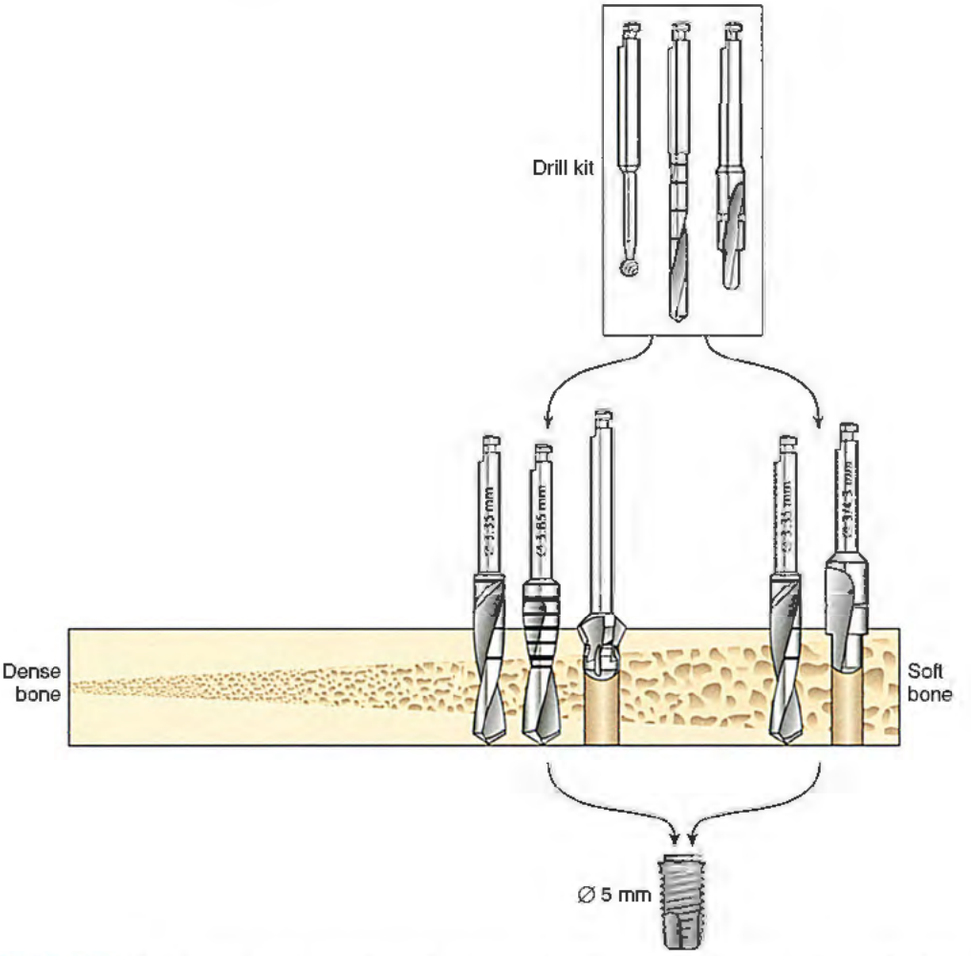


FIGURE 10-9. Mk IV wide body external hex implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Zygoma Implant

The Zygoma implant is used in patients with severe alveolar atrophy in the posterior maxilla when augmentation procedures are not possible because of financial or medical considerations. These extremely long endosseous implants can be secured into the zygomatic processes. When inserted there, along with two to four strategically placed, standard implants in the anterior maxilla, a bar-overdenture (two Zygoma implants + two anterior implants) or a fixed-detachable or fixed prosthesis (two Zygoma implants + four anterior implants) can be fabricated and put into function.

Compared to a standard implant, the Zygoma implant has a greater tendency to bend under horizontal loads. This is related to two factors:

- The much longer length of these implants (30 to 52.5 mm)
- The limited bone support available in the maxillary alveolar crest under some circumstances

Consequently, Zygoma implants should be rigidly connected to stable conventional fixtures in the anterior maxilla. Based on clinical experience and biomechanical theoretical calculations, a full arch restoration in the maxilla with two Zygoma implants (one on each side) should be assisted by at least two stable, standard Brånemark implants in the anterior maxilla, or even better, by four standard implants (Fig. 10-10).

Bending moment forces are known to be the most unfavorable type, because they have the potential to jeopardize the long-term stability of an implant-supported restoration. To reduce bending moments, the distribution of forces should be optimized by:

- Cross-arch stabilization
- Reduced buccal lever arms
- Reduced cantilevers (mesial/distal and anterior/posterior)
- Balanced occlusion
- Reduced cuspal inclination

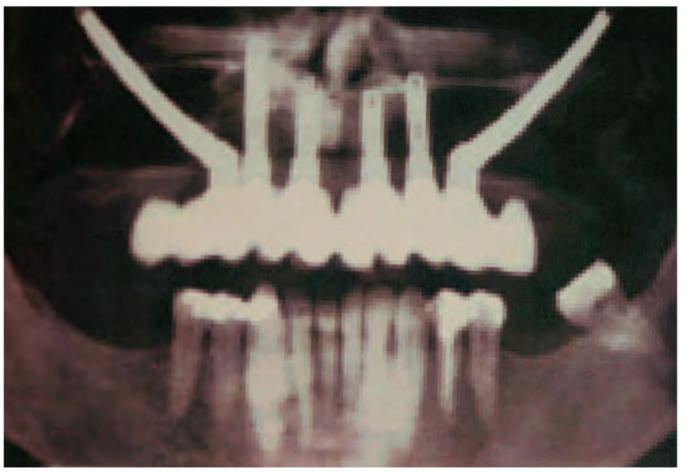


FIGURE 10-10. Two 35-mm long Zygoma implants, along with conventional Brånemark implants, were used in the anterior maxilla to support this fixed, cross-arch stabilized prosthesis. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Zygoma implants are available in the TiUnite line and with a machined titanium surface. The surgeon must have experience in maxillofacial surgical techniques to perform the implantation procedure. (A detailed description of the surgical technique is presented in Chapter 17.)

The Zygoma implant is available in only one diameter, 3.5 mm, but in several lengths (30, 35, 40, 45, 50 and 52.5 mm). Drilling during the osteotomy should not exceed 2000 rpm, and sufficient irrigation throughout the osteotomy sequence is important.

1. The palatal mark for the implant's entrance is made with a round burr.
2. The 2.9-mm twist drill then is worked well into the Zygoma implant, and the desired length of the implant is measured with the depth gauge.
3. A 3.5-mm pilot drill is used to lengthen and finish off the drill sequence.
4. At every stage of the osteotomy sequence, the surgeon must check the depth and path of insertion to avoid overpreparation of the site. Care must be taken to ensure the correct angulation and to prevent drill wobble, which can widen the preparation site.
5. The implant is rotated clockwise, using the handle, until the desired depth and head position have been achieved. The head of the implant can be positioned accurately by observing the screw that locks the implant mount to the implant. The screw position exactly marks the future position of the abutment screw.

Caution Bending forces must not be applied during this procedure. Such forces may distort the implant head or cause the implant mount screw to fracture or loosen. If the hand wrench has to be used excessively, the implant mount screw should be checked for loosening and retightened if necessary.

6. The implant is rotated to such a position that the angulated hexagonal top is directed toward an ideal occlusal plane. This can easily be verified by observing the position of the implant mount screw, which corresponds to the position of the abutment screw.
7. The insertion tool is removed and replaced with a cover screw.

NobelActive Implants

NobelActive is a new line of implants that has shown high initial stability with an insertion torque of nearly 70 Ncm, even in compromised bone, and good bone-condensing capability. Even after the implant has been screwed in, if the implantologist is not happy with the angulation, the implant can be backed out and, using the same crestal access, it can be redirected into a more acceptable plane without the need for a new osteotomy. The unique tip and thread design slice through bone and, unlike conventional self-tapping implants, which scrape away the bone as they tap, the back-tapered coronal region allows for maximum alveolar bone volume around the implant, for improved soft tissue support.

The expanding tapered body of the implant acts as a threaded osteotome, allowing expansion of narrow ridges, and accounts for the implant's high stability in compromised bone. In the implant body area, the reverse cutting flutes allow gradual widening of the osteotomy. In the apical area, osteotomy blades create a smaller apical osteotomy.

Abutments are securely positioned by the hexagonal interlocking of the internal conical connection. With the abutment in place, the built-in platform shifting is apparent. Platform shifting is designed to enhance soft tissue integration, and provide more natural-looking esthetics.

The implant also has built-in dual-function prosthetic connection; a conical connection acts as a deeper internal connection for increased mechanical strength, and a second internal hexagonal interlock ensures secure repositioning of prosthetic components.

The maximum insertion torque for NobelActive was established at 70 Ncm and was designed with high torque strengths in mind:

- 282 Ncm maximum implant torque strength for NobelActive 3.5 mm
- 452 Ncm maximum implant torque strength for NobelActive 4.3 mm

When compared to the maximum insertion torque of 70Ncm, a significant safety margin exists.

The implant is available in 3 different diameters 3.5, 4.3, 5.0 mm and restorative platforms of 3.5 mm and an abutment interface of 3.0 mm for the 3.5 mm implant and 3.9 mm restorative platform and 3.4 mm abutment interface for the 4.3 and 5.0 mm implant. All three diameters come in varying lengths of 8, 10, 11.5, 13, 15, and 18 mm.

The drill sequence is similar to that of the other implants by the same manufacturer. The pilot drill is a 2.0 mm twist drill, which is used to 2 to 4 mm shy of the implant length as the implant will self-tap drill its final path during the insertion step. In type III bone, the next drills to be used are the 2.4 mm/2.8mm twist drill. From here, the 3.5 mm implant can be self-threaded into position. In types II and I bone, a 3.2 mm twist drill is to be used, and then the implant can be hand threaded. The same protocol is used when inserting the 4.3 and 5.0 mm diameter implants. Depending on the quality of bone, fewer drills can be used for softer bone. For denser bone, additional drills of increasing diameter are to be used before the insertion of the implant. For example, in type IV bone, before the insertion of implant, the last drill can be a 2.8 or 3.2 mm drill for the 4.3 mm implant. In type III the sequence should be 2.0, 2.4, 2.8, 3.2, 3.6, and then the insertion. In type II and I, depending on the resistance met, 3.8 and 4.2 mm drills might be used before the insertion of the 4.3 mm implant.

For the 5.0 mm implant, the sequence can be 2.0, 2.4, 2.8, 3.2, 3.6, 3.8, 4.2, and 4.6 mm drills before the insertion of the implant. The sequence can be terminated at any point when the surgeon feels that not enough resistance is being met during the osteotomy procedure and that the implant can be hand-inserted without much stress.

Self-drilling should not be attempted in dense bone or if the osteotomy preparation is deeper than the planned implant. If at any point during the self-insertion, the surgeon feels that the direction

of the implant is incorrect (either for prosthetic or anatomic concerns), he or she can simply back the implant out and redirect it so that the implant will self-thread into a new plane.

Using a variety of different abutments available for the implant system, it can be immediately restored using either a matching or switch platform abutment as the implant is cleared for both immediate or delayed prosthetic rehabilitation.

NobelSpeedy Replace (Internal Hex); NobelSpeedy Groovy and NobelSpeedy Shorty (External Hex) Implants

The NobelSpeedy Replace, NobelSpeedy Groovy, and NobelSpeedy Shorty are available in a range of diameters: 3.5, 4, 5, and 6 mm (Replace); and 3.5, 4.1, and 5.1 mm (NobelActive, NobelSpeedy Groovy, and NobelSpeedy Shorty [which is only 5.5 mm long]). Except for the Shorty, these implants also have a range of lengths: 10, 11.5, 13, 15, and 18 mm.

The osteotomy procedure and placement protocol for these implants are the same as for the Brånemark system.

At this point, the 2.4-mm twist drill described in the generic system (see Chapter 9) will have been used to its final depth. The procedure then moves through the following steps.

1. For dense bone, the 2.8-mm twist drill is used next. The surgeon must proceed with care, particularly if internal cooling is not available. For the 4-mm implant, a 3.2- or 3.4-mm drill will be the final one used to drill to depth, depending on the density of the bone.
2. The compatible end of a paralleling pin is placed in the osteotomy to verify the angulation of the preparation.
3. The appropriate countersink is used at the top of the osteotomy. The short countersink is recommended for implants 10 mm long or shorter and the long countersink for implants longer than 10 mm.
4. The osteotomy is measured with the depth gauge, and any necessary corrections are made.
5. The handpiece connector is attached to the ultra-low-speed handpiece, and the console is set to its lowest speed.
6. Unless self-tapping implants are used or the bone is a compliant, bone tapping is performed. The appropriate bone tap is snapped into the handpiece connector while the tap is stabilized in the fixture rack with titanium-tipped hemostat. Bone taps and implants must not be handled with fingers, gloved or otherwise. The rack and forceps are used for mounting and removal.
7. The low-speed handpiece (8 to 18 rpm) is used (along with copious saline irrigant) in a forward or clockwise direction to tap the bone.
8. When the tap has arrived at a point 3 mm short of the full depth, the motor is stopped, and tapping is completed with the handheld wheel or handheld ratchet.
9. The tap is removed by turning the handheld wheel or ratchet wrench counterclockwise (reverse mode).
10. The outer container of the chosen implant is opened, and titanium-tipped forceps are used to transfer the implant into the proper-diameter hole in the rack. The implant is attached to the handpiece connector with the screwdriver, while it is stabilized with notched-beak, curved hemostatic forceps.
11. The ultra-low-speed handpiece rotates the implant into the prepared site at less than 20 rpm, until it is 3 mm short of full seating. Most motors stop when the implant is fully seated, but the risk of stripping the bone threads does exist. The safest course, therefore, is to seat the implant for the last 3 mm with the handheld wheel or, if necessary, the handheld ratchet device. The handpiece is detached from the connector, leaving the latter attached to the implant. The ratchet handle is held as close to the implant as possible to enhance tactile sensitivity and to minimize the excessive distracting movements the long handle can cause.
12. The implant's stability is ensured by tightening with the handheld wheel or ratchet wrench. If the operative site had stripped internal bony threads, the implant system has a 4-mm backup implant for the 3.5-mm implant of commensurate lengths. The backup implants should be introduced into their sites directly, without pretapping.
13. The screwdriver is used to back off the fixation screw while the open-ended wrench provides countertorque to the implant.
14. The wounds are irrigated, and the cover screw is then placed. A throat pack should always be in place when small instruments and fittings, such as cover screws, are used. Techniques for placing the cover screw include the following:
    - A special screwdriver in a low-speed handpiece can be used to place the cover screw, which is tightened with either the short or long blade screwdriver.
    - The flat-top cover screw can be seated with the hexagonal screwdriver.
15. The flap may now be sutured (see Chapter 6).

The uncovering procedure is described in Chapter 9. The appropriate healing collar or cuff or an abutment is placed, depending on the thickness of the tissue and esthetic needs. Healing cuffs should protrude approximately 2 mm above the free gingival margin. Special abutments are used that are similar in contour and diameter to the anticipated restoration. These abutments are kept in position until the tissues have matured sufficiently to allow impression procedures. Generally, this takes 2 weeks.

NobelDirect 3.0 Implant

The NobelDirect 3.0 implant combines the osseous and restorative components into one piece. It was the first threaded implant approved by the U.S. Food and Drug Administration (FDA) to have a 3-mm diameter and an integrated abutment designed for one-stage surgical procedures and cemented restorations. The abutment can be prepared to an optimized adaptation to the gingival margin.

Insertion of the implant requires only a few steps.

1. A tissue punch or a flap reflection can be used to expose the osseous crest.
2. With copious irrigation, a 1.5-mm twist drill is used to plan the direction of insertion and to prepare a guide path for the next-size drill (either a 2- or 2.4-mm twist drill), which is used to full depth.
3. After the patency of the osteotomy site has been confirmed, a 3-mm twist drill is used to the full depth.
4. The implant is transferred to the site, with its abutment component used as a carrier. At a very slow handpiece speed (15 rpm), the implant is screwed down. The implant is seated for the final 3 mm with the manual torque wrench.
5. The tissues can be closed in the usual manner. A healing cap is placed on the abutment, which can be used as the understructure for the temporary prosthesis.

NobelDirect Posterior Implant

Like the NobelDirect 3.0 implant, the NobelDirect Posterior implant combines the osseous component and the restorative component into one piece. It, also, is based on the one-stage placement concept.

The NobelDirect Posterior implant is available in diameters of 3.5, 4.3, 5, and 6 mm and in lengths of 8, 10, 13, 16, and 18 mm. Like the NobelDirect 3.0, it is a threaded implant with an integrated abutment designed for one-stage surgical procedures and cemented restorations. The abutment can be prepared to an optimized adaptation to the gingival margin. This model, too, requires few steps for placement.

1. A tissue punch or a flap reflection can be used to expose the osseous crest.
2. With copious irrigation, a 2-mm twist drill is used to plan the direction of insertion and to prepare a guide path for the next-size drill. The implant's insertion path is confirmed with a direction indicator.
3. A 3.5-mm tapered drill is used to the full depth, and the direction is verified again.
4. Depending on the density of the bone, either a 4.3-mm bone drill or a 4.3-mm screw tap is used, and the implant is then inserted (Fig. 10-11).

BIOMET-3I: INTERNAL AND EXTERNAL CONNECTIONS

As mentioned earlier, although implant systems are quite similar, they are packaged differently. For example, Noble Biocare is available in a scored glass or plastic tube that snaps in half on finger pressure. Biomet-3i implants come in a blister pack that includes the surgical cover screw. Some designs are manufactured as self-tapping implants in large and small diameters.

The OsseoTite surface and the NanoTite surface create a more complex surface topography. The NanoTite surface is a microtopography of the OsseoTite surface combined with Discrete Crystalline Deposition (DCD)] of calcium phosphate particles 20 to 100 nm in size. The NanoTite implant surface, therefore, interlocks with the newly formed cement line matrix of bone.

These implants are available in diameters ranging from 3.25 to 6 mm and in lengths from 8.5 to 18 mm. The insertion techniques vary slightly with each size (Fig. 10-12).

The decade-old OsseoTite surface implant is a hybrid, threaded implant in which the apical threads up to the fourth level are coated, and the three most cervical threads are machine finished. On the OsseoTite Certain Prevail, the entire implant surface, including the neck, is surface coated The purpose of this design is to incorporate the most desirable features of similar products into one implant (i.e., greater retention apically, less irritating finish cervically). Entire implant lines are available with the NanoTite surface either on the bottom of the polished collar or on the top of the collar (Prevail).

The NanoTite Prevail implant incorporates integrated platform switching and an internal connection with the OsseoTite surface and nano-scale crystals on the top the collar, creating a continuous bone-loading surface (Fig. 10-13).

The four major categories of implants are micro, mini, standard, and wide. Diameters range from 3.25 to 6 mm. The difference between a microimplant and a mini-implant is the emerging cervical area. The microimplant has a 3.4-mm diameter; the mini-implant is available in a 4.1-mm diameter for improved cosmesis and a better emergence profile. The following steps are used to place the implants.

At this point, the 2.75-mm twist drill described in the generic system in Chapter 9 will have been used to its final depth.

1. For dense bone, the 3-mm twist drill is used next. The surgeon must proceed with care, particularly if internal cooling is not available.
2. The compatible (3 mm) end of a paralleling pin is placed in the osteotomy to verify the angulation of the preparation.
3. The appropriate countersink is used at the top of the osteotomy. The short countersink is recommended for implants 10 mm long or shorter and the long countersink for implants longer than 10 mm.
4. The osteotomy is measured with the depth/direction gauge, and any corrections needed are made.
5. The handpiece connector is attached to the ultra-low-speed handpiece, and the console is set to its lowest speed.
6. Unless self-tapping implants are used or the bone is compliant, bone tapping is done. The appropriate bone tap is snapped into the handpiece connector while the tap is stabilized in the fixture rack with the titanium-tipped hemostat. The bone taps and implants should not be handled with the fingers, gloved or otherwise. The rack and forceps are used for mounting and removal. Some manufacturers prepare each implant with its own handpiece connector (e.g., Biomet-3i). Others (e.g., Straumann) prepare some of their implants with a handpiece connector and some require attachment of a connector at the time of surgery.
7. The low-speed handpiece (8 to 18 rpm) is used (along with copious saline irrigant) in a forward or clockwise direction to tap the bone.
8. When the tap arrives at a point 3 mm short of the full depth, the motor is stopped, and tapping is completed with the handheld wheel or handheld ratchet wrench.
9. The tap is removed by hand, using counterclockwise turns of the wheel or the ratchet wrench (reverse mode).
10. The glass container with the chosen implant is snapped open, and the implant is allowed to fall gently into the small, square container marked "T" (for titanium). A titanium-tipped forceps is used to transfer the implant to a hole of the proper diameter in the rack. The implant is stabilized with notched-beak, curved hemostatic forceps and is attached to the handpiece connector with the closed blade screwdriver.
11. The ultra-low-speed handpiece rotates the implant into its prepared site at less than 20 rpm, until the implant is 3 mm short of full seating. Most motors stop when the implant is fully seated, but the risk of stripping the bone threads exists. The safest method, therefore, is to seat the implant for the last 3 mm with the handheld wheel or, if necessary, the handheld ratchet device. The handpiece is detached from the handpiece connector, which is left attached to the implant. The ratchet handle is held as closely as possible to the implant to enhance tactile sensitivity and to minimize excessive distracting movements, which the long handle can cause.
12. The implant's stability is ensured by tightening with the wheel or ratchet wrench. If the operative site shows stripped internal bony threads, the Nobel Biocare system offers 4-mm backup implants of commensurate lengths. They should be introduced into their sites directly, without pretapping.
13. The closed blade screwdriver is used to back off the fixation screw while the open-ended wrench provides countertorque to the implant.
14. The wounds are irrigated, and the cover screw is then placed. A throat pack should always be in place when small instruments and fittings, such as cover screws, are used. Techniques for placing the cover screw include the following:
    - A special screwdriver in a low-speed handpiece can be used to place the cover screw, which is tightened with either the short or long blade screwdriver.
    - The flat-top cover screw can be seated with the hexagonal screwdriver.
15. The flap may now be sutured (see Chapter 6) (Fig. 10-14).

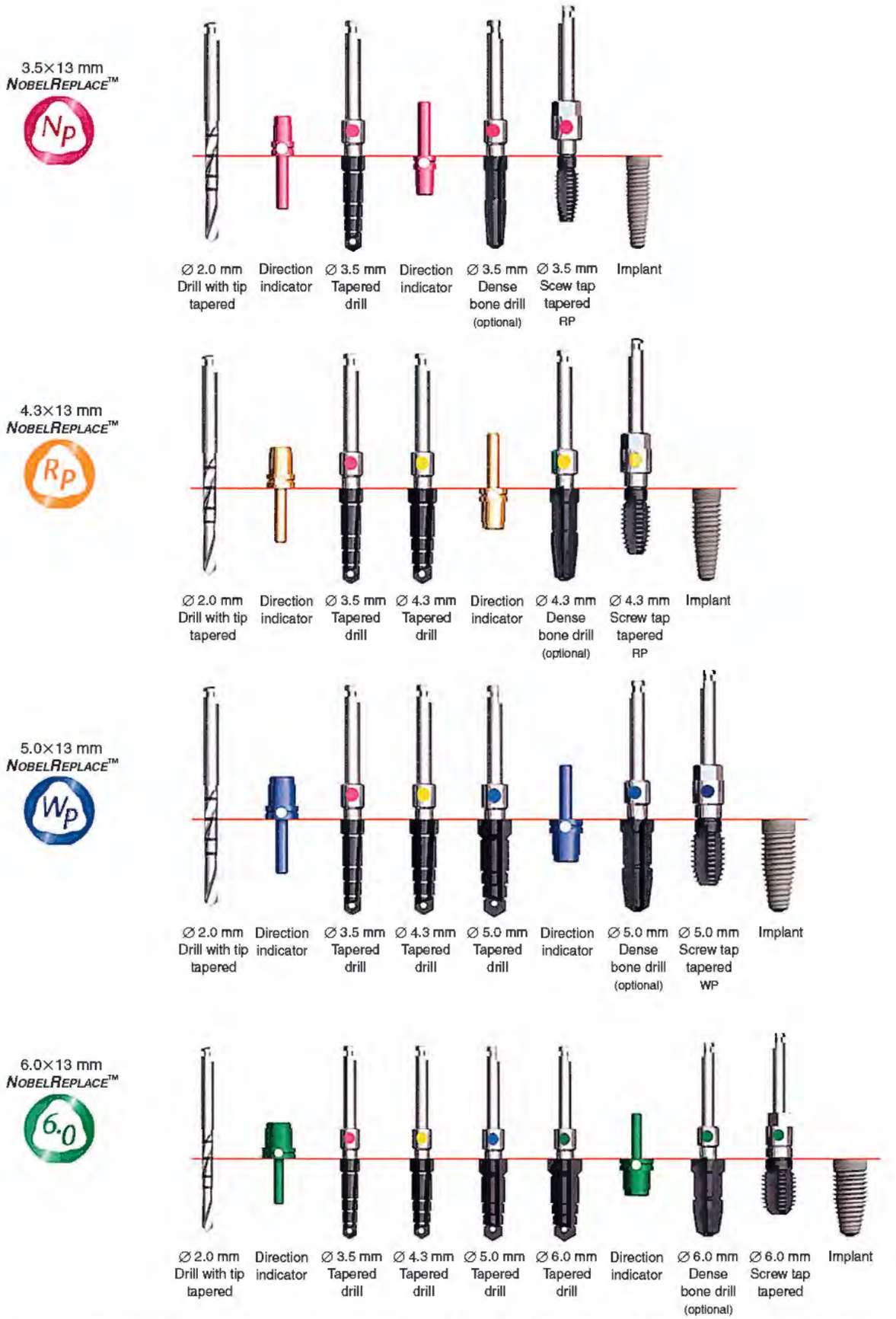


FIGURE 10-11. Osteotomy sequence for a Nobel Direct posterior wide body implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

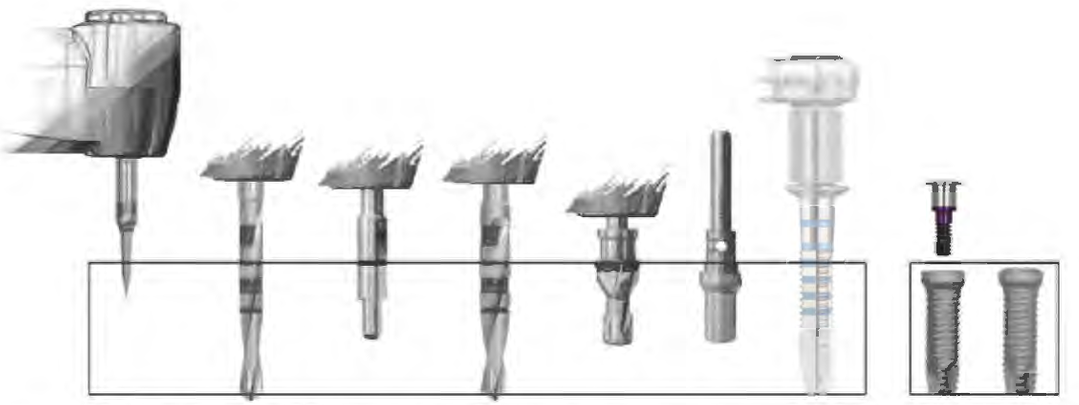


FIGURE 10-12. General guideline for choosing the diameter and restorative platform of an implant, based on the diameter of the root to be replaced. (Courtesy Biomet-3i, Palm Beach Gardens, Fla.)

FIGURE 10-13. Prevail implant with a prepable Gold-Tite abutment in a platform switching style. (Courtesy Biomet-3i, Palm Beach Gardens, Fla.)

The uncovering procedure is described in Chapter 9. The appropriate healing collar or cuff or an abutment is placed, depending on the thickness of the tissue and the esthetic needs. Healing cuffs should protrude approximately 2 mm above the free gingival margin. Special abutments similar to the contour and diameter of the anticipated restoration are used. These abutments are kept in position until the tissues have matured sufficiently to allow the impression procedures. Generally, this takes 2 weeks.

For tapered implants, the osteotomy sequence illustrated in Fig. 10-15 should be followed.

ZIMMER IMPLANT SYSTEMS

AdVent (Internal Hexed) Single-Stage Spline Cylinder & Twist (Groove and Slot Abutment Connection System) SwissPlus System (Internal Hexed) Screw-Vent System (Internally Hexed) Spline Cylinder (Press-Fit)

Press-fit implants are available in 3.25-, 4-, and 5-mm diameters. Each has its own instrumentation, including final sizing drills. These systems suggest use of a rosette bur at the outset. This creates a dimple half the implant's diameter on the surface of the bone before the first osteotomy, which encourages subsequent bur stabilization during the initial cutting. This technique can be used for all systems. The following are the steps of the process.

At this point, the 3-mm spade drill will have been used to its final depth.

1. The final osteotomy is completed with the full diameter spade drill (final sizing drill) according to the length and diameter of the selected implant. All lengths are marked clearly on the spade drills of each diameter.
2. The accuracy of the preparation is confirmed by placing or mallet-tapping the appropriate implant body try-in into the osteotomy. The line on the try-in that corresponds to the implant depth must be level with the crest of the ridge.
3. If the try-in is successful, the implant container is opened. The implant is attached to the plastic cap. The plastic cap is used as a handle to place the implant into the prepared site. Firm finger pressure is used until the implant is firmly seated. The plastic cap then is removed by rocking and twisting it, mesial to distal. The cap should not be drawn in the long axis of the osteotomy, because the implant may become dislodged.
4. The nylon-tipped tapper is placed on the head of the implant and tapped gently with a mallet until the implant is seated completely. Great care must be taken not to drive the implant beyond the bone level (i.e., into the antrum, nasal floor, or mandibular canal). This can be prevented if the tip of the implant driver is larger than the diameter of the implant's head. As an alternative, an orangewood stick is a safe, gentle, and satisfactory disposable seating instrument.
5. After each implant has been seated, its healing screw is tightened with the hex screwdriver (Fig. 10-16). Press-fit implants should never be tapped without their healing screws in place because of the risk of distorting the internally threaded environment.
6. The flap may now be sutured.

Uncovering follows the same techniques as described in Chapter 9.

Zimmer Dental makes a complete spectrum of titanium and coated threaded implants, as well as their HA-coated press-fit designs. These are inserted in the same manner as the BioHorizons, Screw-Vent, and Brånemark implants (Fig. 10-17).

Screw-Vent Implant

The process for insertion of the Screw-Vent implant is described here.

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FIGURE 10-14. **A** to **M,** Osteotomy sequence for a Certain Prevail straight-walled implant. (Courtesy Biomet-3i, Palm Beach Gardens, Fla.)

At this point, the 3-mm internally irrigated spade drill will have been used to the planned depth.

1. The 3-mm spade drill is the final sizing drill for the 3.3-mm implant. The 3.2-mm drill is the final sizing drill for the 3.7-mm Screw-Vent implant, and the 4.2-mm drill is the final sizing drill for the 4.7-mm implant body.
2. If the bone is dense, a bone tap may need to be used at 15 to 30 rpm to the final depth. If possible, however, tapping should be completed by hand.
3. The implant is brought to the osteotomy with its prepackaged handpiece connector. Before it is seated, the handpiece connector screw is loosened by turning the hex driver a half turn counterclockwise. The implant is seated to its final depth by turning the hand ratchet in a clockwise direction until the implant is flush with the crest of bone.
4. The handpiece connector is backed out with the hex tool, and the healing screw is placed with the same driver.
5. The flaps are sutured in the standard fashion.

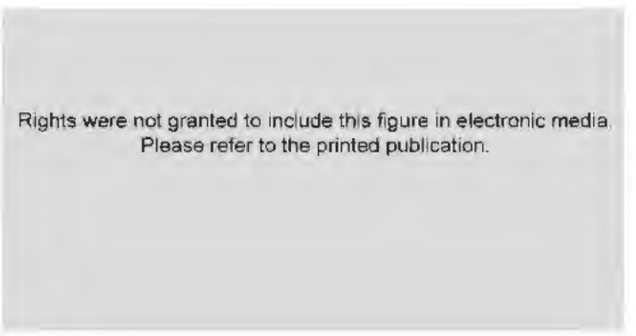


FIGURE 10-15. **A** to **N,** Osteotomy sequence for a Certain Prevail tapered implant. Starter drill/round bur, 2-mm twist drill, shaping drill, depth/direction indicator, C'sink drill, bone tap (optional), implant. (Courtesy Biomet-3i, Palm Beach Gardens, Fla.)

Uncovering of these implants follows the standard technique.

Taper-Lock Screw-Vent Implant

Zimmer Dental has added a taper design to its product line. Three diameters are available: 3.3, 3.7, and 4.7 mm. The method of insertion is the same as for the standard screw. A primary advantage of this design is that it allows immediate attachment of an abutment for one-stage utilization (see Chapter 21).

AdVent Implant

Placement of the AdVent implant is accomplished through the following steps.

At this point, the 3-mm internally irrigated, generic drill will have been used to the planned final depth of the osteotomy.

1. The 3.4-mm drill is the final sizing drill for the 3.7-mm system; the apex of the drill is only 2.5 mm in diameter. The 4.4-mm drill is the final sizing drill required for the wider diameter 4.7-mm system; the apex of the wide implant drill is only 3 mm.

FIGURE 10-16. Hex screwdrivers. **A,** Short. **B,** Long.

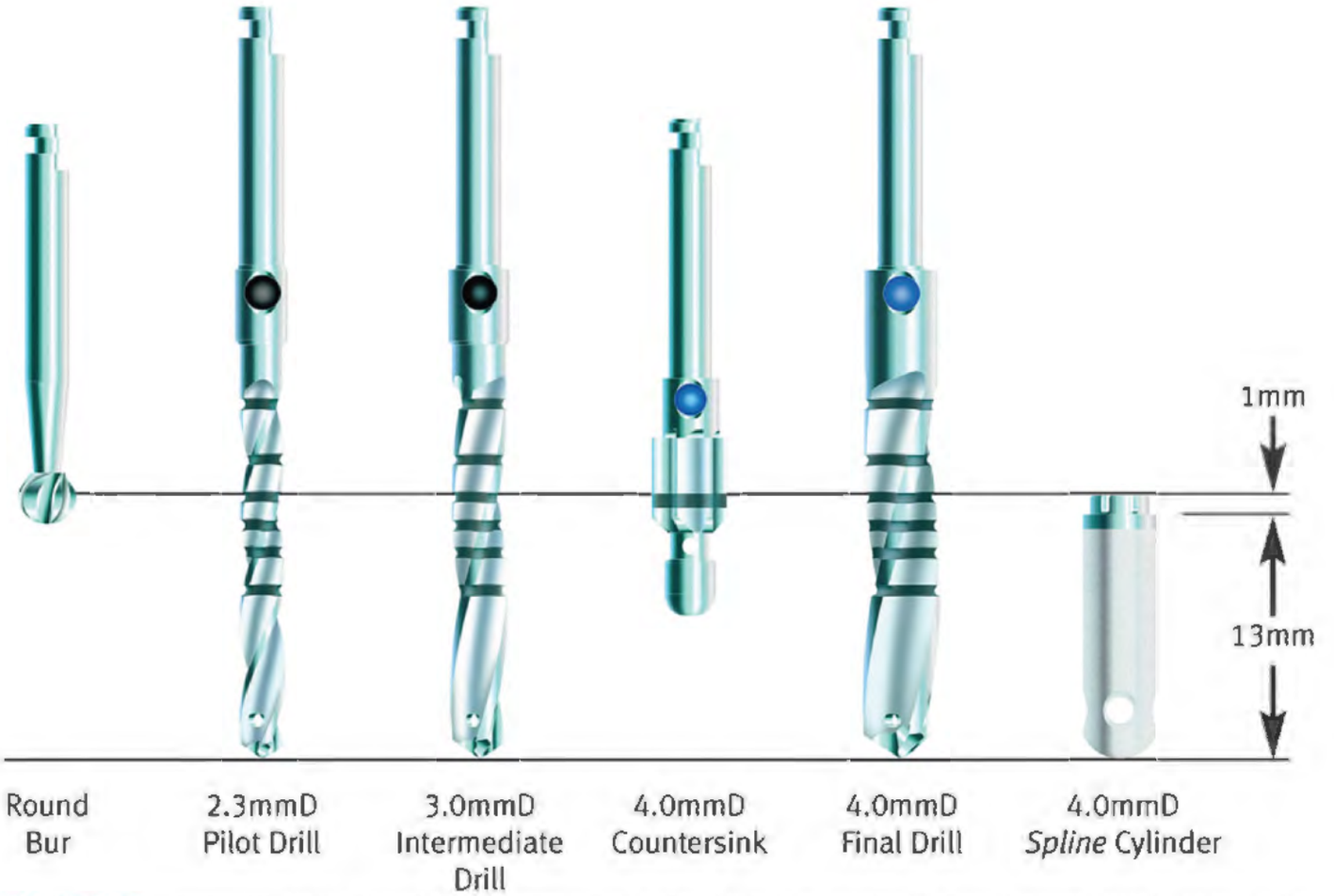


FIGURE 10-17. Generic osteotomy protocol for the preparation of a press-fit, cylindric implant. (Courtesy Zimmer Dental, Carlsbad, Calif.)

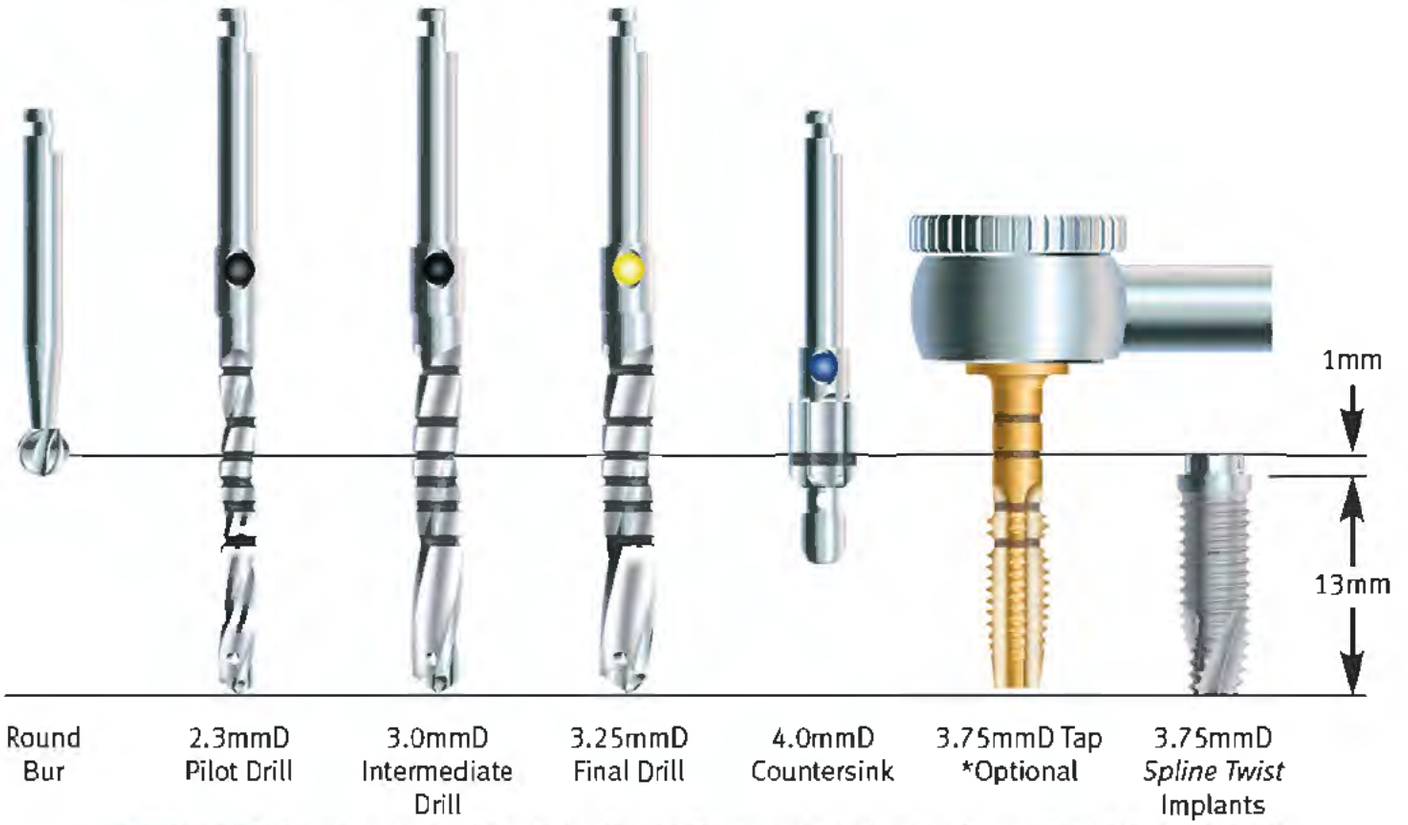


FIGURE 10-18. Osteotomy protocol for a Spline Twist 3.75-mm implant. (Courtesy Zimmer Dental, Carlsbad, Calif.)

2. The implant is transferred to the osteotomy with its prepackaged handpiece connector, which should be loosened before use. The implant is seated completely by turning the ratchet wrench in a clockwise direction.
3. The implant connector is removed with the hex tool and replaced with the cover screw.
4. The flap is sutured in the standard fashion.

Uncovering follows the standard techniques described previously.

Spline Twist Implant

Placement of the Spline Twist implant is accomplished through the following steps.

At this point, the 3-mm internally irrigated spade drill will have been used to the planned depth.

1. The 3.25-mm drill is the final sizing drill for the 3.75-mm implant. Depending on the density of the bone, the 4- or 4.5-mm drill is the final sizing drill for the 5-mm implant body.
2. A countersink drill is used to prepare for the neck of the implant. This is done before bone tapping, which is performed at 15 to 30 rpm to the final depth if the bone is dense. If possible, however, tapping should be completed by hand.
3. The implant is transferred to the osteotomy with its prepackaged handpiece connector. Before it is seated, the handpiece connector screw is loosened by turning the hex driver a half turn counterclockwise. The implant is seated to its final depth by turning the hand ratchet in a clockwise direction until the implant is flush with the crest of bone.
4. The handpiece connector is backed out with the hex tool, and the healing screw is placed with the same driver.
5. The flaps are sutured in the standard fashion.

These implants are uncovered using the standard technique (Fig. 10-18).

CAMLOG

The core element of the Camlog system is the patented "tube in tube" design, which ensures an accurate, mechanically secure implant to abutment connection with antirotational stability (Fig. 10-19).

As a result of the positive press-fit and the specially designed cams of the tube-in-tube connection, all forces acting on the connection are distributed in an ideal manner. The abutment screws are hardly loaded and perform only a holding function; this almost eliminates the problems of screw loosening and screw fractures. The drills have depth stops for different lengths and are color coded for the different diameters.

Camlog has four product lines: the Screw-Line, Root-Line, Cylinder-Line, and Screw-Cylinder-Line, all of which have the internal connection.

Screw-Line

Screw-Line screw implants are adequate for most clinical conditions. The excellent self-centering of the implant is achieved through the slightly tapered shape and the self-cutting thread of the screw (Fig. 10-20).

Root-Line

The root-shaped Root-Line screw implants have a self-cutting thread. Because of their taper and special type of thread, which ensure a perfect fit and primary stability, they are particularly suitable

FIGURE 10-19. Cross section of a Screw-Line implant (Camlog), showing the 6-mm-deep internal abutment retention cam, or "tube in tube," design. (Courtesy Camlog, Basel, Switzerland.)

for immediate and delayed immediate implantation to ensure healthy loading of the peri-implant bone.

Cylinder-Line

Cylinder-Line implants have proved their benefits for almost all clinical indications. They are easy to insert with good primary stability, thanks to the press-fit, and they are a good backup salvage implant when the threads of an osteotomy of the same diameter are stripped.

Screw-Cylinder-Line Implants

Screw cylinder implants should be used for the weak bone of the maxillary posterior region, along with sinus floor elevation and augmentation. In regions where the residual bone of the alveolar process allows a better fit for the implants, the threaded screw ensures higher primary stability.

Screw-Line and Cylinder-Line implants are available in diameters of 3.3, 3.8, 4.3, 5, and 6 mm. Root-Line implants and Screw-Cylinder-Line implants are available in diameters of 3.8, 4.3, 5, and 6 mm. All the implants are available in lengths of 9, 11, 13, and 16 mm.

The surgical protocol and steps are very similar for all threaded lines, because the diameters and lengths are the same (Fig. 10-21).

1. The implant site is indented with a 3.1-mm round bur.
2. The 2-mm pilot drill is then used, and the angulation of the preparation is checked with a paralleling pin.
3. If the angulation is satisfactory, a 2.8-mm predrill is used to the depth that will enlarge the osteotomy, followed by a 3.3-mm form drill. Larger drills are used to widen the osteotomy.
4. A form drill that matches the size of the implant is used to finish off the osteotomy.
5. The attached carrier is used to insert the implant into the prepared osteotomy, and the implant is hand-torqued to finish.
6. When the implant has been fully seated, the carrier is unscrewed and replaced with a cover screw.
7. The tissues are closed in the usual manner and the surgical area is allowed to heal.

The Promote surface used on several of the Camlog implant lines (i.e., Screw-Line, Root-Line, and Screw-Cylinder-Line) is abrasive blasted and acid etched and extends to the bottom of the collar, which is machined. Cylinder-Line implants have a titanium plasma spray (TPS) surface.

The Screw-Line implants are also available with the Promote Plus configuration, in which the Promote surface extends all the way to the top of the collar.

Cylinder-Line

Once the implant has been placed in the osteotomy, the seating instrument and the placement head are positioned and tapped into place with the surgical hammer. The final position can be recognized by a satisfying hollow sound. At this point, the placement head is broken away from the implant. The placement head stays in the seating instrument because of its silicone O-ring. The tightness of the sealing screw is checked with a hand screwdriver (Fig. 10-22).

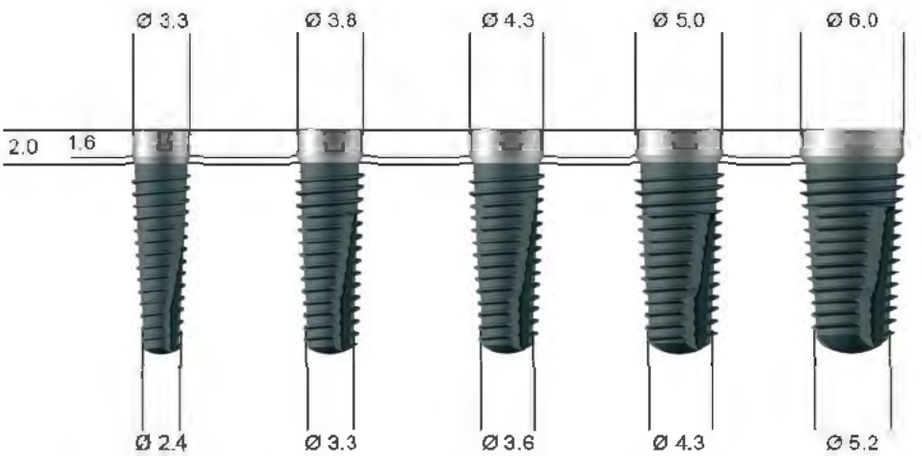


FIGURE 10-20. Tapered-wall implant with threads up to the base of the collar. (Courtesy Camlog, Basel, Switzerland.)

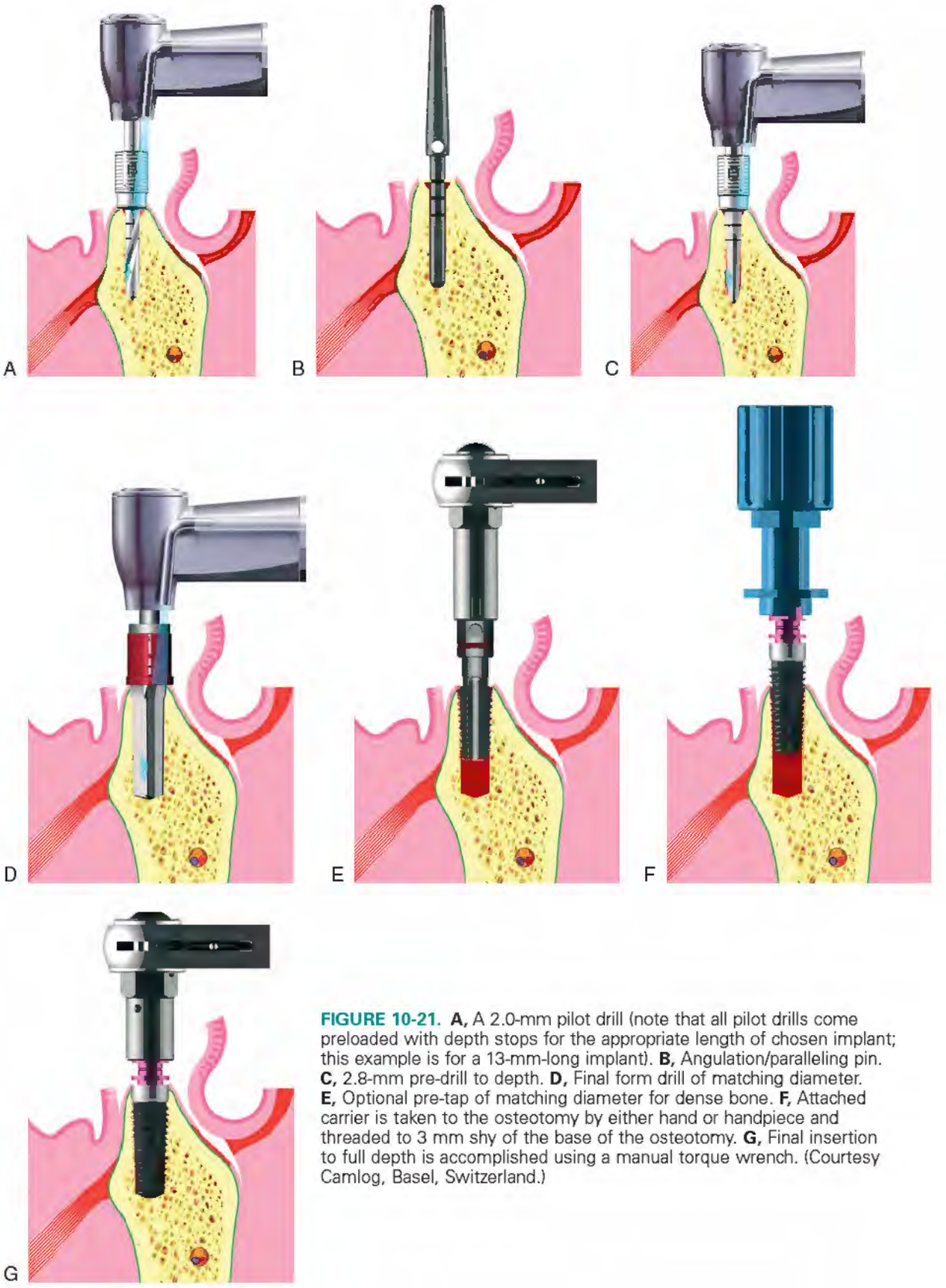


FIGURE 10-21. **A,** A 2.0-mm pilot drill (note that all pilot drills come preloaded with depth stops for the appropriate length of chosen implant; this example is for a 13-mm-long implant). **B,** Angulation/paralleling pin. **C,** 2.8-mm pre-drill to depth. **D,** Final form drill of matching diameter. **E,** Optional pre-tap of matching diameter for dense bone. **F,** Attached carrier is taken to the osteotomy by either hand or handpiece and threaded to 3 mm shy of the base of the osteotomy. **G,** Final insertion to full depth is accomplished using a manual torque wrench. (Courtesy Camlog, Basel, Switzerland.)

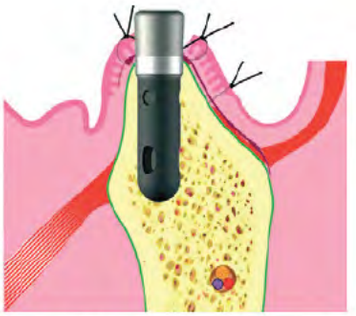


FIGURE 10-22. Press-fit parallel-wall implant. (Courtesy Camlog, Basel, Switzerland.)

KEYSTONE DENTAL

Keystone Dental makes three designs of threaded implants: Renova (which has an internal hex); tapered and straight-walled Restore (which have an external hex [threaded and cylinder]); and the Stage-1 single-stage system.

Renova Implant

Renova's resorbable blast media (RBM) surface texture has an internal hex. It is available in diameters of 3.75 and 4.5 mm and in lengths of 8.5, 10, 11.5, 13, and 14.5 mm. The steps for placement are as follows.

At this point, the 2-mm generic spade drill will have been used (to a depth at least 1 mm shorter than the length of the implant, which is always a good rule to follow).

1. For the 3.75-mm implant, the appropriate length 3.75-mm finishing drill is used to complete the osteotomy.
2. For a 4.5-mm implant, the matching diameter finishing drill is used to the planned depth, but only after a 4.5-mm drill has been used as an interim device.
3. The implant is placed in the preparation with a placement head, which is the carrying implement. The head is then unscrewed and removed.
4. The appropriate healing screw is placed in the implant. In addition to the conventional design, Orthomatrix makes flanged healing screws, which are intended for areas where the implant may be seated too deeply (e.g., into the maxillary sinus or nasal floor). The flanged screws have a lip that extends beyond the implant's circumference and serves as a stop against the bone, preventing the implant from being impelled into an undesirable zone. Flanged screws must be placed in the implant before it is seated (Fig. 10-23).
5. Flap closure now may be performed.

Restore Implant

Restore, Keystone's external hex series of implants, is available in a variety of lengths and widths. Depending on the surface design (RBM or HA), the diameters are 3.3, 3.75, 4, 5, and 6 mm, and the lengths are 8 to 18 mm. The RBM model is a hybrid design that has textured threads apically and, depending on the diameter, machined threads (two to four) beneath the cervices.

The insertion technique for Restore follows the general outline presented in Fig. 10-24.

The press-fit cylinder system has a smooth surface design. The steps for insertion are described here.

At this point, the 3-mm spade drill will have been used to its final depth (1 mm shorter than the length of the implant, which is always a good rule to follow).

1. For the 3.4-mm implant, the 3.4-mm trispade finishing drill of the appropriate length (10, 13, or 15 mm) is used to complete the osteotomy.
2. For the 4.2-mm implant, a generic 3.4-mm drill is used first as an interim device. Then the matching-diameter trispade finishing drill (available in lengths of 8, 10, 13, and 15 mm) is used to the planned depth.
3. For a 5-mm implant, a 4.2-mm drill is followed by the 5-mm trispade finishing drill (also in lengths of 8, 10, 13, or 15 mm), which is used to its final depth.
4. The Restore system supplies steel try-ins in 3.4-, 4.2-, and 5-mm diameters. These are used to confirm that the proper depth and width have been obtained.
5. Firm finger pressure on the package cover, which carries the implant, is used to place the implant in the preparation. The head is then twisted off and removed.
6. Final implant seating is done with a Biocare mallet supplied by the manufacturer and an anterior straight or the posterior bayonet tapper. The tapper has been designed with a wide-diameter plastic tip, which prevents overdriving of the implant. When properly seated, the implant is at rest level with the alveolar crest.
7. The appropriate healing screw is placed in the implant. In addition to the conventional healing screw design, Orthomatrix makes flanged healing screws (Fig. 10-25). These are intended for use in areas where the implant may be seated too deeply (e.g., into the maxillary sinus or nasal floor). The flanged screws have a lip that extends beyond the implant circumference and serves as a stop against the bone, preventing the implant from being impelled into an undesirable zone. Flanged screws must be placed in the implant before it is seated.
8. Flap closure now may be performed.

Stage-1 Single-Stage Implant

The Stage-1 single-stage implant system combines the RBM surface with an internal locking prosthetic connection and eliminates the need for a second surgery, which reduces treatment chair time. Restoratively, the Stage-1 implant provides esthetic results using simple restorative procedures that require minimal components and instrumentation.

Stage-1 implants are available in diameters of 3.3, 4.1, 4.8, 5.5, and 6.3 mm (4.8-mm regular and 6.5-mm wide prosthetic connections). Collar heights are 1.8 or 2.8 mm, and the available lengths are 8, 10, 12, 14, and 16 mm.

The locking Morse taper connection and the tissue level prosthetic connection improve visibility during abutment seating. The internal tapered connection automatically centers the abutment during placement. The smooth, flared neck provides a natural emergence profile and facilitates soft tissue management (Fig. 10-26).

STRAUMANN ITI

All but one implant series from Straumann ITI are the single-stage type. The implant neck or abutment-receiving position remains exposed after suturing. The healing screw, therefore, is exteriorized (Fig. 10-27). All the implants are available with the SLA or SLActive surface treatments.

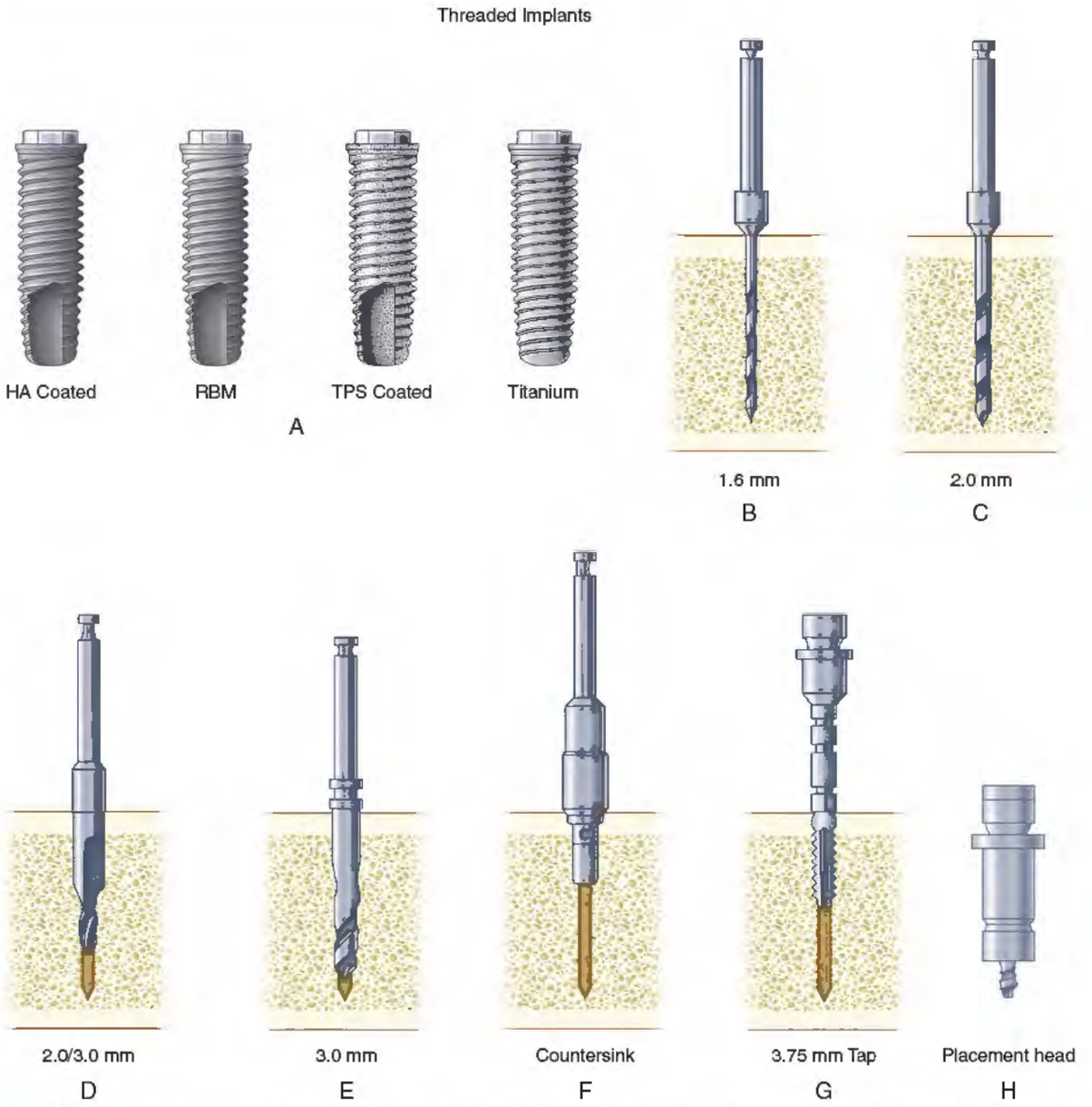


FIGURE 10-23. **A** to **H**, The Keystone Dental threaded implant system has three universally acceptable designs. For implants 3.3 mm in diameter, the sequence is: the 1.6-mm drill is used, then the 2-mm twist drill, then the pilot drill, then the 3-mm twist drill, and finally the finishing drill. For the three implants with larger dimensions, this sequence is followed with increasing twist drill and bone-tap diameters as needed.

Straumann implants soon will be made of a material called *Roxolid* (pronounced rock-solid), which will have been released by the time this text is available for distribution. This material is the first of its kind, an alloy of pure titanium and zirconium (neither metal inhibits the growth of osteoblasts). The manufacturer maintains that the alloy is 50% stronger than pure titanium and that titanium's ability to osseointegrate is not compromised, as it is in some titanium alloys (e.g., Ti-6Al-4V [TAV]). Roxoloid thus would be ideal for narrow-diameter implants and could open the door for a new generation of smaller, safer implants, which could be particularly advantageous in narrow ridges, where wider implants would require bone augmentation or grafting procedures.

The manufacturer also claims that the alloy can be surface treated with SLActive, which creates an implant that has proved to develop faster and greater bone to surface contact than the SLActive implant during a similar healing period.

SLA Surface

To produce the SLA surface, large-grit sandblasting creates a macro-roughness on the titanium surface. This is followed by acid etching that superposes a micro-roughness. The resulting topography offers the ideal structure for cell attachment and also is the basis for the further developed SLActive surface.

SLActive

Besides the SLA topography, the SLActive surface has properties such as hydrophilicity and chemical activity that significantly accelerate the entire osseointegration process. The hydrophilic properties of SLActive provide a larger accessible surface area for increased blood contact and bone cell attachment, and the chemical activity of SLActive allows for direct protein adsorption, which stimulates immediate new bone formation (Fig. 10-28).

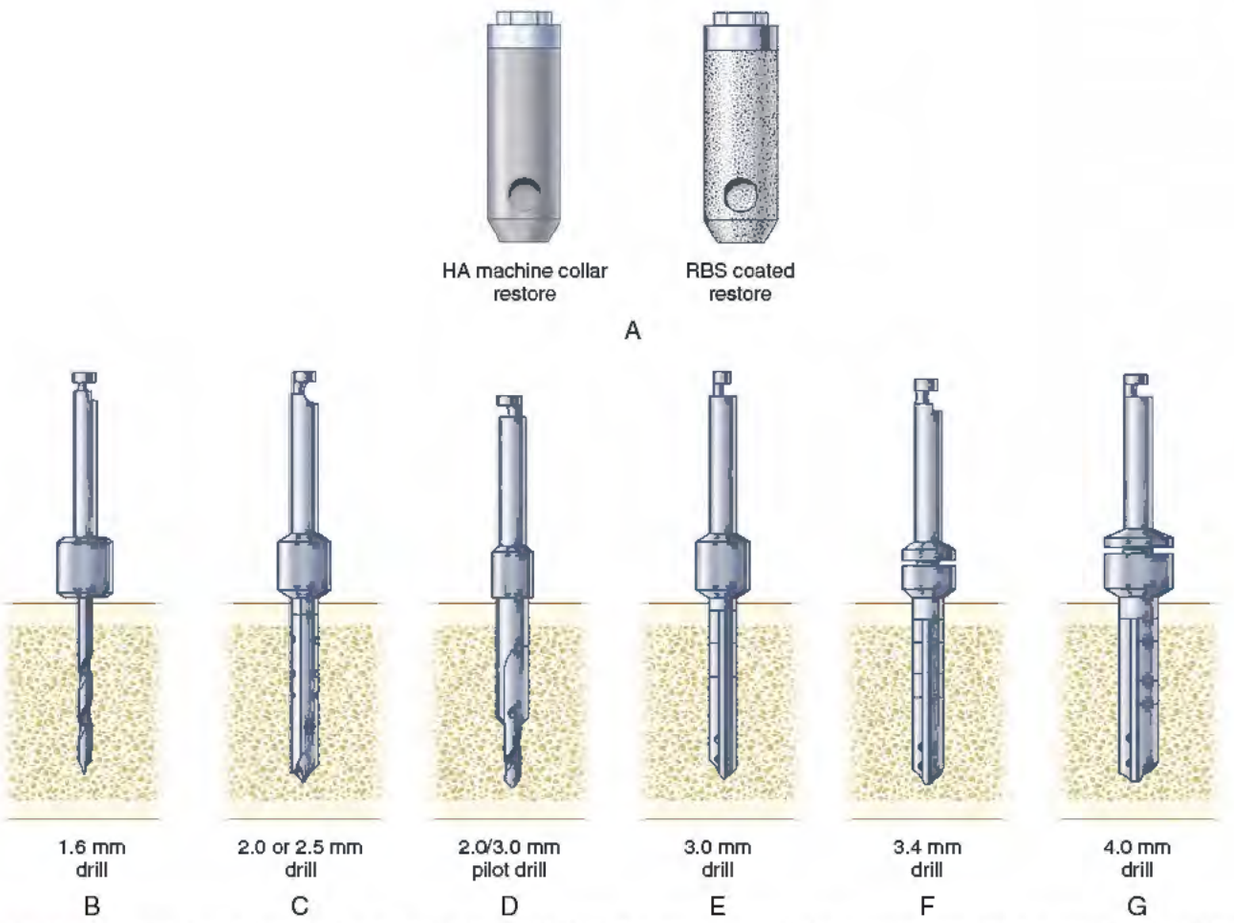


FIGURE 10-24. Keystone Dental makes five press-fit implants. They are available with the external hex and are coated with either hydroxyapatite (HA) or titanium plasma spray (TPS). Under the Restore name, a TPS and an HA design are available, each hexed and with diameters from 3.4 to 5 mm. In the Sustain product line, three versions are available, with the same dimensional choices. These implants are all HA coated, and two are plasma-sprayed over the entire implant, leaving a machined titanium collar. A screw-in Morse taper abutment is used for the Sustain design without the exposed metal collar. The Sustain group is further distinguished from the Restore implants by the three concentric grooves that are made below the cervix. This figure presents the classic steps for the seating of any of these five designs. Drills of appropriate width must be coordinated with implants of matching diameters. The mandatory steel implant try-ins for each design are not shown, nor is the step involving the use of the bayonet tapping instrument with its nylon tip.

Soft Tissue Level Standard Implant

Straumann's soft tissue level Standard implant has a smooth neck section of 2.8 mm and is especially suitable for classic, single-stage procedures in which the implant is placed at soft tissue level and not covered with soft tissue during the healing phase. The Standard implant uses Straumann's synOcta connection with its corresponding prosthetic components, the synOcta portfolio and the solid abutment.

The thread pitch on the Standard implant measures 1 mm for the 3.3-mm implants and 1.25 mm for all other diameters. The various diameters (3.3, 4.1, and 4.8 mm) and several lengths (6, 8, 10, 12, 14, and 16 mm) are available in narrow, regular, and wide-neck profiles.

Standard Plus Implant

The Standard Plus implant has a shorter smooth-neck section that allows flexible coronoapical implant placement with transgingival or subgingival healing. It is a one-piece design that has an external connection with a shoulder diameter of 3.5 mm, an endosteal diameter of 3.3 mm, and a smooth-neck section of 1.8 mm. This gives the implantologist options that are particularly useful in the anterior region of the maxilla, where esthetic demands are high. Similar to Straumann's standard implants, The Standard Plus uses the synOcta connection, along with its prosthetic components, the synOcta portfolio and the solid abutment.

The thread pitch on the Standard Plus implant is 1 mm for the 3.3-mm implants and 1.25 mm for all other diameters. The Standard Plus Narrow Neck implant, which uses its proprietary narrow neck (NN) prosthetic components, can be used as an alternative in narrow interdental spaces.

Tapered Effect Implant

The Tapered Effect implant has a special anatomic design that combines a cylindric shape in the apical region with a conical shape in the coronal region. This configuration makes the implant particularly suitable for immediate or early implantation after extraction or loss of natural teeth. The 1.8-mm smooth-neck section allows healing to occur transgingivally or subgingivally. Tapered Effect implants also have the synOcta connection; therefore the synOcta portfolio and solid abutment prosthetic components can be used. The thread pitch of 0.8 mm provides excellent primary stability.

FIGURE 10-25. **A** and **B,** Healing abutment for Restore product line. (Courtesy Keystone Dental, Burlington, Mass.)

FIGURE 10-26. Final seating sequence for the Screw-Cylinder/Cylinder implant. (Courtesy Keystone Dental, Burlington, Mass.)

Bone Level Implant

The Bone Level implant is suitable for bone level treatment combined with transgingival or subgingival healing. The implant's rough surface extends to the top of the implant, and the connection is shifted inward. The bone level implant uses a conical-cylindric connection, the CrossFit connection, along with its corresponding prosthetic CrossFit components from the Bone Level product portfolio. A cylindric outer contour and a thread pitch of 0.8 mm that tapers off in the coronal part of the implant provide excellent primary stability.

Standard Screw Implants

ITI solid screw implants are available in 3.3-, 4.1-, and 4.8-mm diameters. For the 3.3-mm implant, a 3-mm round bur should be used to mark the crest. The initial osteotomy then should be started with a 2.2-mm diameter using the generic, internally irrigated burs described in Chapter 9. The final ITI sizing bur is the 2.8-mm twist drill for the 3.3-mm implant (Fig. 10-29, *A*). For the standard diameter, 4.1-mm implant, the osteotomy may be completed to a 3.5-mm diameter (Fig. 10-29, *B*). When the wide diameter (4.8 mm) implant is selected, the final sizing drill is a 4.2-mm twist drill (Fig. 10-29, *C*).

The profile drill prepares the implant bed for a specific Straumann implant.

Caution The profile drills are suitable only for the corresponding implant type! The entire length of the implant bed must be pretapped (Fig. 10-29, *D*). The implant with the handpiece is placed in the implant bed (Fig. 10-29, *E*), and the closure screw is hand-tightened with the cover screwdriver (Fig. 10-29, *F*). The flaps now are ready to be closed with sutures placed in purse-string fashion around the exposed neck (see Chapter 6).

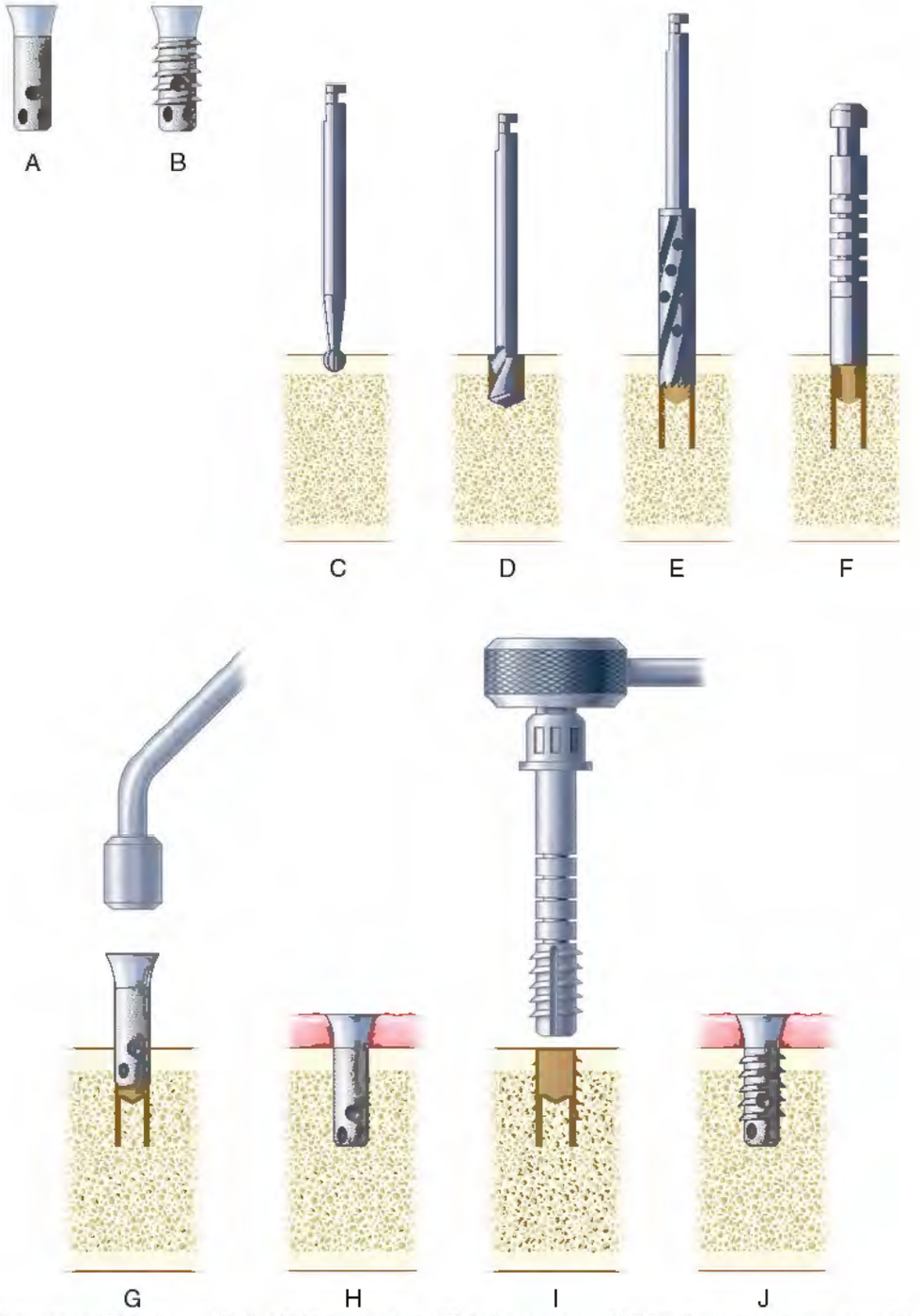


FIGURE 10-27. **A**, Straumann ITI hollow cylinder (HC) implant. **B**, ITI hollow screw (HS) implant. **C**, A 3-mm round bur. **D**, A 3.5-mm drill. **E**, Trephine drill. **F**, Depth gauge. **G**, The HC implant is gently tapped into position. **H**, The HC implant is seated so that it protrudes through the soft tissue after suturing. **I**, Thread tap with attached ratchet wrench. **J**, The HS implant is seated so that it protrudes through the soft tissue.

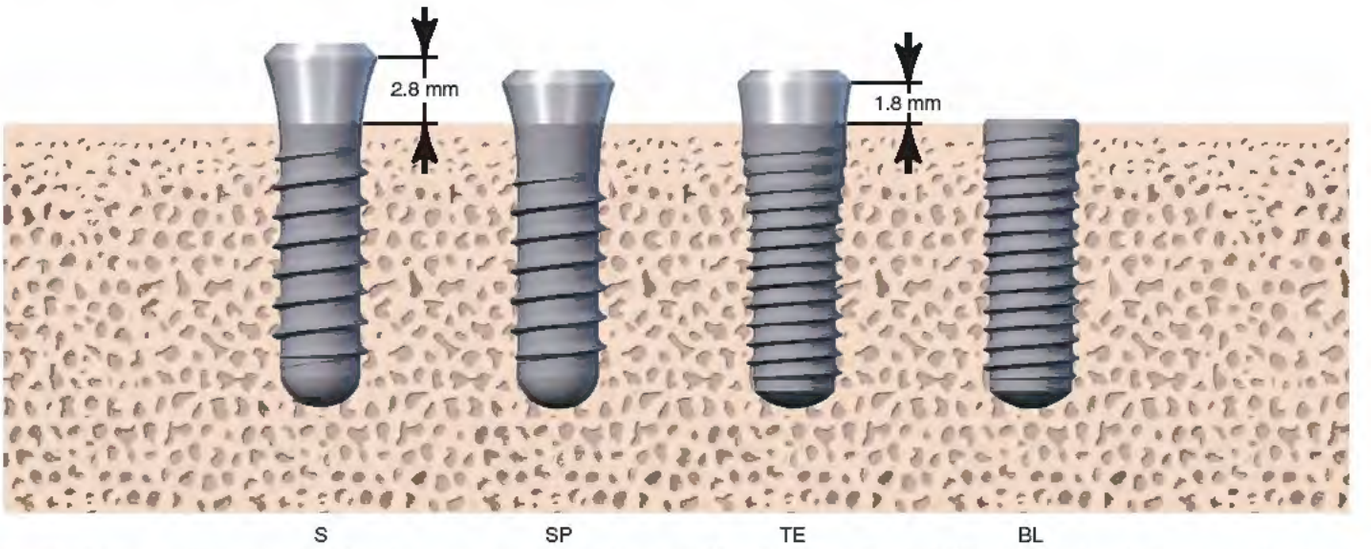
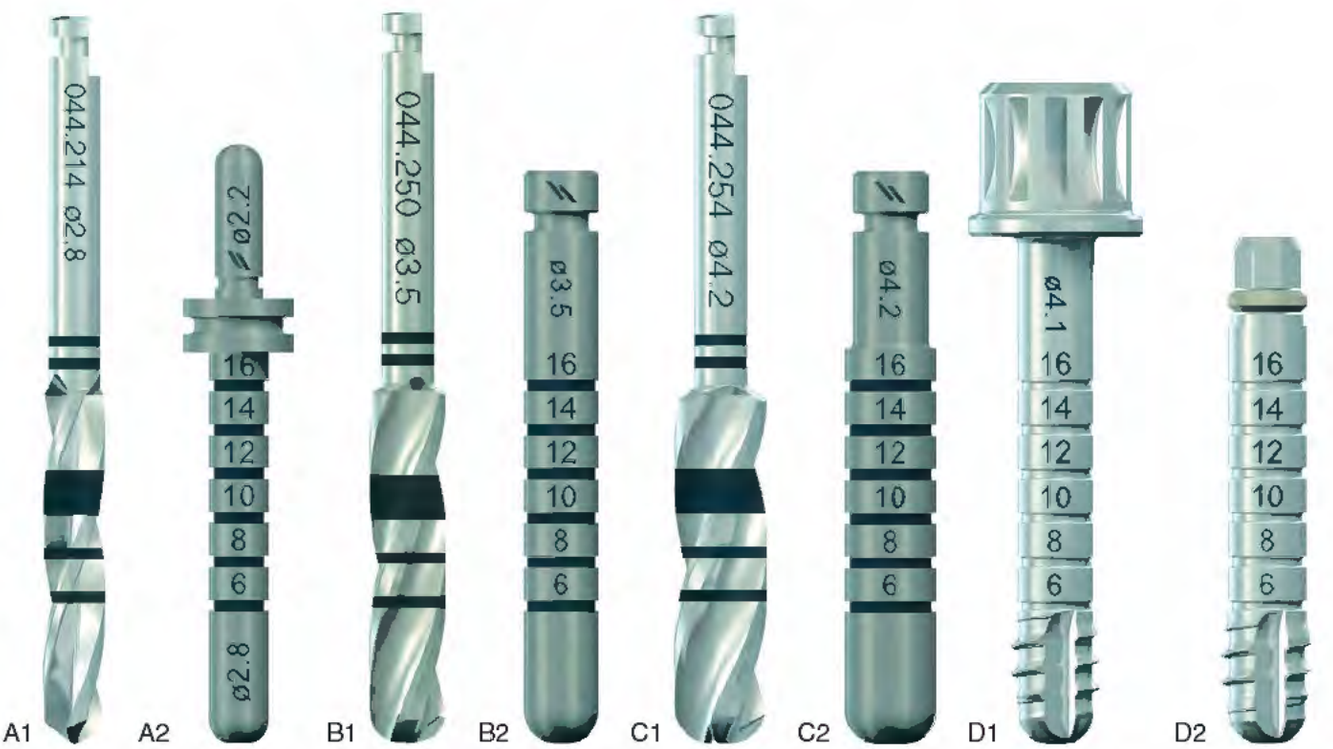


FIGURE 10-28. Straumann implant line *(left to right)*: Standard implant, Standard Plus, Tapered Effect, Bone Level. (Courtesy Straumann, Waltham, Mass.)



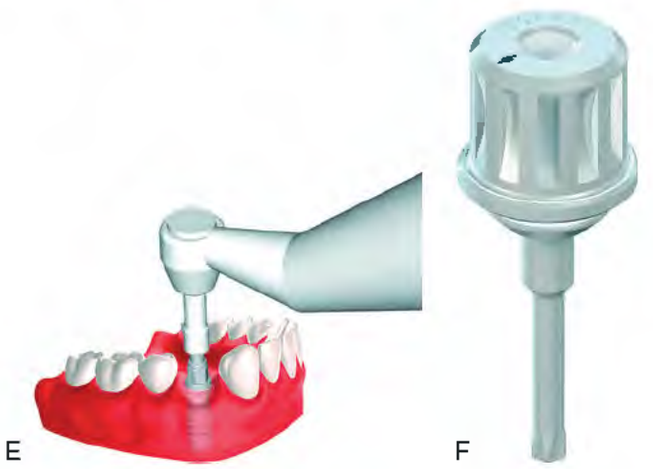


FIGURE 10-29. **A,** 2.8-mm pilot drill, and 2.8-mm twist drill. **B,** A 3.5-mm twist drill with a depth verification pin. **C,** A 4.2-mm twist drill and depth verification pin. **D,** Bone tap. **E,** The implant is seated using the implant carrier. **F,** After the implant carrier has been removed, the cover screwdriver is used to affix the cover screw before the soft tissue is sutured. (Courtesy Straumann, Waltham, Mass.)

Root Form Implant Surgery: Proprietary II

11 CHAPTER

BIOHORIZONS IMPLANTS

The BioHorizons implant system consists of six styles of titanium alloy implants. These implants, which are threaded (reverse buttress threads), have either resorbable blast texturing (RBT) or a hydroxyapatite (HA) surface coating. The Tapered Internal design also has the proprietary Laser-Lok microchannels. The microchannels are a series of 8- and 12-µm grooves engineered onto the collar of the Internal implants, which come with an abutment and its retaining screw and a healing cover screw. The other implants have a polished collar. All of the implants have a lifetime unconditional restoration-to-implant warranty (Fig. 11-1, *A*).

Overdenture Implant

The Overdenture implant is an affordable device for patients whose ridges are too narrow for wider, two-piece systems. The Overdenture's one-piece, titanium alloy construction provides maximum strength, and its 3-mm diameter allows placement in narrow ridges. These implants are placed using a single-stage protocol, with options for either flap or flapless surgery. Each implant is packaged with the complete attachment system, with options for three levels of retention.

External Implant

The External implant features the 3inOne prepable titanium abutment and a 1-mm high external hex. The modified-square threads provide greater bone to implant contact and reverse torque values than V-thread designs. The series is available in four diameters (3.5, 4, 5, and 6 mm) and four lengths in each diameter size (9, 10.5, 12, and 15 mm).

Tapered Internal Implant

The Tapered Internal implant has the proprietary Laser-Lok microchannels and reverse buttress threads on an anatomically tapered implant body. The Tapered Internal Implant also has the 3inOne prepable titanium abutment, with the same 1.5-mm deep internal hex connection as the Internal and Single-stage implants. The Tapered Internal implant is available in three diameters (3.8, 4.6, and 5.8 mm) and five lengths (7.5, 9, 10.5, 12, and 15 mm).

Single-Stage Implant

For the Single-stage implant, the same surgical kit is used as for the Internal (two-stage) implant. The Single-stage also has the same internal hex connection. This allows the clinician to choose the implant design best suited to a particular case. The Single-stage implant is available in four diameters (3.5, 4, 5, and 6 mm) and five lengths (7, 9, 10.5, 12, and 15 mm).

Internal Implant

The Internal implant has the 3inOne prepable titanium abutment, a 1.5-mm deep internal hex connection, and the modified-square thread design. The Internal implant is available in four diameters (3.5, 4, 5, and 6 mm) and five lengths (7, 9, 10.5, 12, and 15 mm).

One-Piece 3.0 Implant

The One-piece 3.0 implant has an integrated crown and bridge abutment. It is specifically indicated for replacement of maxillary laterals and mandibular incisors. This implant allows the dental surgeon to treat spaces that cannot be handled with conventional two-piece implants. The prepable gold-colored titanium nitride coating on the abutment portion also improves soft tissue esthetics. The surgical protocol follows steps similar to those of the other implant lines.

Generic Surgical Protocol for BioHorizon Implants

The generic surgical protocol for BioHorizon implants proceeds through these steps.

1. A No. 6 round bur is used to start the osteotomy.
2. A 2-mm twist drill is used to create the initial osteotomy site to verify the angulation.
3. If the angulation is satisfactory, a 2.5-mm twist drill is used to a depth equal to the length of the implant.
4. The width-increasing drills then are used in ascending order (to the size just thinner than the diameter of the implant), depending on the density of the bone.
5. When the osteotomy is the correct size, the crestal bone drill is used, followed by the bone tap (depending on the bone quality) to complete the fully threaded osteotomy (Fig. 11-1, *B* to *E*).

BICON

Since 1985, Bicon implants have been promoted as the short implant of choice for the anatomically challenged areas where there is non-optimal alveolar height present in proximity to the inferior alveolar canal or the maxillary sinus. Implants are available with a grit blasted acid etched surface known as Inegra-Ti or with a calcium phosphate treatment (HA) known as Integra-CP.

In accordance with the manufacturer's instructions for using a Bicon implant, initial cortical perforation is made with a 2.0-mm pilot drill with external irrigation to a depth 2.0 - 3.0-mm deeper than chosen implant (when practical) (Figure 11-2, *A*). Widening of the osteotomy is performed with sequentially larger reamers beginning with a 2.5-mm diameter and ending with the diameter of the intended implant (Figure 11-2, *B*). Reamers have horizontal markings at 6.0, 8.0, 11 and 14 mm, whereas older reamers may

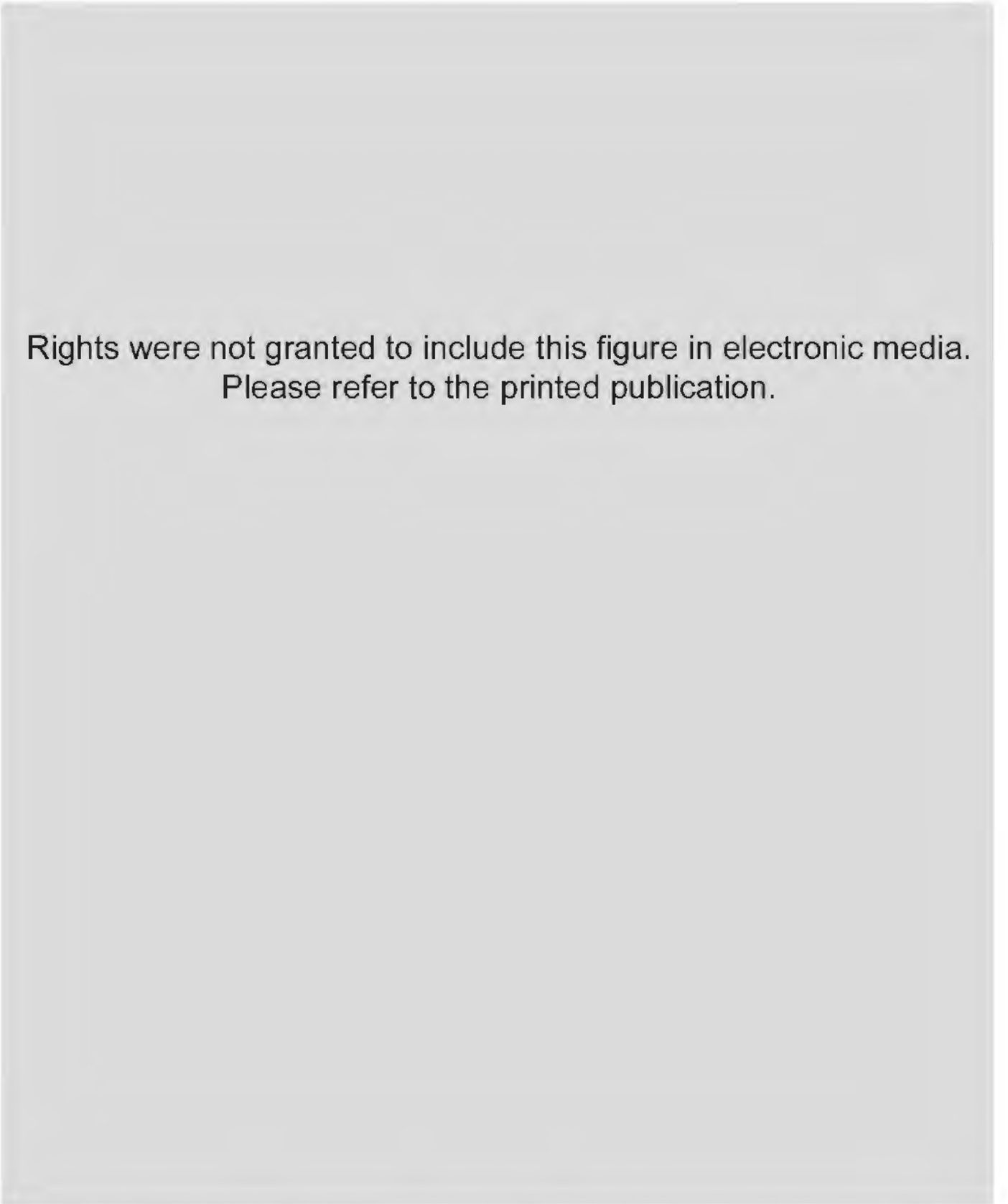


FIGURE 11-1. **A,** BioHorizons implants. These implants are made of a titanium alloy and have resorbable blast texturizing (RBT) threads (reverse buttress threads) with the proprietary Laser-Lok microchannels. **B-E,** The osteotomy method follows classic techniques using drills of increasing diameter. (Courtesy BioHorizons Implant System, Birmingham, Ala.)

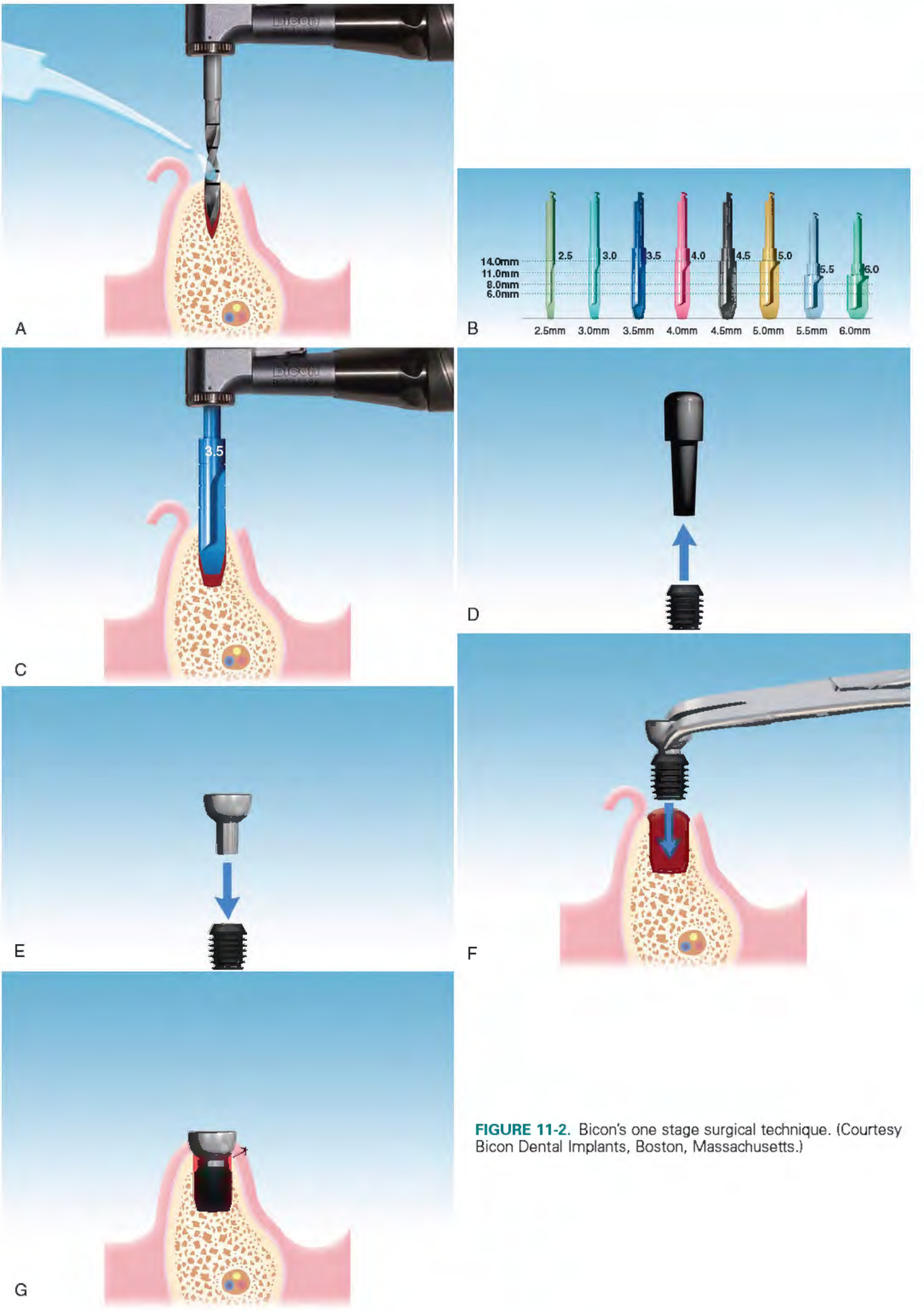


FIGURE 11-2. Bicon's one stage surgical technique. (Courtesy Bicon Dental Implants, Boston, Massachusetts.)

have different markings. It is imperative that the depth indicators on the latch reamers are known before surgery. No assumptions should be made about the height of the first marking on any latch reamer. If there is any doubt about the markings on any drill or reamer, take a measurement before using the reamer. Bone may be harvested from within the flutes of the reamers as no irrigation is utilized.

1. Widen the socket with successively wider reamer burs without any irrigation and at a maximum of 50 RPM (Figure 11-2, *C*).
2. For a one-stage procedure, remove the black healing plug (Figure 11-2, *D*).
3. Replace the black healing plug with an appropriate temporary abutment (Figure 11-2, *E*).
4. Insert the implant with abutment into the socket (Figure 11-2, *F*).
5. Trim tissue if necessary. Wait for a minimum of 10-12 weeks for osseointegration before removing temporary abutment (Figure 11-2, *G*).

PARK DENTAL STAR/VENT

The Star/Vent implant is a single-stage, one-piece, titanium plasma spray (TPS) screw implant that allows immediate loading. It is available in diameters of 3.3 and 4 mm and lengths of 8, 11, 14, and 17 mm.

The Star/Vent implant has the Star★Lock internal hex screw and a press-fit cylinder in non-coated, restorable blast media–surface roughening treatment (RBM), TPS, or HA coated. Abutments are straight or 15 or 25 degrees. The implants are available in various diameters (3.3, 3.8, 4, 5, and 6 mm) and lengths (8, 10, 11, 13, 14, and 15 mm).

The external hex system in screw and press-fit cylinder shapes also is available. The different surfaces include RBM, surface roughening for noncoated implants, HA, and TPS. The HA and TPS coatings are available in all sizes.

For the osteotomy for the Star/Vent, the 3-mm generic spade drill is used to its planned depth.

1. The osteotomy is enlarged with the 3.17-mm spade drill to the predetermined depth.
2. The steps of enlargement are continued with the handheld final sizing reamer (3.3 mm).
3. Gentle finger pressure is used to form the countersink. The osteotomy is completed by hand and by using the counterbore reamer in a clockwise direction.
4. The millimeter-calibrated depth gauge should be used to confirm the depth of the osteotomy.
5. The one-piece Star/Vent insertion instrument is screwed to the implant.
6. The implant is seated, and the surgeon starts to thread it into the surgical preparation with the Star/Vent hand wrench. Seating is completed by using the ratchet wrench in a clockwise direction.
7. When the implant has been fully seated, the healing closure plug is placed using the plug socket and hex-head wrench.
8. The flaps are sutured.

MIS IMPLANT TECHNOLOGIES

MIS has a wide range of implants that allow reconstruction of a single tooth, screw-retained or cemented fixed bridges, and overdentures. These implants are made of biocompatible, medical grade titanium, and their surface is dual roughed by sand-blasting and acid-etching procedures. The product line ranges from root form implants to temporary provisionals to orthodontic anchorage.

The screw-type root form lines (i.e., BioCom, Seven, and Mistral) have an internal connection. Placement of these implants follows the generic surgical protocol for root form implants using either the flap or flapless approach. The osteotomy is created in incrementally increasing diameters of 0.5 to 1 mm until the ideal shape and size have been created. The implant then is either hand or engine driven to the full depth. A healing cover screw or an abutment is inserted on top of the implant, depending on whether a one-or two-stage protocol is used.

NEOSS IMPLANT SYSTEM

Neoss implants are manufactured from commercially pure grade 4 titanium. A multistage blasting process is used to achieve an ultraclean, high-energy surface with high wetability. A controlled roughness with a finer texture in the cortical part of the implant ensures optimum soft and hard tissue response. The self-tapping, double-threaded design provides unique stability and safe insertion.

The same abutment connection (internal) is used for all the implants; this simplifies installation, because only one implant driver is used. The implant's design makes it suitable for all treatment protocols, including one- or two-stage surgery, immediate placement, and early or immediate loading.

The Neoss implant kit (Fig. 11-3, *A*), includes the implant, implant cover screw, and two Peek healing abutments with a screw. All of the components come in separate sterile compartments, which can be opened individually. The surgeon should have all the components necessary to facilitate one- or two-stage surgery at the time of implant placement.

Neoss implants are available in five diameters (3.5, 4.0, 4.5, 5.0, and 5.5 mm) and in lengths that range from 7 to 15 mm in increments of 2 mm.

When the Neoss system is used, the 3-mm generic spade drill is used to its predetermined depth, which is checked with the direction/depth gauge (Fig. 11-3, *B* and *C*). The process then moves through these steps.

1. The intermediate drill is rotated to its final depth (Fig. 11-3, *D*).
2. The countersink bur is inserted into the osteotomy to prepare the osseous crest for proper seating of the implant. The bone tap is used for dense bone; it is rotated while firm apical pressure is applied (Fig. 11-3, *E*).
3. The 3.2-mm twist drill creates the requisite width for the 3.5-mm implant.
4. For the 4.5-mm implant, the osteotomy is flushed with sterile saline, and step 3 is repeated using the 4.1-mm twist drill.
5. The 5.5-mm implant requires the use of the 4.4-, 4.9-, and 5.1-mm twist drill. The osteotomy must be flushed with sterile saline between progressive drilling episodes.
6. Finger pressure is used to place the implants in the bone.
7. The implant is driven into the osteotomy at a speed not to exceed 50 rpm and then hand-tightened with a torque wrench to its final position level with the alveolar crest (Fig. 11-3, *F*).
8. The procedure is completed by suturing the flaps.

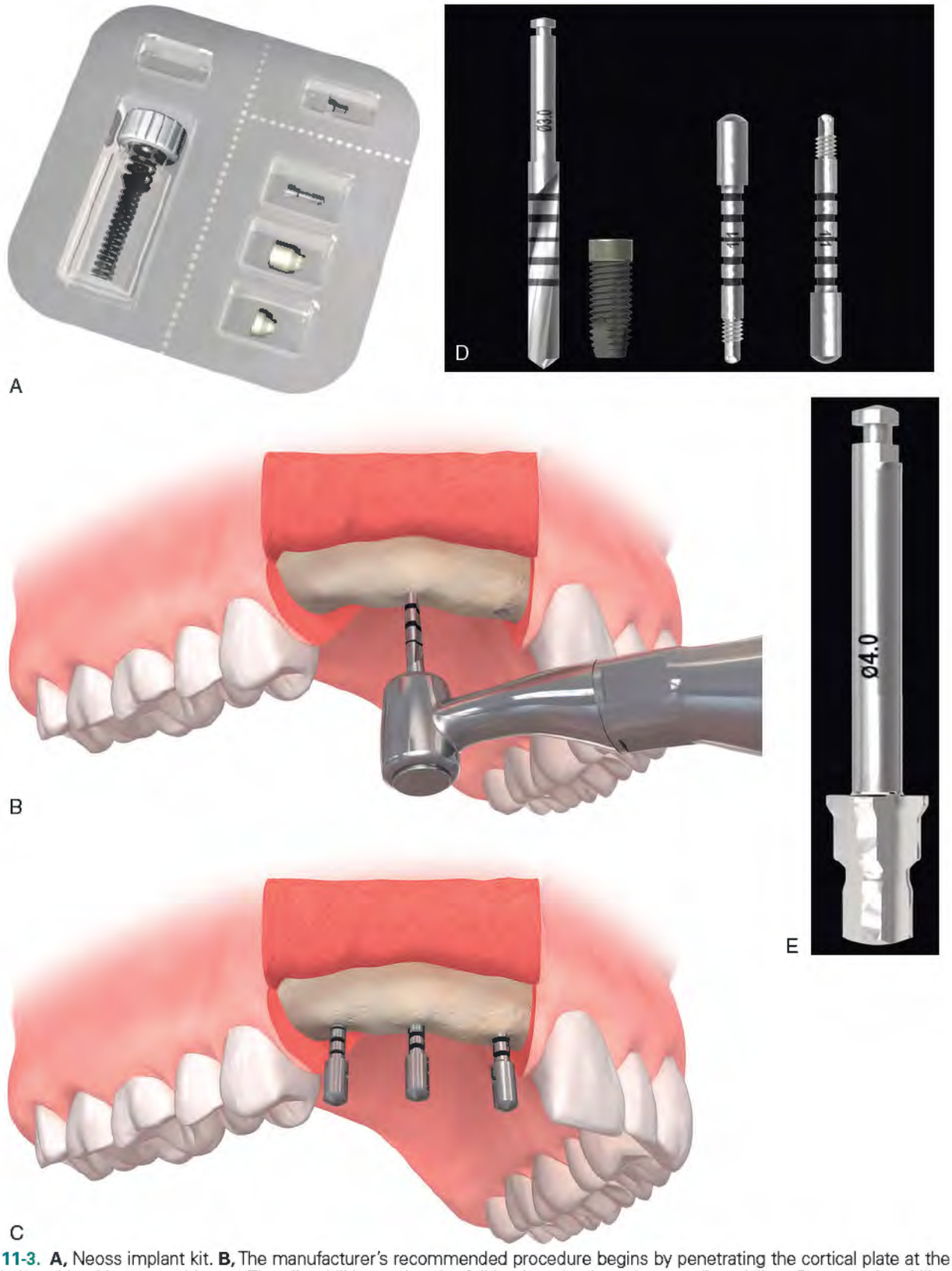


FIGURE 11-3. **A,** Neoss implant kit. **B,** The manufacturer's recommended procedure begins by penetrating the cortical plate at the proposed site with a No. 6 round bur. **C,** The pilot drill is used to the full implant depth. **D,** Intermediate drill. **E,** Bone-tapping drill.

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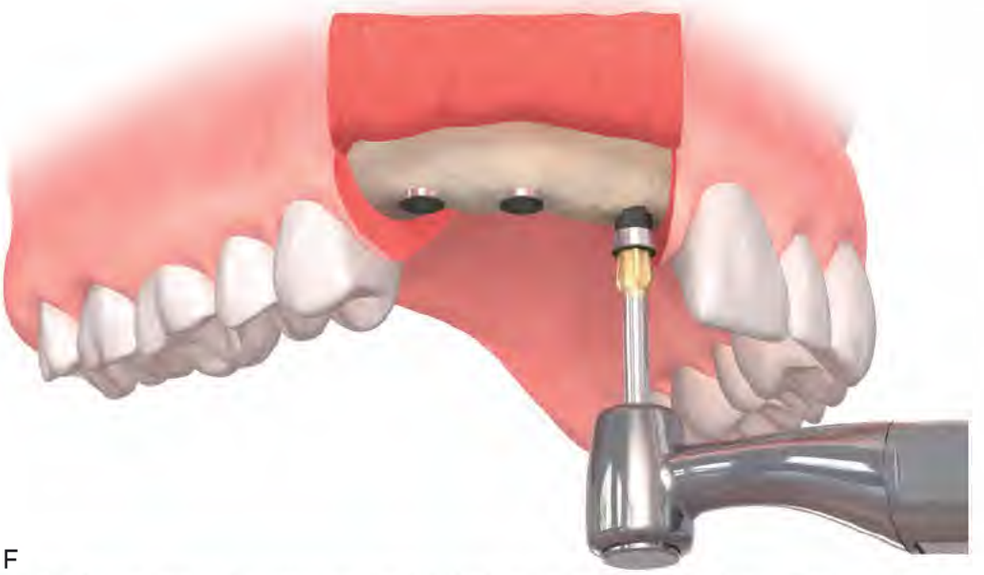


F

FIGURE 11-3, cont'd. F, The Neoss implant is seated so that it is flush with the crest of the bone. (Courtesy Neoss, Woodland Hills, Calif.)

SYBRON IMPLANT SOLUTIONS (FORMERLY INNOVA CORPORATION): ENDOPORE IMPLANT

One-Stage Internal Connection and Two-Stage External Connection

The Endopore implant with a one-stage internal connection comes in diameters of 4.1 and 5 mm and has a transgingival height of 1.8 or 2.8 mm. The platform diameter is 4.8 mm, therefore the prosthetic components fit both the 4.1- and 5-mm implants. The Endopore implant with the two-stage external connection comes in diameters of 3.5, 4.1, and 5 mm. Both the one-stage and the two-stage implants are available in a range of lengths: 5 mm [(5-mm implant only)], 7, 9, and 12 mm.

The first-stage surgical procedure for the Endopore dental implant system is completed in four basic steps.

1. An incision is made to expose the crestal bone, and the ridge is reduced, if necessary, with a tapered, irrigated, carbide bur (2000 to 3000 rpm). The crest is dimpled at the pilot drill site with a No. 6 round bur (1800 to 2000 rpm). The pilot drill (1000 rpm) is used to create a bone passage for the implant bur. Drilling is recommended in short bursts and only to the depth that corresponds to the chosen implant. Bone chips are removed with frequent irrigation (Fig. 11-4, *A*).
2. An implant bur that corresponds to the width and length of the chosen implant is used to deepen and widen the osteotomy. The bur is operated at 700 rpm, and constant irrigation is provided to minimize heat (Fig. 11-4, *B*).
3. The appropriate-sized trial-fit gauge is inserted into the site. All aspects of the gauge must be inspected to confirm that its shoulder is 1 to 2 mm below the bone surface. This ensures that the implant will be placed deeply enough in crestal bone to help prevent micromovement during the healing phase. If the shoulder margin is visible, the implant bur should be reintroduced to deepen the host site. Final rechecking with the trial-fit gauge precedes implant placement (Fig. 11-4, *C*).
4. The implant is transferred aseptically to the prepared bone site. The implant delivery tool then is disengaged with a gentle rocking motion. The plastic tip of the seating punch should be set on the implant cap. Several sharp taps of the mallet on the punch firmly and completely seat the implant into the site. The gingiva is closed with interrupted 4-0 Vicryl mattress sutures, moving from distal to anterior (Fig. 11-4, *D* and *E*).

DENTSPLY

Frialit Plus Implant

The Frialit Plus implant is a stepped screw, TPS-coated implant designed to increase primary stability in poor-quality bone (Fig. 11-5, *A*). The implant is placed in a tapered, stepped osteotomy, first with finger pressure; for final seating, it is ratcheted into a deeper, threaded environment. Which is used to tap the implant fully into place in its incrementally shaped, infrabony site. The implants are available in diameters of 3.4, 3.8, 4.5, 5.5, and 6.5 mm.

The procedure for implantation of the Frialit Plus follows these steps.

1. A 3-mm round drill is used to prepare a primary purchase point at the planned osteotomy site.
2. The 2-mm generic spade drill already has been used to create the final depth of the osteotomy, followed by a conical bone condenser (Fig. 11-5, *B* and *C*).
3. The receptor site is enlarged to its final diameter with the 3.4-mm stepped drill. (When the 3.8-, 4.5-, 5.5-, or 6.5-mm implants are used, successive use of the 3.8-, 4.5-, 5.5-, and 6.5-mm stepped drills is required) (Fig. 11-5, *D*).
4. The implant is insert into the osteotomy site, and the placement head is removed. The stepped screw implant driver is inserted into the internal hex of the implant, and the ratchet is placed on the other end of the driver. Three full turns are sufficient to seat the implant in its final position.
5. The ratchet and stepped screw implant driver are removed, and the cover screw is threaded into position with a screwdriver.
6. The flaps are sutured into place.

The uncovering of these implants is performed in the standard fashion.

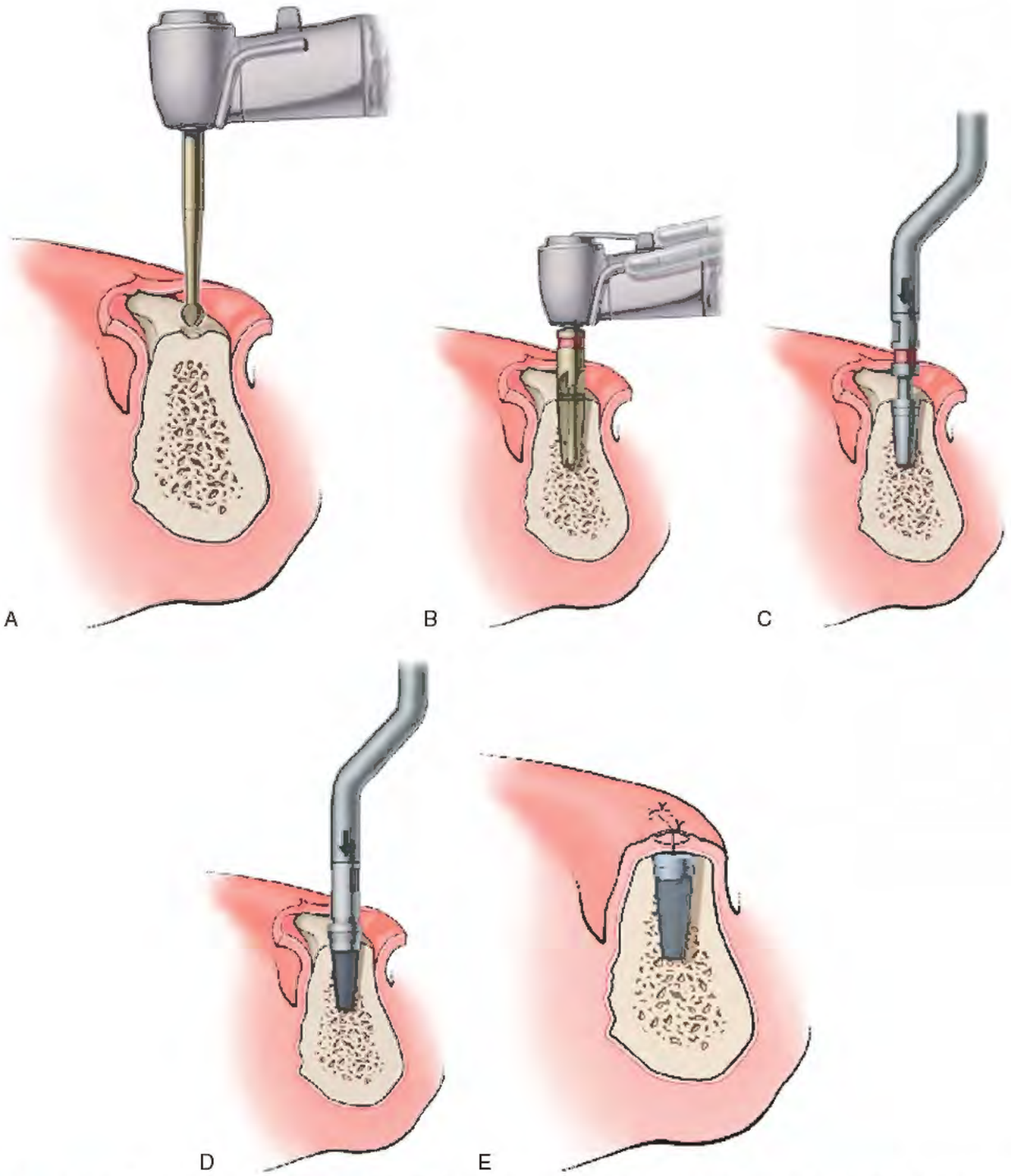


FIGURE 11-4. **A** to **E,** The surface macrostructure of the Endopore implant is made of sintered titanium beads. This design greatly increases the surface area and encourages greater intraosseous retention. The seating technique uses the classic bone enlargement drill, a steel try-in, and placement of the implant in the press-fit mode. (Courtesy Sybron Implant Solutions, Orange, Calif.)

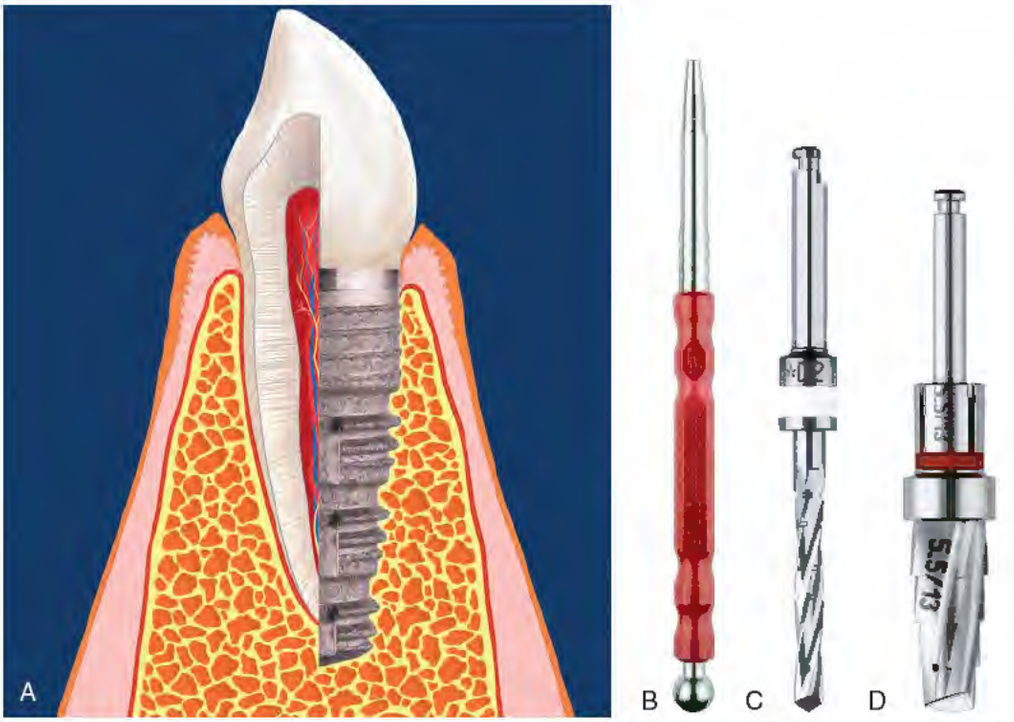


FIGURE 11-5. **A** to **D,** The titanium Frialit Plus implant was preceded by the polycrystalline Al_2O_3 Tübingen Frialit 1 implant. Excellent results were obtained at Tübingen University with this early press-fit design. The grit-blasted, thermal-etched construction of the Frialit Plus allowed production of a threaded, stepped screw version. (Courtesy Dentsply, Encino, Calif.)

XiVE Series Implants

The XiVE S, XiVE Plus, and XiVE TG implants are screw, TPS-coated implants designed to increase primary stability in poor-quality bone. They are placed in a straight-walled osteotomy, first with finger pressure; then, for final seating, they are ratcheted into a deeper, threaded environment. Which is used to tap the implant fully into place in its incrementally shaped, infrabony site. The implants are available in diameters of 3, 3.4, 3.8, 4.5, and 5.5 mm and lengths of 8.0, 9.5, 11.0, 13.0, 15.0, and 18.0 mm.

1. A 2.0-mm round bur is used to prepare a primary purchase point at the planned osteotomy site or a 2.0 mm twist drill is used to prepare the site to the depth of the planned implant.
2. The 3-mm twist drill already has been used to create the final depth of the osteotomy.
3. The 3.4-mm twist drill is used to enlarge the receptor site to its final diameter. (When the 3.4-, 3.8-, 4.5-, or 5.5-mm implants are used, successive use of the 3.8-, 4.5-, 5.5-, and 6.5-mm twist drills is required.
4. The matching-diameter crestal twist drill is used to prepare the crest of the osteotomy to allow for full insertion of the implant; otherwise, the implant will bind at the crest before it can be fully seated.
5. For dense bone, the matching-diameter bone tap is used to create the thread pattern for ease of placement and to prevent excessive torque during insertion, which could deform the prosthetic platform.
6. The implant is inserted into the osteotomy site, and the placement head is removed. The stepped screw implant driver is inserted into the internal hex of the implant, and the ratchet is placed on the other end of the driver. Three full turns are sufficient to seat the implant in its final position.
7. The ratchet and stepped screw implant driver are removed, and the healing screw is threaded into position with a screwdriver.
8. The flaps are sutured into place.

The uncovering of these implants is performed in the standard fashion.

Ankylos Implant

The Ankylos implant (Fig. 11-6) is a tapered-wall, screw implant made of uncoated grade 2 pure titanium; it has one prosthetic diameter. The Ankylos implant is designed to increase primary stability in poor-quality bone. The basic feature is the rotation-locked. In addition, the manufacturer maintains that its TissueCare connection is practically bacteria proof. The implant is inserted into a tapered osteotomy; first, rotary preparation is performed, and then for final seating, the implant is ratcheted into a deeper, threaded environment. The implant is available in diameters of 3.5, 4.5, 4.5, 5.5, and 7 mm and in lengths of 8, 9.5, 11, 14, and 17 mm.

The procedure of implantation of the Ankylos implant follows these steps.

1. A 2-mm round drill is used to prepare a primary purchase point at the planned osteotomy site.
2. The 3-mm Tri-Spade drill already has been used to create the final depth of the osteotomy.
3. The receptor site is enlarged to its final diameter with the 3.4-mm Tri-Spade drill. (When the 3.4-, 3.8-, 4.5-, and 5.5-mm implants are used, successive use of the 3.8-, 4.5-, 5.5-, and 6.5-mm twist drills is required.)
4. A matching-diameter conical reamer is used manually (using the reversible ratchet) to the full depth to further prepare the osteotomy.

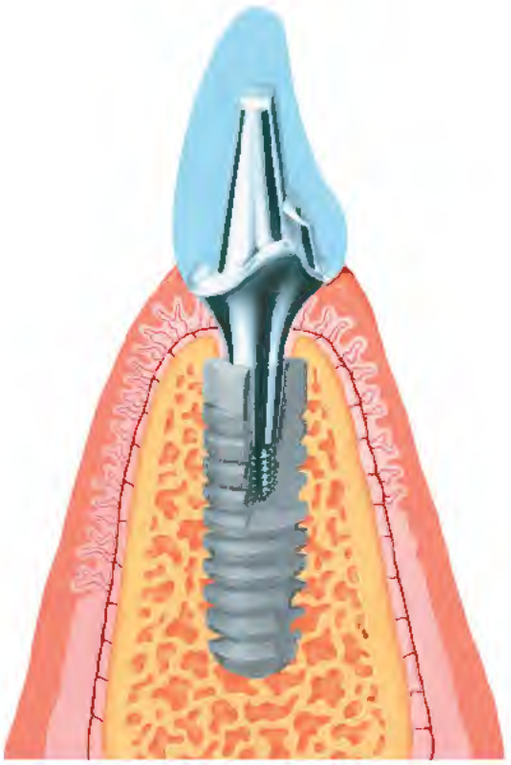


FIGURE 11-6. The Ankylos implant has one prosthetic diameter and a TissueCare connection. (Courtesy Dentsply, Encino, Calif.)

5. For dense bone, the matching-diameter thread cutter is used to create the thread pattern for ease of placement and to prevent excessive torque during insertion.
6. The implant is inserted into the osteotomy site, and the placement head is removed. The stepped screw implant driver is inserted into the internal hex of the implant, and the ratchet is placed on the other end of the driver. Three full turns are sufficient to seat the implant in its final position.
7. The ratchet and stepped screw implant driver are removed, and the healing screw is threaded into position with a screwdriver.
8. The flaps are sutured into place.

The uncovering of these implants is performed in the standard fashion.

SARGON

The Sargon implant has an apical expansion design that allows immediate placement of a functional restoration. The implant is activated at the time of surgery so that it expands, much like a molly bolt, into the surgical site. The implants are 4.3 and 5.1 mm in diameter, with collar diameters of 5 and 6.2 mm and a collar height of 2 mm in addition to the length of the implant (10, 13, and 16 mm) (Fig. 11-7, *A*).

The universal one-step drill is used first to create the generic width and the angulation of the host site. The process then follows these steps.

1. The osteotomy is prepared for the implant by rotating the counterbore drill 2 mm, the height of the implant collar.
2. The tap is started, and the direction of the threads is set with the pilot tap.
3. The surgical site is threaded to the desired depth with the final tap. To prevent binding while the site is threaded, the tap should be reversed a few turns periodically, before the final threading to the appropriate line is completed. Sargon implants are not designed to be self-tapping.
4. The implant is screwed manually into the surgical site with the implant assembly driver until the implant bottoms out in the site; the assembly driver is then removed with a quick turn.
5. The screwdriver is inserted into the head of the implant's slotted screw and turned clockwise to draw the expansion mechanism up into the implant. As the mechanism rises, the body of the implant expands into the walls of the surgical site. When the screw no longer turns, the implant has been completely expanded and seated (Fig. 11-7, *B*).
6. The implant is tapped lightly with a metal instrument; the sound should be that of a fully integrated implant. If the sound does not indicate full integration or if the implant is mobile, retightening of the internal screw further expands the implant. As an alternative, the Periotest can be applied; readings of –2 or lower should be seen.
7. A healing collar of appropriate length or an immediate fixed abutment can be placed.
8. The flaps are then sutured into place around the abutment neck in the same fashion as for a blade or ITI implant.

ASTRA TECH DENTAL IMPLANT

The Astra Tech implant is a self-tapping, parallel-sided implant with a conical seal design (Morse taper; see Chapter 2) that allows for simple, self-guiding seating of the abutment. The implant is available in diameters of 3.5, 4, 4.5, and 5 mm (Fig. 11-8, *A*). The implant sites are prepared in a step-by-step procedure using Tiger drills of different diameters with indicators that give a direct reading of the correct depth (Fig. 11-8, *B* and *C*).

The procedure ensures efficient, gentle widening of the host site. The Tiger drills should be replaced when they become less efficient, normally after preparation of 50 to 60 implant sites, or when the surgeon judges it necessary (Fig. 11-8, *D* to *G*).

All preparation of the bone tissue is carried out with profuse irrigation with room-temperature saline and using an intermittent drilling technique. This prevents overheating of the bone and creates a pumping effect for efficient removal of ground tissue debris. After the osteotomy is complete, the implants are placed according to the following protocol.

1. The glass ampule holding the implant is snapped open, and the implant is dropped into a saline-filled titanium bowl.
2. Titanium forceps are used to pick up the implant by the smooth, cylindric part, and the adapter is screwed into the implant. The lock nut is gripped with the forceps, and the adapter is turned clockwise.
3. The implant is installed by fastening it manually with a few turns. The self-tapping implant is turned further with the contra-angle, and the ratchet is used to finalize the placement.
4. The adapter is released by turning the lock nut clockwise and unscrewing it completely. The cover screw is placed with the hexagonal screwdriver (Fig. 11-8, *H*).
5. The flaps are then sutured in the usual fashion.

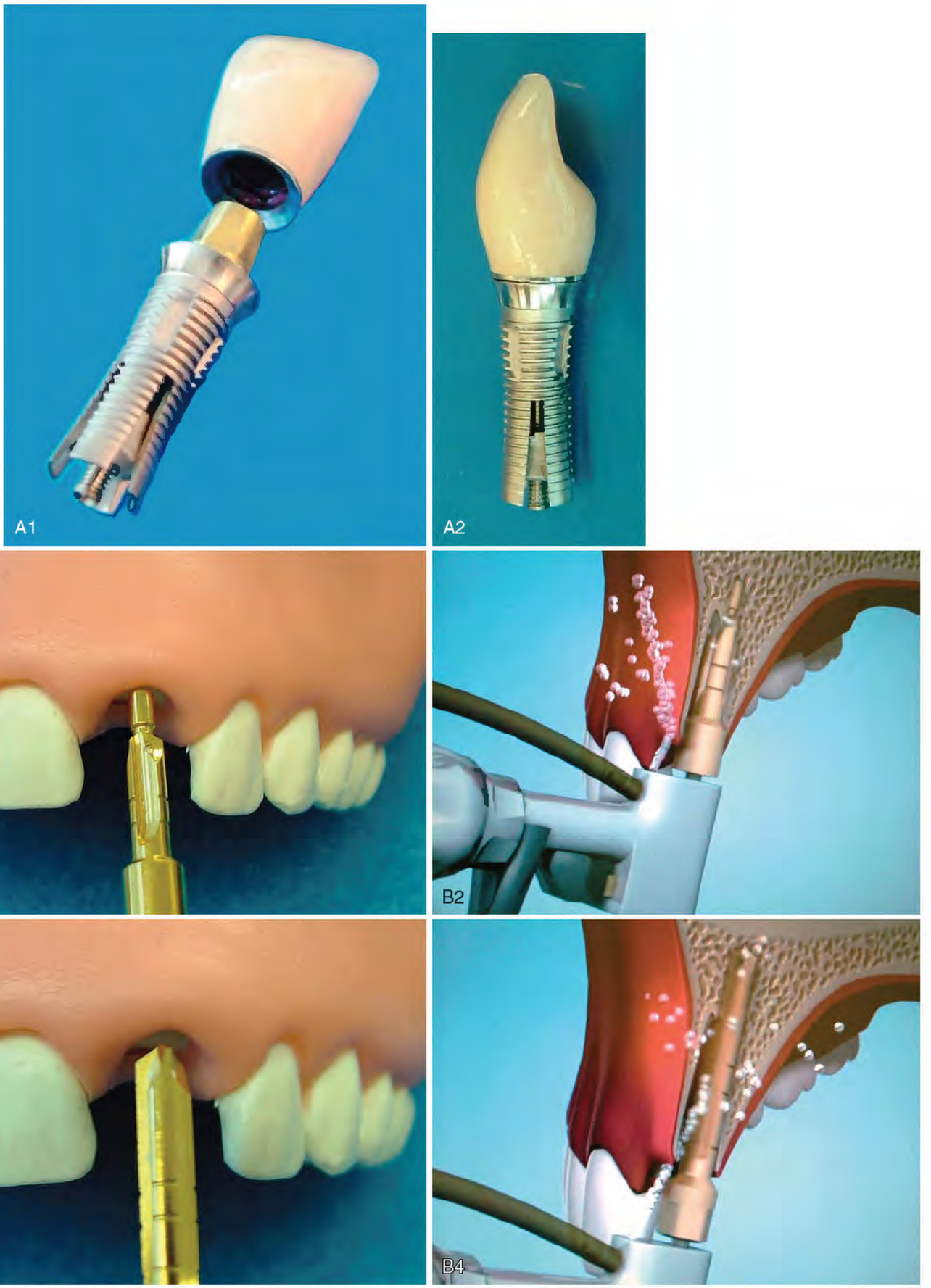


FIGURE 11-7. **A,** The Sargon expandable implant, which is designed for extraction sites. **B,** The implant is seated using the technique shown here. This design provides immediate high levels of stability after activation of the expansion mechanism. After pilot drilling, the osteotomy is enlarged and tapped. The implant is fully seated in deep virgin bone, and the wrench is used to open the expansion mechanism. (Courtesy Sargon Enterprises, Beverly Hills, Calif.)

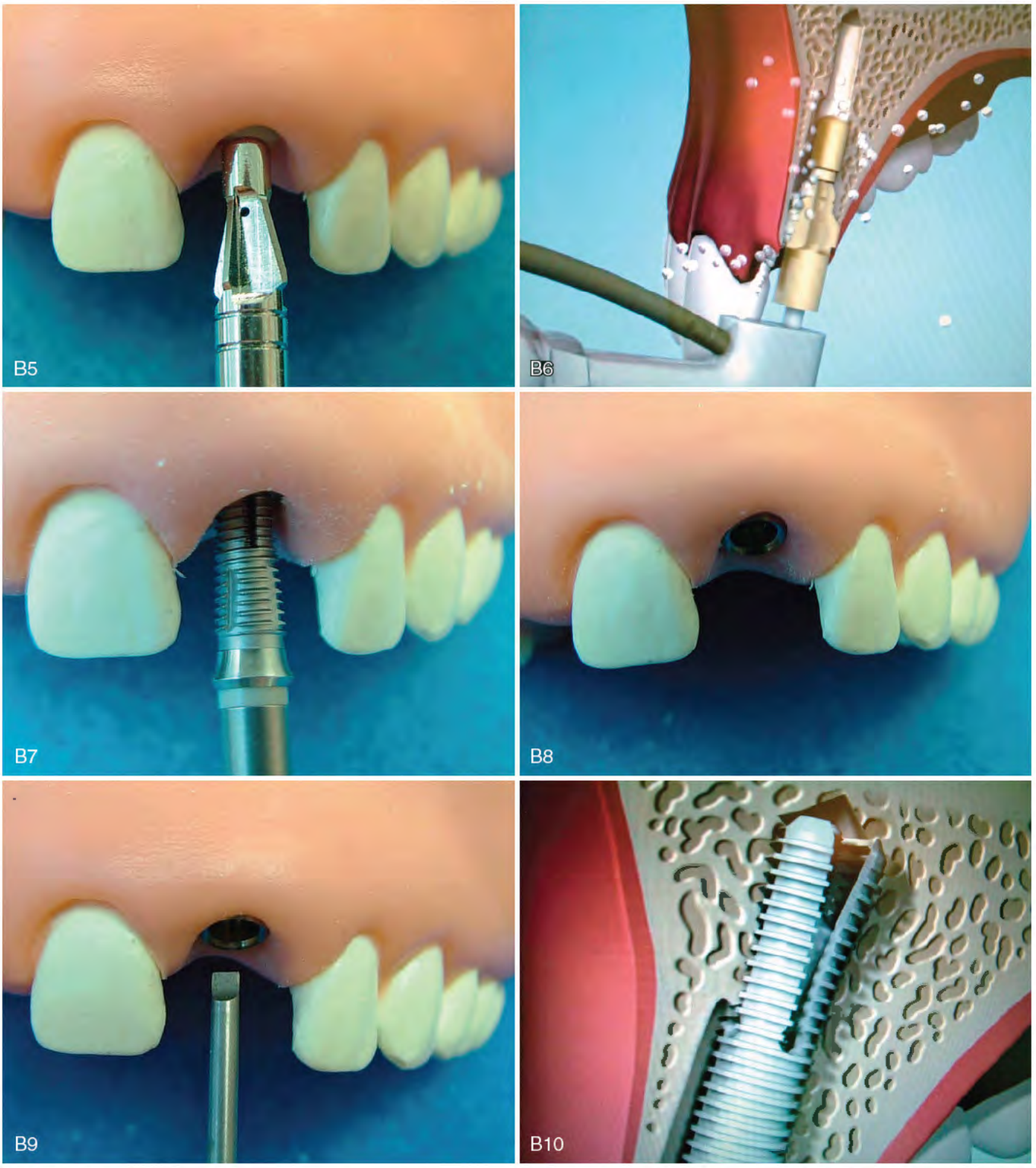


FIGURE 11-7, cont'd.

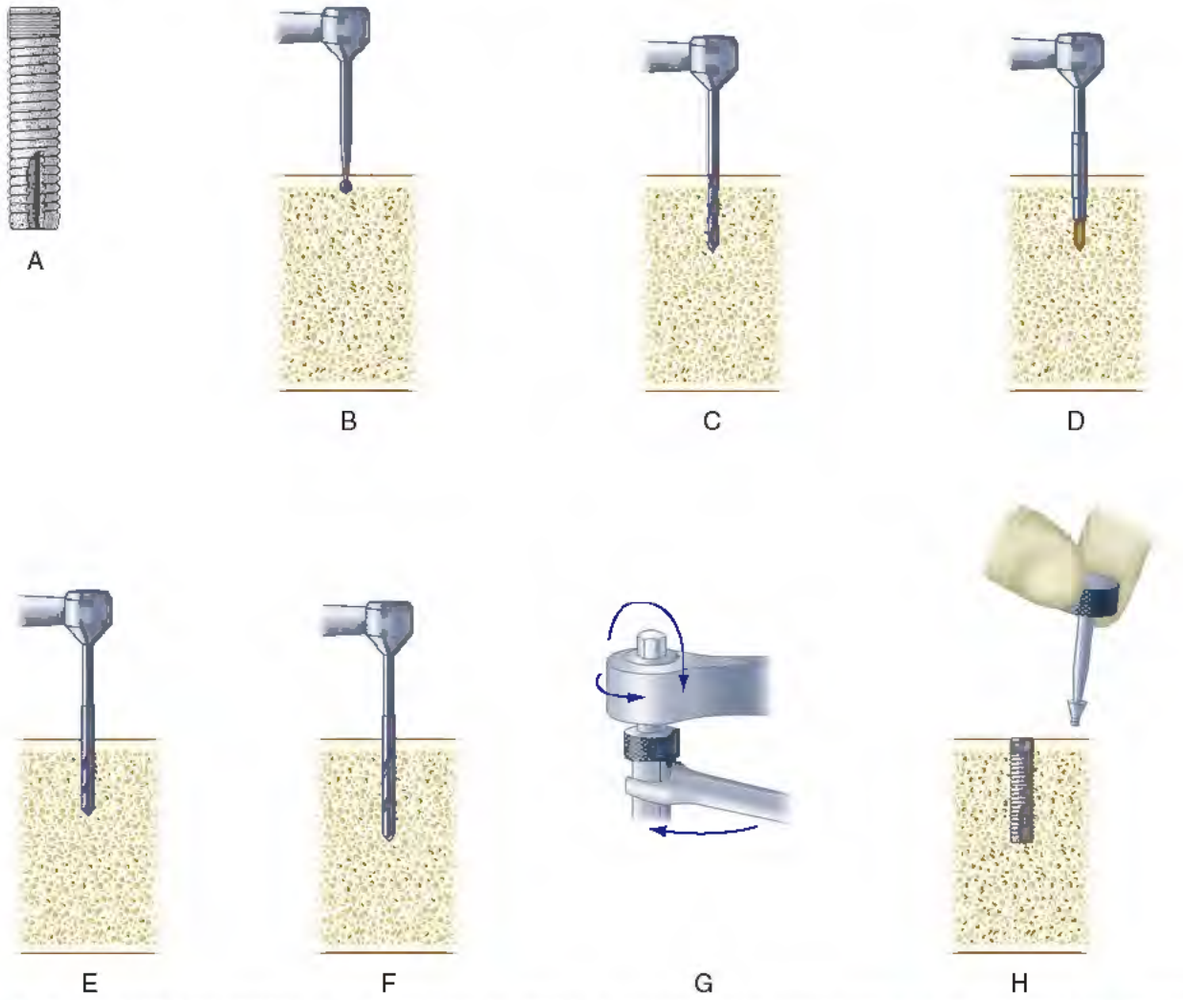


FIGURE 11-8. **A,** The Astra Tech implant. **B,** The guide drill is used to penetrate the marginal cortical bone layer and the underlying spongy bone. During the initial preparation, the guide drill should be tilted to allow more precise and efficient cutting. **C,** Initially, the implant site is prepared with the 2-mm twist drill (white). Careful positioning of the drill ensures the correct depth and angulation of the holes. The objective is to level or slightly submerge the fixture in relation to adjacent marginal bone. Direction indicators (paralleling pins) may be placed in the sites to facilitate the angulation of subsequent drilling. **D,** The pilot drill is used as an intermediate step in spongy bone. For the 3.5-mm implant, the pilot drill is guided to make a 2.5-mm osteotomy, and followed by the creation of a 3.2-mm osteotomy. **E,** As a standard procedure, all implant sites are drilled to full depth with the 3.2-mm Tiger drill (green). **F,** For the 4-mm implant, the 3.2-mm hole is widened with the 3.7-mm twist drill (black). **G,** Cortical drills are used when the marginal bone layer is thick and dense. The cortical drills create a hole of the same diameter as the smooth neck of the fixtures (3.55 and 4 mm, respectively). **H,** For the 3.5-mm implant, the 3.35-mm twist drill (purple) is used. For the 4-mm implant, the 3.85-mm twist drill (brown) is used if the medullary bone is dense (i.e., at the symphysis of the mandible). The final step before suturing is placement of the healing screw.

12 CHAPTER

Blade and Plate-Form Implant Surgery

ARMAMENTARIUM

Amalgam carrier: nylon-tipped plunger type
Blades: Bard Parker (BP) No. 12, No. 15
Bone substitute materials
Burs: No. 1, 700XL and 700XXL
Channel cutting wheels: low-speed
Curettes: surgical
Diamond: pear-shaped (SFX-30/L)
Forceps: Gerald or Adson (toothed) pickup
Handpieces: high-speed friction grip (FG), Impactair, low-speed (laboratory type)
Hemostat: titanium or plastic tipped, small, curved (mosquito)
Implant sham or try-in (when available)
Mallet: nylon head
Metal cutter: broad blade, heavy duty
Periodontal probe
Periosteal elevators
Pliers: titanium tipped, cone socket (for bending when needed)
Polishing wheels: aluminum oxide impregnated (⅝ inch) and mandrel for mounting
Retractors: Henahan, beaver tail, Seldin, blunt Mathieu
Syringe: irrigating
Sterile saline
Suction: Frazier No. 12 tips (plastic)
Seating instruments: straight and bayonet (for abutment and shoulder seating)
Suture with FS2 needles or C12, 4-0 dyed Vicryl, Polysorb, or Biosyn
Scissors: tissue and suture
Sterilizer: glass bead
Sterile glass beaker filled with sterile saline
Scalpels, handles

CAVEATS

The surgeon must have completed each of the steps described in Chapter 4.

The thickness and depth of the prospective host site must be established. If the ridge is less than 3 mm wide, it should be flattened to the required width, and the remaining height then should be measured to determine whether room still exists for blade placement.

The surgeon must know the presence, locations, and depth of fossae, depressions, and undercuts (see Chapter 4) and must make all osteotomies midway between the buccal and lingual cortices.

The surgeon must be aware of the floors of the antra and nose, as well as the mandibular and mental neurovascular bundles, which are critical structures. However, the bundles can be rerouted, and the antral floor can be elevated (see Chapter 8). Novel S-shaped or visor-type incisions should not be used, because the tissues between the crest of the ridge and the incision may be lost (see Chapter 7).

Unless the mucoperiosteal reflection is restricted, the surgeon should not attempt to "spring" thin cortical plates, particularly in the mandible, after completing the osteotomy, because fracture or devascularization of these bony walls may result. Before an implant is seated, the depth, patency, and integrity (i.e., absence of perforations) of each osteotomy are tested with a periodontal probe.

Talc should be washed from rubber gloves, and the implant should be handled as little as possible. Between manipulations and try-ins, it should be stored in a glass beaker of sterile saline. The bead sterilizer can be used to sterilize it again if it has become contaminated through handling. Saline should be used to wash residual glass beads from the interstices.

The surgeon should select implant systems that come supplied with try-ins. Blades with the anchor-shoulder-cervix configuration are preferable (Fig. 12-1).

If the infrastructure requires revision, it should be cut, trimmed, and polished impeccably. If the infrastructure or cervix needs to be bent or curved for a better fit or for better alignment, this should be done slowly and carefully and never at sharp angles. For maximum control during bending, the surgeon's elbows should be braced against the body and the wrists kept stiff. Overbending must be avoided, because further reshaping may cause fractures. With finger pressure only, the implant is fitted gently into the osteotomy after each alteration, and it is stored in saline or a bead sterilizer between steps. An aluminum oxide–impregnated wheel is used to polish all cut ends, which are then rinsed carefully with saline.

Continuous horizontal mattress sutures are used for closure (see Chapter 6).

SURGICAL TECHNIQUES

Conventional Blade Implants: Single Stage

Incision and Reflection

When possible, anesthesia for the posterior mandible (see Chapter 4) should be administered only by infiltration. This allows the lower lip to remain unanesthetized, which grants the surgeon the built-in protection of having the patient possibly respond as the neurovascular bundle is approached (Fig. 12-2).

The incision is made by placing a BP No. 15 blade against bone and, using the fine linea alba at the ridge crest as a guide, drawing the scalpel firmly forward. Care must be taken not to deviate from this critical narrow avascular zone. Novel crestal incisions of any design (e.g., S-type or visor type) that deviate from the crest should not be used, because areas of gingivae included within them may become necrotic. When the incision must be extended distally beyond the fixed gingiva in the posterior mandible and into the retromolar pad, the surgeon must keep in mind the location of the pterygomandibular space and its contents. To avoid injuring these tissues, the surgeon should palpate the anterior border of the ramus and direct the incision over this structure, which often is found about 5 mm laterally.

The incision should be sharp and clean so that it need not be retraced. Retracing the incision creates strips of periosteum that interfere with the gingival and superficial osseous vascular supply (Fig. 12-3).

The incision needs no buccal or lingual relief posteriorly; however, at the anterior end, it should be extended buccally and lingually around the most distal tooth in position. These two extensions offer sufficient relief to allow adequate exposure of the host bone. Reflection of the flaps is initiated anteriorly at the mesial papilla of the most distal tooth and completed by moving the elevator posteriorly (Fig. 12-4). This exposes the ridge to the base of the vestibules buccally and lingually.

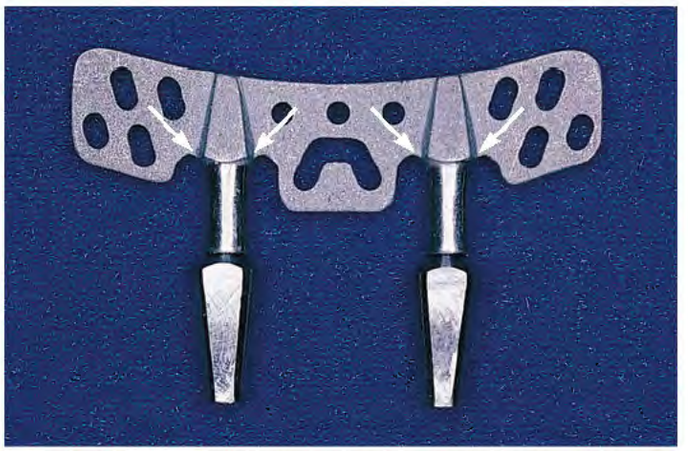


FIGURE 12-1. A two-abutment blade implant with an anchor configuration shoulder *(arrows)*. This design discourages complications caused by saucerization.

FIGURE 12-2. A conventional, single-stage mandibular blade implant. Bone, connective tissue, or both anchor the infrastructure in place by growing through the interstices. The shoulder is placed at least 2 mm below the ridge crest. Such titanium implants may be adjusted by bending for abutment parallelism.

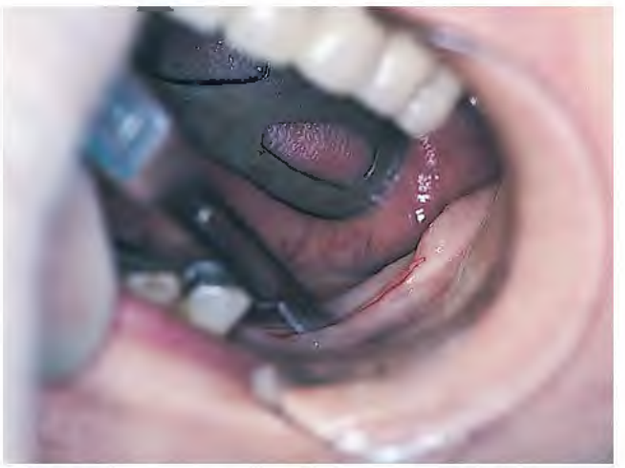


FIGURE 12-3. Incisions for blades are made in the linea alba at the crest of the ridge.

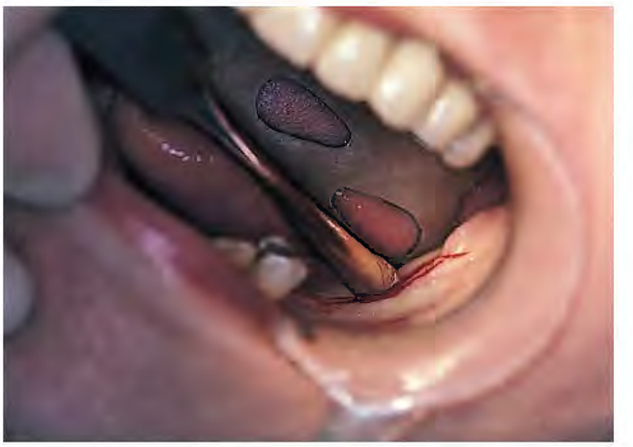


FIGURE 12-4. Flaps should be reflected with a sharp periosteal elevator to expose enough bony structure to permit entry of the bur for the osteotomy.

The periosteal elevator should be sharp so that it incises the periosteal fibers rather than tearing them. If these fibers are resistant to the elevator, the full-thickness flap may be lifted with a mouse-tooth (Adson) forceps, and the periosteal fibers can be cut with a No. 12 blade (see Chapter 8).

The ideal location for the osteotomy is at the crest of the ridge. If the ridge is knife edged, it must be flattened (Fig. 12-5). This can be done by placing retractors (beaver tails, blunt rakes, or periosteal elevators) and using a pear-shaped diamond (SFX-30/L) in the high-speed handpiece or Impactair. A minimum width of 3 mm must be achieved.

The operative then site should be inspected, using the following steps.

1. The mental neurovascular bundle is located. It should not be exposed or dissected unless its integrity is threatened by the procedure.
2. The external oblique and mylohyoid ridges, as well as the configuration of the cortical plates inferior to them, are evaluated. Extreme undercuts or exaggerated concavities, such as the submandibular and canine fossae, require redirection or relocation of the osteotomy.
3. The width of the ridge is recorded, not only at the crest but also at all points apically that correspond with the planned

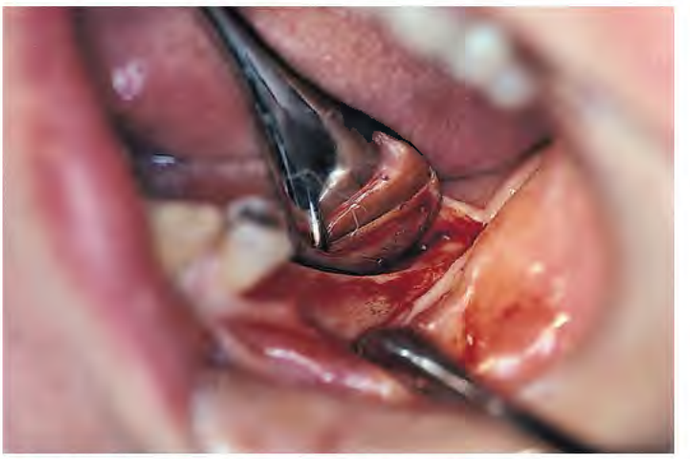


FIGURE 12-5. Retraction must be sufficient to allow evaluation of the ridge morphology; however, excessive exposure should be avoided. This knife-edged ridge requires flattening with a diamond bur or rongeur forceps.

depth of the implant. If the ridge is less than 4 mm wide at the deepest part of the planned implant site, the operative plan must be carried out with great care. Perforations of the bone must be detected and treated with grafting materials (see chapters 7 and 8).

4. The nature and quality of the cortex must be established. Its color, consistency, and morphology should be noted, because these elements offer evidence of good local health (i.e., ivory color, free porosities, and properly shaped with minimal irregularities or defects).
5. The condition of the newly reflected mucoperiosteal flaps is assessed. Tears, loss of tissue, and ischemic appearance are recorded. If the flaps are considered irreparable, the surgery should be cancelled or delayed. Chapter 7 explains how to make primary closures when the supply of tissue is absent or the flaps fall short of approximating each other.

Osteotomy

The surgeon is well advised to use a preoperatively prepared surgical template (see Chapter 4 for fabrication details). Once the ridge height, morphology, and width are considered acceptable, the osteotomy site is selected. A No. 1 round bur is placed in the high-speed handpiece, and after the anteroposterior length has been established by measuring the chosen implant, bur holes are made at the anterior and posterior ends of the planned groove.

A saline-cooled, No. 1 round bur is used to make a series of bur holes just through the cortex between the anterior and posterior witness marks, along the crest of the ridge (Fig. 12-6). When this is finished, the alignment and location of the holes are assessed. If they are straight and properly located, they can be connected with a 700XXL fissure bur (Fig. 12-7). Light brushing motions and copious amounts of coolant are important. The shank of the bur is scored at the point that signifies the proper osteotomy depth. Using a firm but light grasp, the surgeon deepens the host site to the score line on the bur. The osteotomy must be deep enough to allow the shoulder to be buried beneath the bone margins to a depth of 2 mm. Any deep irregularities are flattened by brushing the bur gently through the bone groove. The osteotomy is tested with the periodontal probe to assess its depth and smoothness and to check for any cortical plate perforations (Fig. 12-8).

Instead of a high-speed bur, the surgeon may use an osteotomy wheel. This device is designed for low-speed, water-cooled operation and can serve as an excellent groove starter. However, final shaping

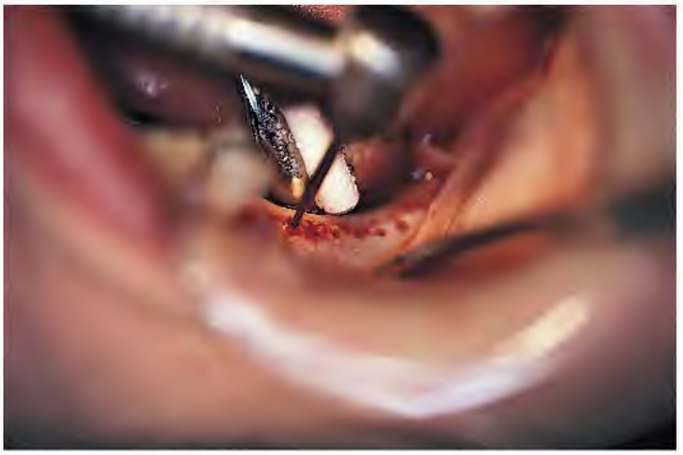
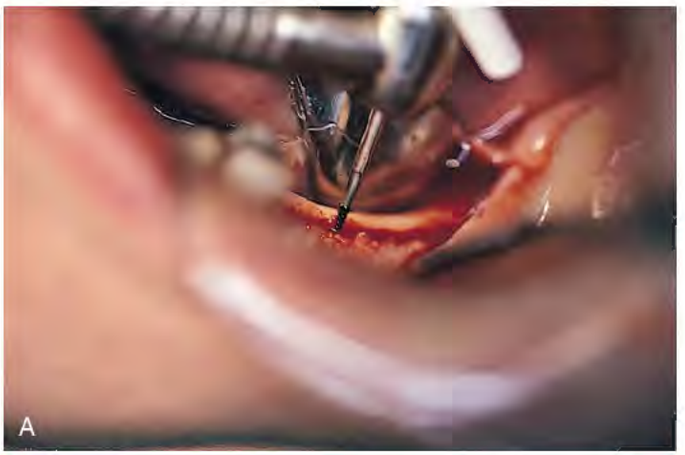


FIGURE 12-6. To start the osteotomies for blade and plate-form implants, the surgeon uses a small, No. 1 round bur in the air turbine to make a series of perforations about 2 mm apart.



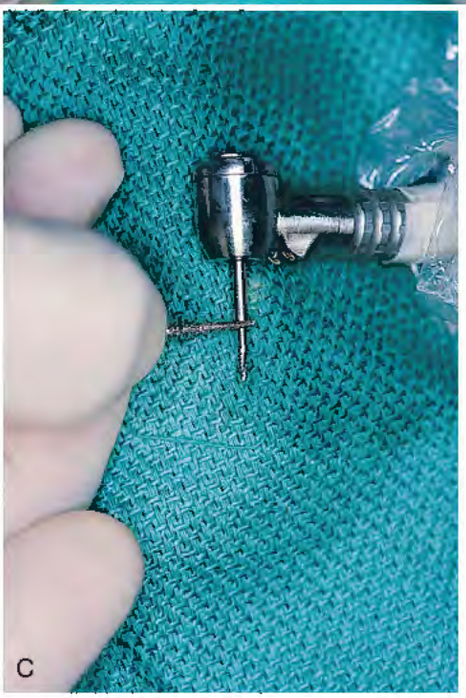


FIGURE 12-7. **A,** If the witness marks create an acceptable alignment, they are connected with a 700XL fissure bur. **B,** The depth of the osteotomy is determined from preoperative radiographs or scans (see Chapter 4) and transferred to the fissure bur shank. **C,** Proper depth of the osteotomy is ensured by scoring the fissure bur shank with a diamond drill. The diamond is held against the rotating bur to make an accurate mark.

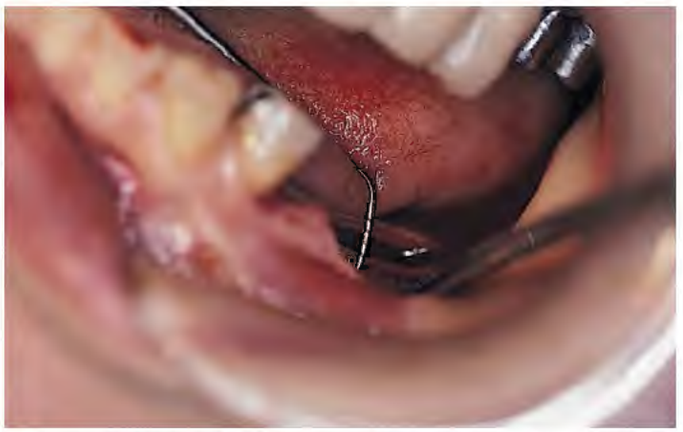


FIGURE 12-8. After the osteotomy has been completed and is satisfactory in length and depth, it is tested for integrity (i.e., no perforations) and smoothness with a periodontal millimeter probe.

and deepening to accommodate the selected blade or plate-form implant must be completed with burs, as described in the previous paragraphs.

Implant Placement

Appendix E offers methods of treating metals if the manufacturer does not supply the implant as ready to insert. When the implant is ready, it is placed in the osteotomy, and strong finger pressure is used to force it down as far as it will go. The surgeon should evaluate for appropriate length of the groove and parallelism of the abutment (Fig. 12-9). If necessary, the implant can be removed and the abutment bent with two titanium-tipped, cone socket pliers (Fig. 12-10). When the abutment is properly aligned, the implant is returned to the osteotomy and positioned over the abutment with light mallet taps on the bayonet or a straight seating instrument while the patient's mandible is supported (Fig. 12-11). The pointed shoulder-seating instrument is used to tap the implant into its final position in the osteotomy (Fig. 12-12).

The implant is placed at the planned optimum depth. The shoulder must be 2 mm below the cortical level (Fig. 12-13). If the shoulder fails to reach this depth and gentle tapping does not resolve the problem, the implant is removed by grasping it with cone socket pliers and placed in a sterile glass beaker filled with saline or in a bead

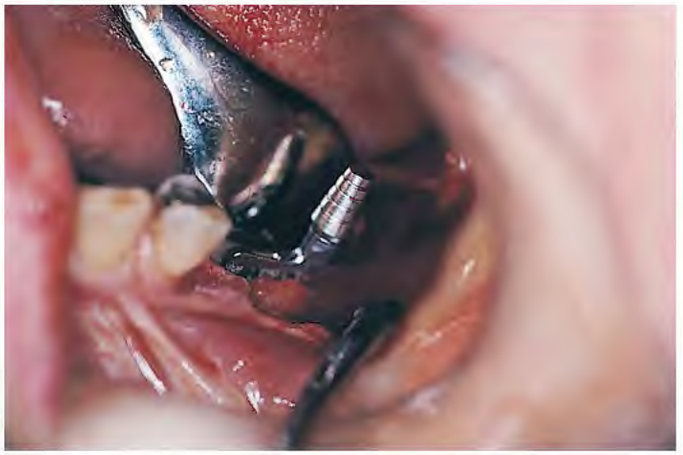


FIGURE 12-9. The implant is placed using finger pressure only. The length and abutment angulation of the osteotomy then are verified.

FIGURE 12-10. If the abutment is malaligned (see Fig. 12-9), it can be bent gently with two titanium-tipped, cone socket pliers. This may be done safely only when single-stage blade implants are used.

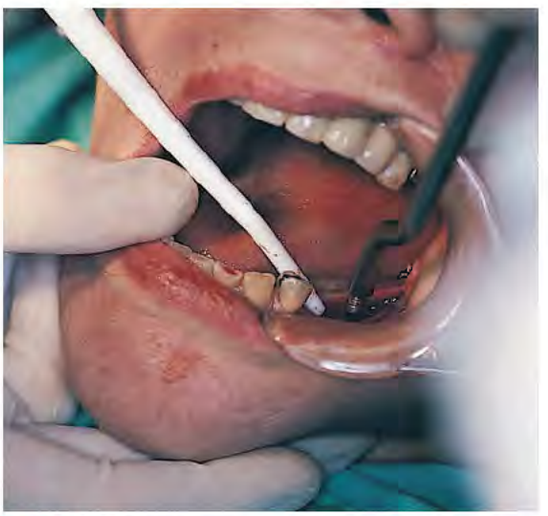


FIGURE 12-11. After alignment of the abutment has been verified, a seating instrument (bayoneted if used for the posterior) is placed over its head. Tapping with a mallet seats the blade shoulder 2 mm beneath the alveolar ridge. The assistant's hand should support the patient's mandible or head.

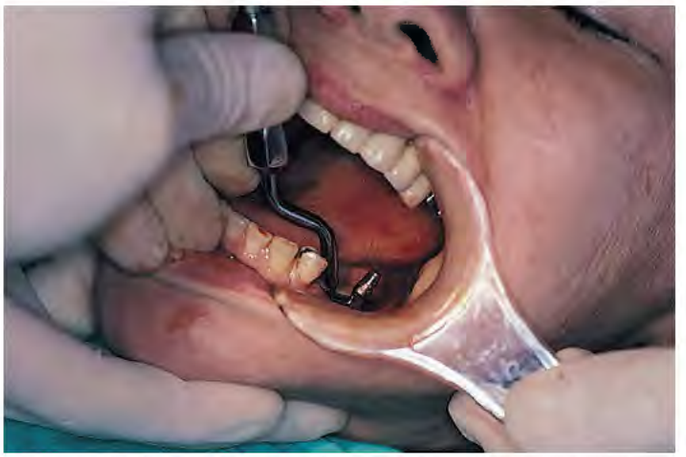


FIGURE 12-12. Further positioning usually is required after the implant has been seated with the abutment bayonet. This is done with the pointed shoulder-seating instrument, which snuggles into appropriately shaped dimples in the upper surface of the shoulder.

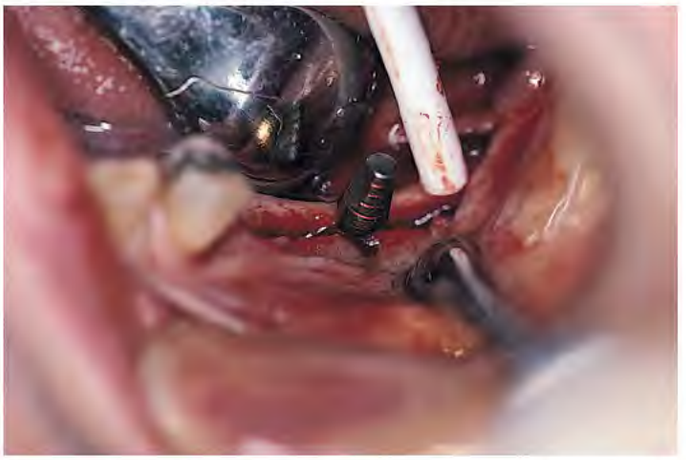


FIGURE 12-13. The final position of a plate-form or blade should reveal its shoulder 2 mm evenly below the ridge crest.

sterilizer. The osteotomy is refined until it is deep enough or cleared of obstacles so that the blade implant can be accommodated.

If a curved osteotomy is necessary, the implant is reshaped so that it, too, becomes curved. The implant infrastructure is placed between the beaks of the two titanium-tipped, cone socket pliers, and the bend is carefully introduced. The curvature must be even and equal from shoulder to base, and the surgeon should frequently check the accuracy of the contour as it relates to the osteotomy. Particular care is needed when the curve is in the anterior maxillary region (see Anterior Blade and Plate-Form Implants later in the chapter). The bone cut not only has been made in a curved course, it also has been canted inwardly (in accordance with the anterior maxillary inclination), introducing a second deviation from the vertical direction. Actually, these osteotomies are segments of truncated cones, and shaping and seating blade implants to fit them are difficult and critical tasks.

Before final placement, a periodontal probe is used along the depth of the osteotomy. If it falls through a defect in a lateral or inferior wall, a perforation is present. In the mandible, these openings occur most often through the lingual cortical plate into the submandibular fossa beneath the mylohyoid ridge or into the mandibular canal itself (Fig. 12-14). In either case, the implant is not placed; instead, a graft is made to repair the defect. Implant insertion is delayed at least 6 months, and then a smaller implant is used.

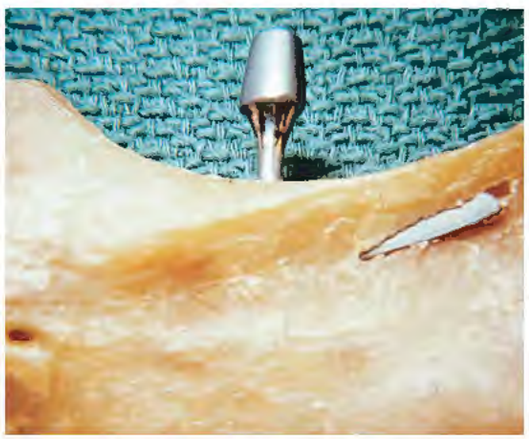


FIGURE 12-14. Care must be taken to respect the mandibular architecture, both before and after osteotomies. A common site of perforation is the submandibular fossa, a major convexity beneath the mylohyoid ridge. This complication is best avoided by canting the osteotomy laterally in this region of the jaw.

When the integrity of the osteotomy has been ensured (after thorough debridement, irrigation with saline, and inspection of the wound), the implant is seated and tapped into its proper position and depth (Fig. 12-15, *A*), and the position is checked with a periapical film.

Closure

A mouse-tooth (Gerald) forceps is used to coapt the flaps. If they appear to be intact and well vascularized and reach across the implant shoulder without tension, they can be sutured closed. A reliable closure can be achieved using 4-0 Polysorb with a C13 needle in the continuous horizontal mattress configuration (Fig. 12-15, *B*). The patient must be able to close into centric occlusion and perform excursions without traumatizing the abutment. Any impediments can be relieved with a cooled, high-speed, pear-shaped diamond. The implant is supported firmly during these maneuvers.

When the occlusion is satisfactory, the patient may be dismissed with an ice pack against the check. The patient should follow the routine postoperative regimen presented in appendixes G and H. Prosthetic reconstruction may be undertaken at the end of week 12 (Fig. 12-16).

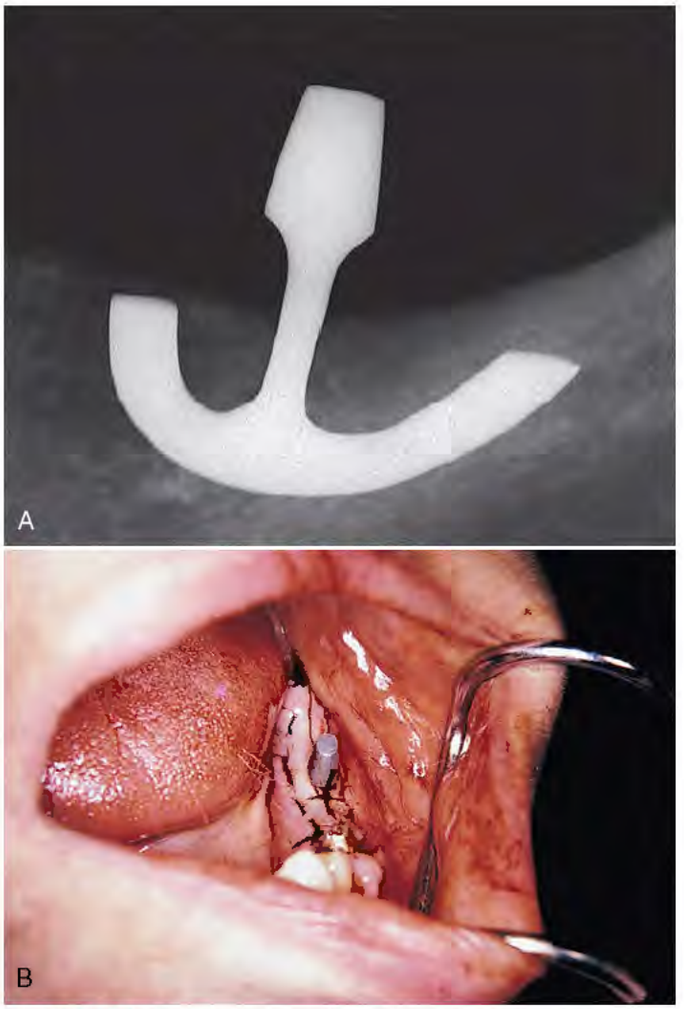


FIGURE 12-15. A, A postoperative radiograph is taken immediately to determine whether the implant is in the proper position. In this case, an additional osteotomy is indicated to allow deeper positioning of the implant. **B,** The most reliable form of closure for ridge crest incisions is the continuous horizontal mattress suture. Coaptation and primary healing are best facilitated when this technique is used.

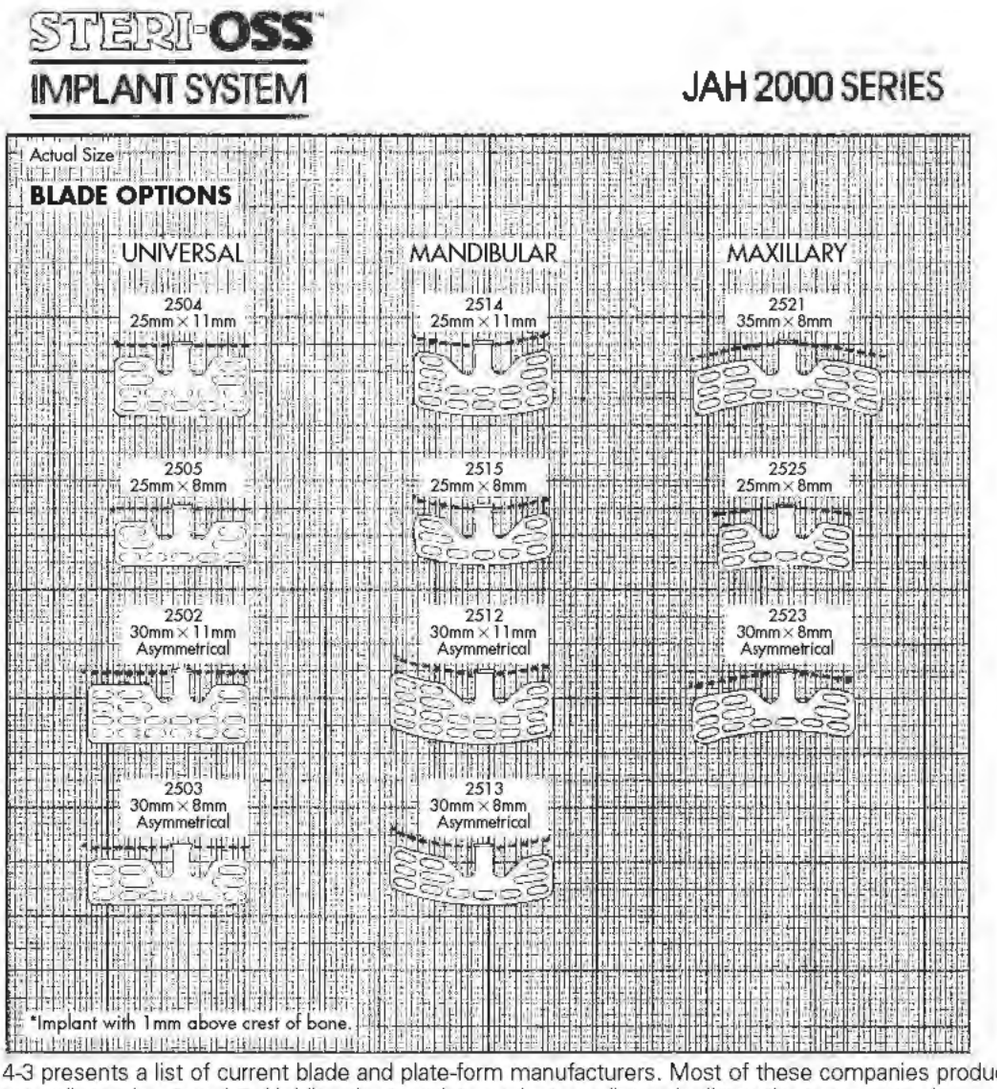
FIGURE 12-16. Reconstruction of blade implants may begin after 12 weeks. The soft tissues should be healed firmly around the cervix, and the implant must be firm and comfortable. Routine prosthodontics (see Chapter 24) may then be completed.

Alterable Blade Implants

(If an alterable blade implant is selected, refer to Table 4-3.) Alterable blade implants may be somewhat more troublesome, but a surgeon who is able to use them does not need to keep a large inventory of fixed or standard designs on hand.

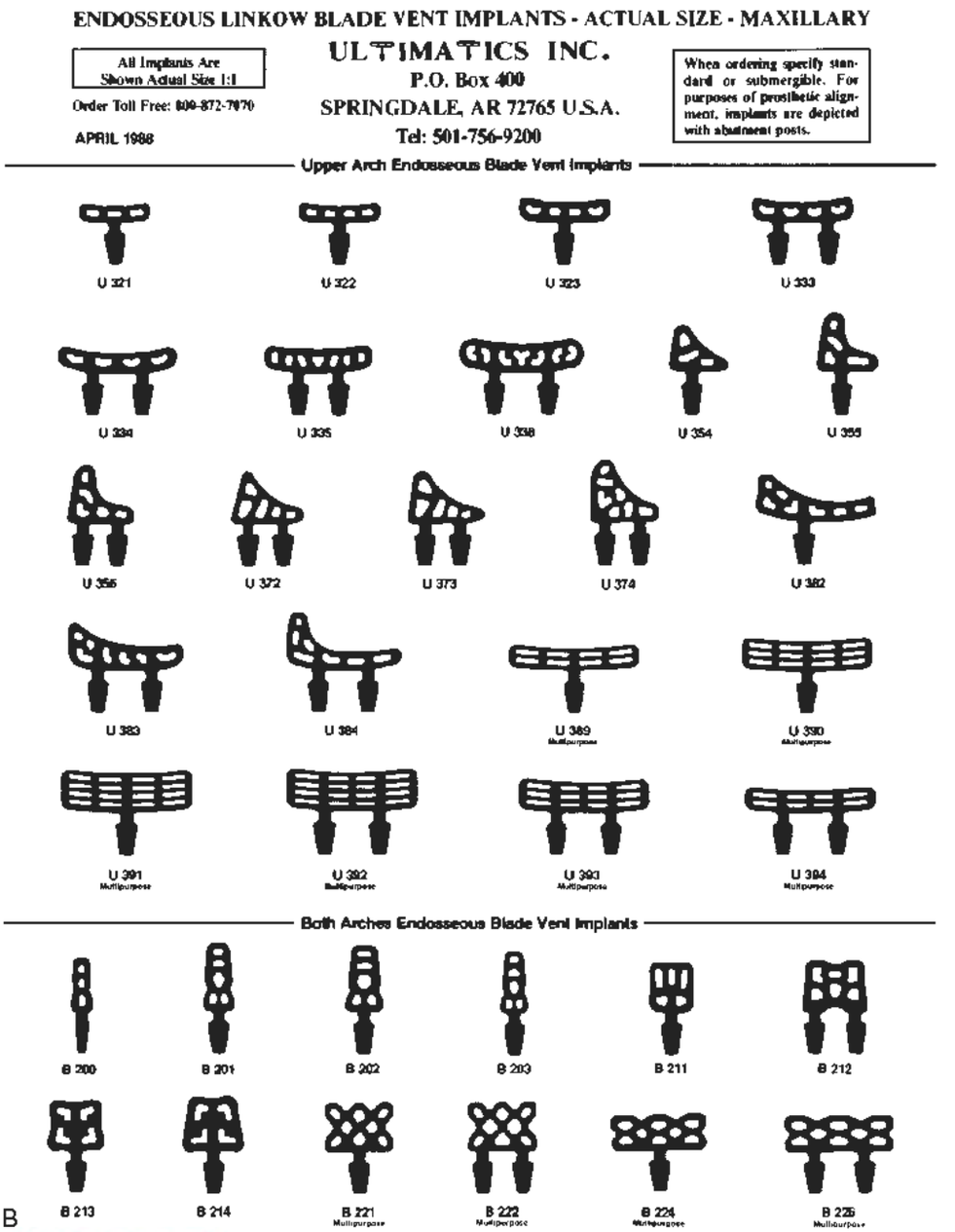
The planning and preparation for alterable blade implants are the same as for standard blade implants. Whether single or double abutments are required, the approximate size of the host site must be determined before surgery. The following section presents the bone preparation technique for the two-stage type of implant; this technique must accommodate the round and enlarged cervix. For one-piece, abutment-bearing blades, the implant closest to the bone size is selected after the osteotomy has been cut to the maximum depth and optimum length. A metal cutter is used to reduce the height and length by snipping, one strut at a time, until the preplanned shape is achieved.

The shape is selected from one of the plastic templates supplied by many of the implant companies (Fig. 12-17) (see Appendix K for a list of manufacturers). The surgeon should proceed slowly, washing debris from the infrastructure at each step and retrying



A

FIGURE 12-17. Table 4-3 presents a list of current blade and plate-form manufacturers. Most of these companies produce templates designed to be held against radiographs. **A** and **B,** Holding the template against a radiograph allows the surgeon to choose the design with the most favorable size and configuration. Templates with 25% enlargements are available for use with panoramic radiographs; however, this is not a reliable technique for final selection.(**A** Courtesy Steri-Oss, Yorba Linda, Calif.; **B** Courtesy Ultimatics, Springdale, Ark.)



B

FIGURE 12-17, cont'd.

the blade frequently in the osteotomy. When the correct shape and configuration are achieved, the altered ends are polished thoroughly with an aluminum oxide wheel, and the implant is seated in the bead sterilizer for 10 seconds, cooled in saline, and placed in its osteotomy. Before final seating, many implantologists prefer to treat blades and plate-form implants as described in Appendix E. Unlike the chrome alloys, titanium is self-passivating (air causes the almost instant formation of a surface oxide layer); therefore this step may be eliminated. Gentle tapping is followed by use of the seating instrument and mallet and then by suturing.

Submergible Blade and Plate-Form Implants

The advantage of a submergible blade is that it can be semiburied to allow a trauma-free period of integration (Fig. 12-18). The disadvantages of a submergible blade are that the cervix is quite large, requiring a large accommodation at the ridge crest, and corrections in abutment angulation and alignment are much more difficult, if not impossible, to achieve. However, some companies do make adjustable angled abutments.

All corrective manipulations on submergible blade implants are made only with the prosthetic abutment screwed or placed firmly in position. If this is not done, the threaded socket is likely to become distorted, destroying the implant.

After the osteotomy is completed, the site that corresponds to the abutment location is marked. A No. 4 round bur, with irrigant, is used to make an ovoid enlargement, half from the buccal, half from the lingual, to accommodate the cervix and allow full seating of the shoulder (Fig. 12-19). The abutment is left attached so that its angulation and prosthetic acceptability can be evaluated before, during, and immediately after implantation. The abutment then is removed and kept for use with that specific implant at the time of second-stage surgery. Threaded or plastic healing caps are available, depending on the type of implant. If the bead sterilizer has been used, the abutment receptacle must be carefully inspected for any entrapped beads.

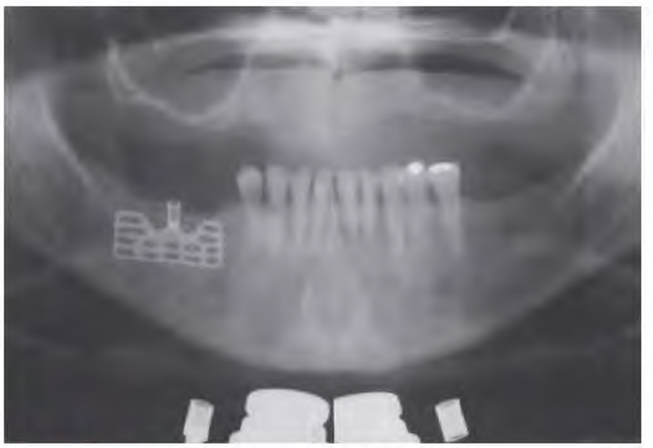


FIGURE 12-18. A submergible blade 8 weeks after placement. The major disadvantage is the blade's large cervical diameter. No zone of lucency is seen about its infrastructure, and integration appears to be progressing.

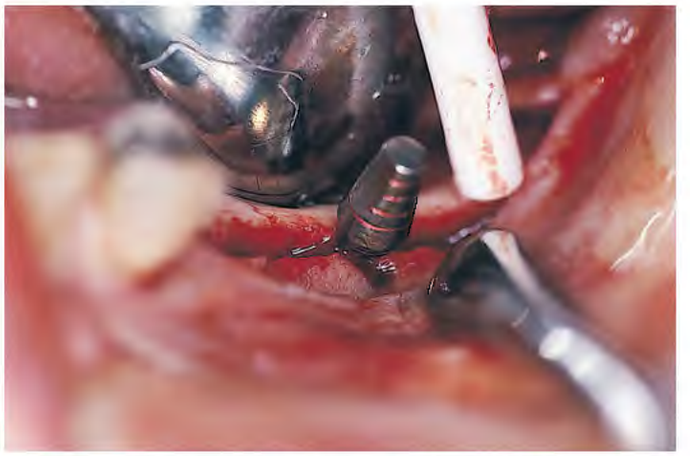


FIGURE 12-19. Some crestal bone must be sacrificed to allow seating of the cervix of a two-stage submergible blade implant. A saline-cooled No. 4 round bur is used to cut the scallops (buccal and lingual).

Vicryl continuous, horizontal mattress sutures (Fig. 12-20) are used for closure. The surgeon should try to suture over the cervix, thereby enclosing the entire implant.

Re-entry to place the transepithelial abutments should take place 3 months later (for mandibular implants) to 4 months later (for maxillary implants). For this surgery, the clear surgical template (if one was used) can be put in place, identifying the buried cervical sites directly beneath the implant locator holes. Particularly with blade implants, which have more pronounced protrusions, a circular cutting trephine is effective, because it makes the cervix so readily identifiable. In fact, the cervix often becomes exposed spontaneously.

The healing cap should be removed, the receptacle irrigated thoroughly, and a healing collar inserted (Fig. 12-21). Two weeks later, the abutment that had been set aside at the time of implantation can be screwed into place (Fig. 12-22). Complete seating should be verified with a bitewing radiograph.

Coated Blade and Plate-Form Implants

Coated blade and plate-form implants require several deviations from the methods presented in the preceding sections.

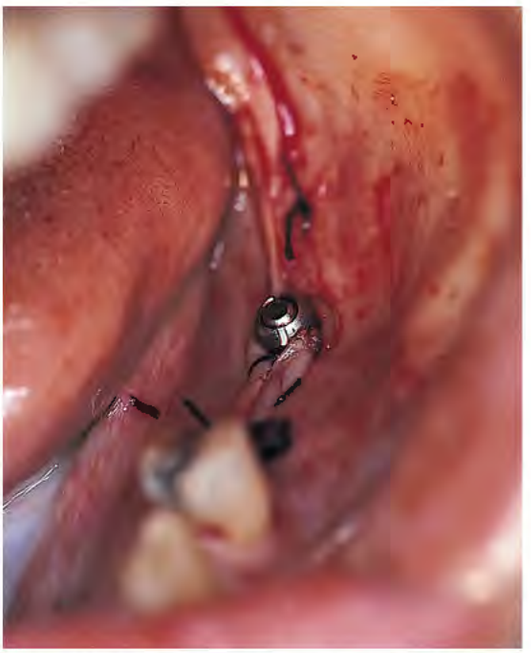


FIGURE 12-20. Some submergible blades are not fully buried. With this design, the cervix must protrude about 2 mm. Healing screws are used to seal the threaded interiors.

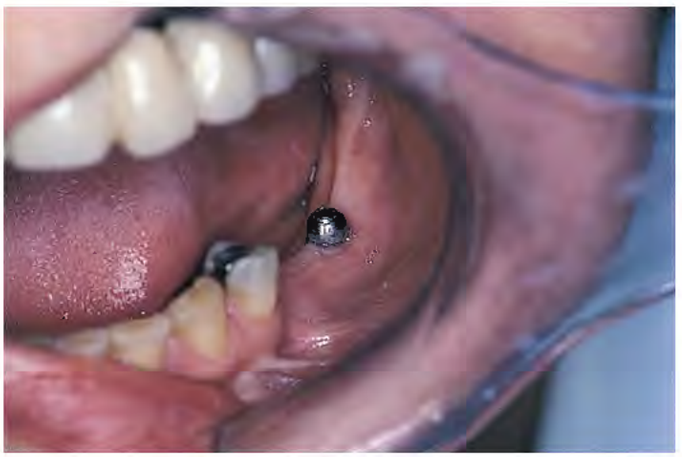


FIGURE 12-21. After healing, a firm, cicatricial, keratinized cervical collar should be evident around the healing cap. It should not be probed.

First, they cannot be bent or altered by cutting. Second, these systems must have a metal try-in or sham available for each implant size and shape. Only when the sham fits passively should the coated implant be seated. Once seated, it may not be removed, because removal may damage the surfaces or cause delamination of the coating. Third, use of coated blade implants requires a large inventory (Fig. 12-23). Despite these disadvantages, one advantage, if the coating is hydroxyapatite (HA), is the potential to create a stable interfacial bond.

Custom-Cast Implants

If the preoperative workup (see Chapter 5) results in the decision to place a blade or anchor as the most acceptable device and neither a manufactured nor an alterable manufactured design is suitable, a custom-cast implant may be made to suit the requirements of the area.

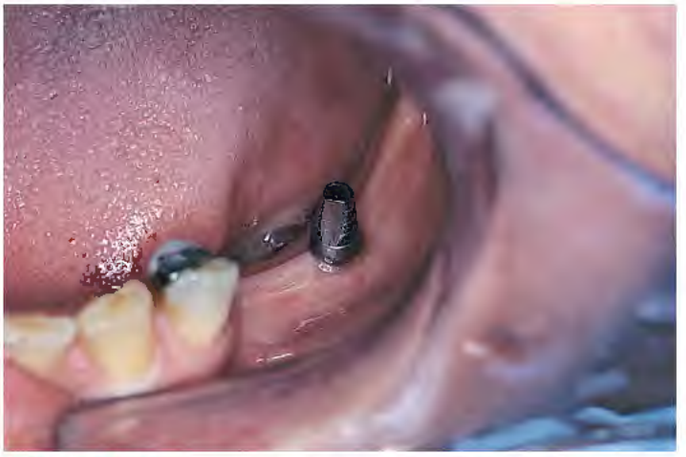


FIGURE 12-22. A variety of abutment shapes and angles can be used after integration is complete (8 to 12 weeks). Abutments often are interchangeable with root form abutments made by the same manufacturer. After placement, the integrity of abutment seating is evaluated on a periapical radiograph.

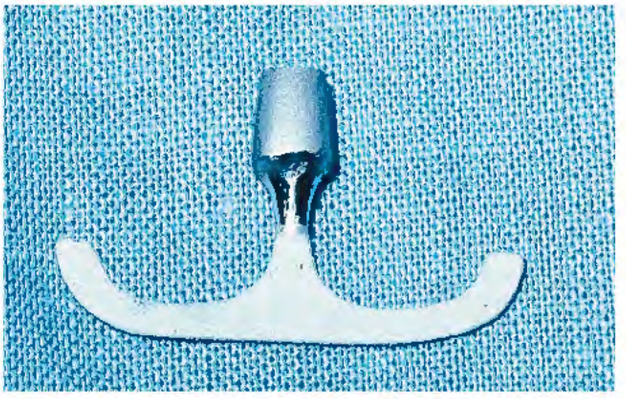


FIGURE 12-23. Hydroxyapatite-coated blade implants, such as this anchor design, encourage a firm, osseointegrated interface. Classic design characteristics, such as a highly polished cervix, must be incorporated.

An oriented, periapical radiograph with accurate dimensions (as verified with the 5-mm steel ball technique described in Chapter 4) is placed on a view box, and the available bony host area is outlined. The infrastructure of a blade or buttressed anchor design is drawn over the available bone, leaving a 2-mm margin at all boundaries. A 4-mm shoulderless cervical zone is created, an abutment and cervix of appropriate size and extension are added, and a titanium or Vitallium casting is made (Fig. 12-24). As an alternative, a blade may be waxed directly on the patient's periapical radiograph (Fig. 12-25) or on a stereolithographic model. This blade may be cast in Vitallium or titanium oxide with an HA coating and annealed so that some infrastructural or cervical bending maneuvers can be done, if necessary, at the time of seating.

The finish should be matte for the abutment and infrastructure, as well as for the lower half of the cervix. The upper half, or permucosal portion of the cervix, must be highly polished.

Before implantation of these custom anchors, the metal should be properly treated and sterilized (see Appendix E).

Maxillary Posterior Blade and Plate-Form Implants

The same principles apply to planning for the maxilla as to planning for the mandible. In some cases, particularly with females or others with less dense maxillae, the osteotomy need not be made to its full depth. The blade itself can be used as an osteotome. When tapped, it seats itself firmly and snugly into an environment that has not been subjected to the trauma of bone drilling. With a few simple taps with the mallet, the surgeon can assess the feasibility of seating the implant without a full-depth bur cut. If the implant does not continue to seat, it should be removed with the cone socket pliers, with care being taken not to stress or snap the cervix. The osteotomy is completed with an irrigated 700XXL bur. The implant then can be seated fully (Fig. 12-26).

Before a posterior maxillary blade is seated, the osteotomy is tested with a millimeter probe. If a defect is found, it probably is the maxillary sinus. The patient should be asked to exhale as the practitioner gently obturates the nares. Air bubbles emanating from the groove confirm the existence of a communication. In such cases, a periosteal elevator is used to tuck a strip of Colla-Cote into the depth of the groove, the osteotomy is filled with tricalcium phosphate (TCP) grafting material, and the wound is closed. In 4 to 6 months, a shallower blade is placed, and an aggressive, watertight closure is made. The antral regimen (see Appendix G) should be prescribed postoperatively.

FIGURE 12-24. Custom-cast blades are popular. This buttressed anchor (designed and produced by Dr. Robert James) was fabricated to fit a specific maxillary host site.

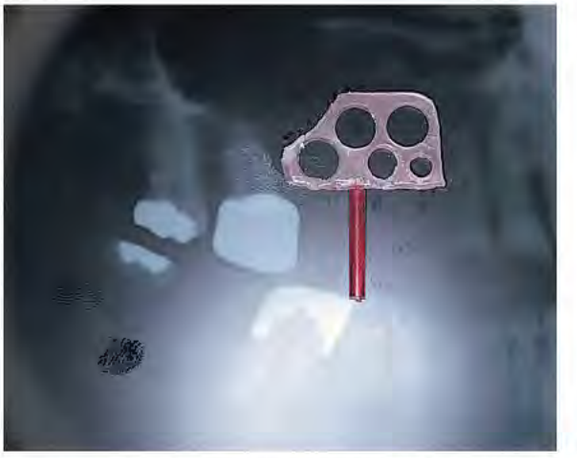


FIGURE 12-25. Plate-form implants can be made by creating a wax base pattern directly against an undistorted apical radiograph.

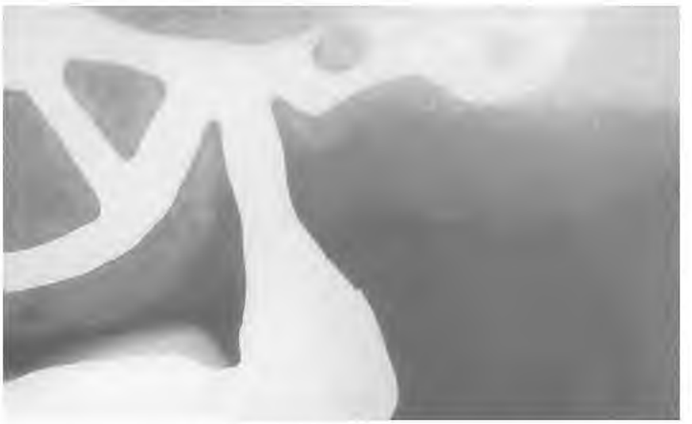


FIGURE 12-26. A buttressed anchor in the maxilla can be restored with a fixed bridge prosthesis. The implant design facilitates the avoidance of vital structures.

Anterior Blade and Plate-Form Implants

The areas anterior to the antrum in the maxilla and the mental foramina in the mandible present less of an anatomic challenge to the placement of implants. Often, however, the ridge is thin, and labial plate fracture is a significant hazard. Fracture is possible because of the curvature of the anterior ridges, which dictates that the osteotomy follow their contour. An additional difficulty, particularly in the maxilla, is its 30- to 45-degree labial inclination, which means that the bur must be canted at the proper angle to keep it midway between the labial and palatal cortical plates. This added geometric complexity puts the bone in jeopardy as the implant is tapped to place.

The implant must be prepared by curving it with the contouring pliers so that it fits into the osteotomy passively. Because the arc at the base of the osteotomy is smaller than that at the crest of the ridge, the implant must be curved in a similar manner. It must be contoured like a truncated cone; otherwise, the labial plate may fracture as the implant is driven to its full depth. As the plate-form is tapped into position, the seating instrument must be angled in the long axis of the infrastructure so that the host bone is subjected to minimal torquing forces. On the positive side, maxillary bone is sufficiently compliant to allow that a thin, modest, gently made osteotomy, and the implant can be seated fully, making its own pathway (Fig. 12-27).

The mandible is denser and requires a sense of feel, judgment, and experience to serve as guides. It is not as procumbent as the maxilla, which presents a less difficult approach. The surgeon's ability to comprehend and behave manually in a three-dimensional geometric field is important.

Suturing and postoperative care should follow the general guidelines outlined in Chapter 6. Even though the use of newly placed single-stage blades is not recommended in the posterior regions, temporary splints must be made in the anterior portions of the mouth. They should be constructed so that they allow hygienic measures and so that they do not put excessive masticatory stress on the implant during the integration period.

Immediate Placement of Blade Implants into Extraction Sites

Immediate placement of endosteal implants in sites of recent extraction is a valuable alternative to the traditional method of waiting for socket mineralization. In some cases, a potential implant site is unsuitable for root form implants. In these cases, when the implantologist prefers blades and plate forms, the implants may be placed immediately after an extraction.

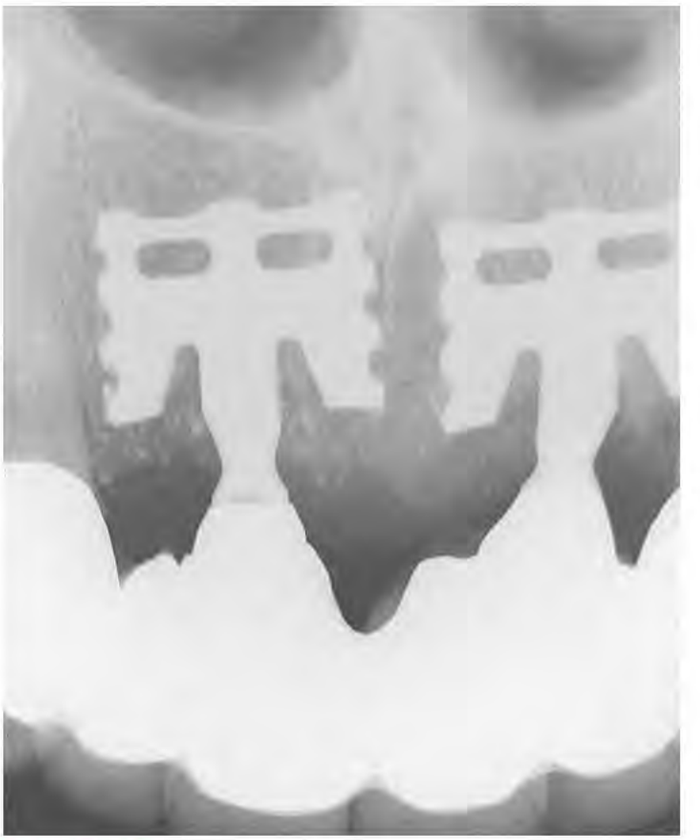


FIGURE 12-27. Manufactured blades can be customized by trimming their infrastructures and polishing the edges with an aluminum oxide–impregnated wheel. These implants may be the two-stage submergible or one-stage type. Particular attention must be paid to contouring them for anterior maxillary placement.

Because blade implants extend mesiodistally, freshly cut osteotomies, both anterior and posterior to the extraction socket, offer greater stability. Blades may be placed in sites that have had several extractions or sites where the vacated alveolus is not in the center of the edentulous zone, but some portion of the blade infrastructure must extend into healthy, intact ridge areas, preferably both mesial and distal to the extraction sockets.

For insertion of a blade implant into an area requiring an extraction, a BP No. 15 blade is used at the crest of the ridge at a distance from the planned extraction adequate to accommodate the blade. The incision is carried from the distal end anteriorly to the tooth, around it buccally and lingually, and on the crest forward to a point that allows the blade to be placed (Fig. 12-28, *A*). Vertical releasing incisions are necessary to allow adequate exposure of the bone. A sharp periodontal elevator is used to reflect the gingivae.

The tooth is extracted in the most atraumatic fashion, and efforts are made to preserve the integrity of the alveolar walls and the interseptal bone (if a molar). The socket or sockets are curetted thoroughly.

The adequacy of the flaps for primary closure over the extraction site is checked before the osteotomy is started. If necessary, the buccal flap is undermined (see Chapter 6). The position of the osteotomy must be planned, and some modification of the socket area may be necessary. The ridge, mesial and distal to the extraction site, often must be flattened to achieve adequate width and to create a homogeneous level for blade placement.

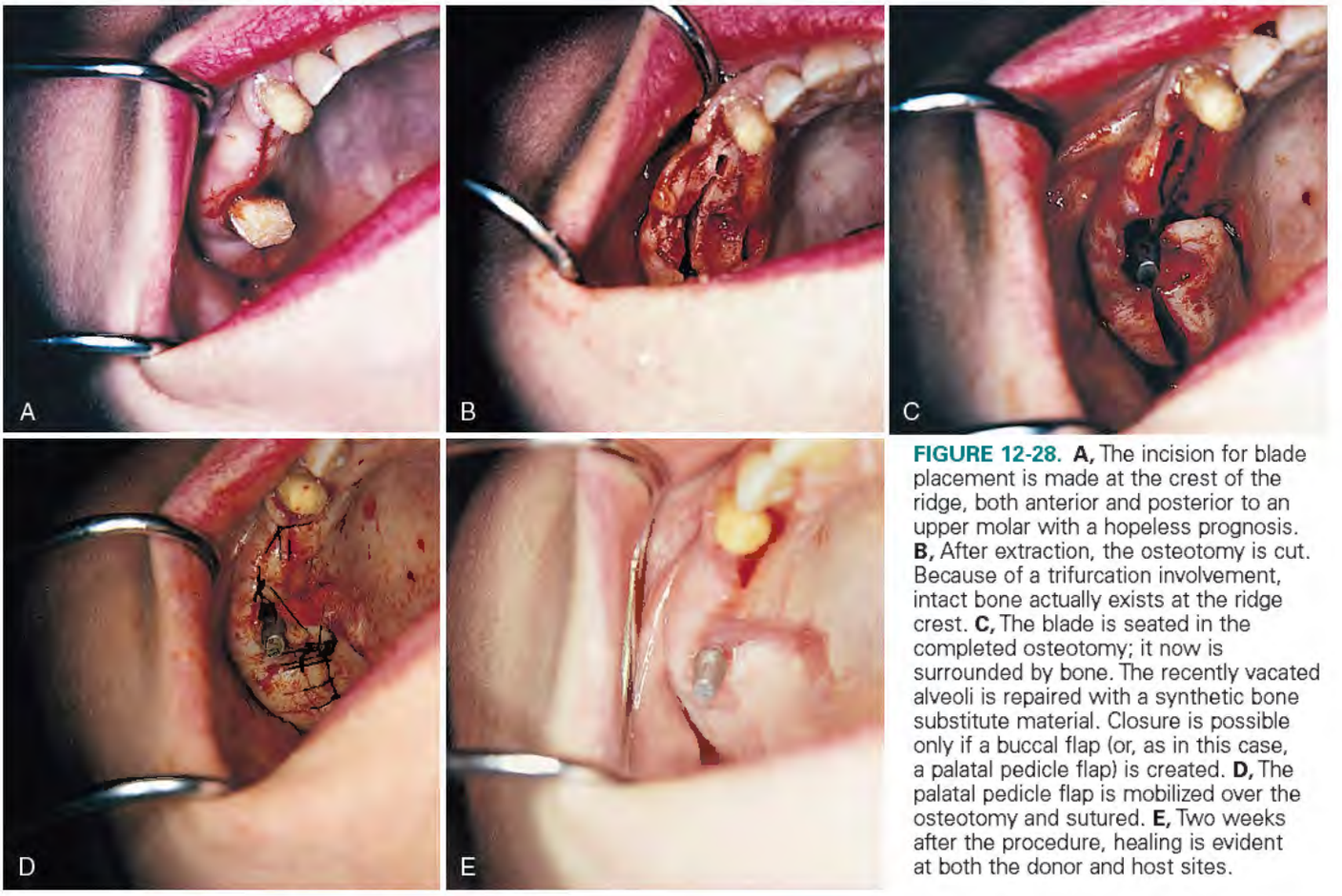


FIGURE 12-28. **A,** The incision for blade placement is made at the crest of the ridge, both anterior and posterior to an upper molar with a hopeless prognosis. **B,** After extraction, the osteotomy is cut. Because of a trifurcation involvement, intact bone actually exists at the ridge crest. **C,** The blade is seated in the completed osteotomy; it now is surrounded by bone. The recently vacated alveoli is repaired with a synthetic bone substitute material. Closure is possible only if a buccal flap (or, as in this case, a palatal pedicle flap) is created. **D,** The palatal pedicle flap is mobilized over the osteotomy and sutured. **E,** Two weeks after the procedure, healing is evident at both the donor and host sites.

A No. 1 round bur in a high-speed handpiece is used to mark the anteroposterior boundaries of the osteotomy, which are determined by the length of the blade selected. A series of holes is made crestally through the cortex, marking the location of the osteotomy. The osteotomy will be disrupted by the presence of the extraction socket, and extra care should be taken to ensure proper alignment of the bony groove (Fig. 12-28, *B*).

A 700XXL fissure bur is used to connect the holes, creating a slot. When the osteotomy is complete, the implant is seated following the steps described earlier in this chapter. After final placement of the implant, the shoulder should be at least 2 mm beneath all borders of the osteotomy (Fig. 12-28, *C*). A graft material, such as demineralized freeze-dried bone (DFDB), is used to fill in voids adjacent to the implant and in the recently vacated socket. After removal of granulomatous tissue and invaginated epithelium from the undersurface of the flaps, a resorbable guided tissue regeneration membrane (GTRM) can be prepared with a poncho design to fit intimately around the implant cervix. It must overlay surrounding healthy bone for at least 2 mm circumferentially, and it must be applied in a smooth, wrinkle-free fashion. Membrane stabilization often is necessary. This can be done with 4-0 dyed Vicryl sutures applied to the deep periosteum at the base of the flaps or with membrane tacks (see Chapter 8). The closure is completed using the horizontal mattress suture method.

The use of submergible blade implants for immediate implantation into extraction sites is strongly recommended. Immediate loading of implants disturbs the regeneration of bone in the socket area and should be avoided whenever possible. (More details on grafting are given in Chapter 8.)

Blade Implants

Single-stage blade implants should not be used with overdentures and should not be incorporated into such appliances unless four or more of them have been used and connected by a bar for a full arch reconstruction.

Two-stage blades, which can achieve osseointegration, may be substituted for root forms if enough ridge length is available for their use, but overdentures are rarely used in such reconstructions. Abutments are available for blades (as described in Chapter 19) of the same dimensions and design as for root forms made by the same manufacturer.

Ramus Frame and Ramus Blade Implant Surgery

13
CHAPTER

ARMAMENTARIUM

Burs: 2L, 557L, 700L, 701L, and 702L
Chisel: long seating or bayonet instrument (titanium tipped)
Handpieces: high speed, Impactair high-speed, contra-angle
Implants: ramus type
Jig: bending
Mallet: surgical
Pliers: Roberts anterior bending
Pliers: Titanium tipped bending
Templates: trial (implant try-ins)

CAVEATS

To keep incisions to the minimum length, preoperative measurements must be taken carefully.

Burs must be kept cool and changed frequently.

A 135-degree angled handpiece (Impactair) facilitates the creation of the ramus osteotomy. The mandibular canal must be avoided.

The anterior foot of the ramus frame must be bent carefully so that it enters the symphysis evenly between the cortical plates and goes directly into the medullary bone; this discourages fracture of the labial cortical plate.

The ramus osteotomies must be cut with care so that perforations are not made laterally, medially, or posteriorly.

Every effort must be made to insert the implant passively, so that it does not create compressive force on the host bone.

RA-2 RAMUS FRAME (PACIFIC IMPLANT COMPANY)

The RA-2 implant may be used to support an overdenture for patients with atrophied mandibles (Fig. 13-1). This implant originally was made of 316L surgical stainless steel, but more recently it has been made of grade 2 surgical titanium. The RA-2 is a one-piece, tripodal design implant and is available in only one size.

With the RA-2, the anterior incision and osteotomy must be made first. The posterior components of this surgery should be performed after satisfactory completion of the anterior portion.

Surgery

The patient is anesthetized with bilateral mandibular and long buccal blocks and local infiltration. A full-thickness incision then is made along the crest of the ridge in the anterior region of the mandible. The incision is started at the area just distal to the mental foramen and proceeds around to the opposite side. It will be approximately 25 mm long (Fig. 13-2).

The flaps are reflected lingually and labially, and an anterior vertical relieving incision is made just lateral to the labial frenulum to facilitate this procedure (Fig. 13-3). The bony site is explored for lingual and labial concavities, as well as for adequate height. The mental nerve should be protected; this is best ensured by exposing the superior halves of the foramina (see Chapter 8).

Rongeur forceps and then bone files and burs are used to level and flatten the alveolar crest.

The anterior try-in template is placed at the crest of the ridge and used as a guide for making the osteotomy (Fig. 13-4). This cut is made with a 557L surgical bur in a high-speed handpiece in the same manner as for conventional blade or plate-form implants. First, sketching perforations are made with a No. 2 round bur. If they are well aligned, the 557L fissure bur is used to convert them into a continuous groove (Fig. 13-5). The osteotomy is deepened to 6 mm if the vertical bone height is 10 mm or less; if 10 to 20 mm of height is available, the osteotomy should be 8 mm deep. The osteotomy is canted labially, and its base is placed in a slightly more anterior position than at the crest. Angling the bur in an anterior direction keeps it parallel to the ideal host site in a midcortical posture.

The anterior template now should be tried in. Its shape may require modification with the Roberts anterior bending pliers. This instrument adapts the template more closely to the shape of the osteotomy. When seating of the template is satisfactory, these same bending modifications are made to the implant.

A full-thickness incision is made, beginning at a point 10 mm above the retromolar pad and just lateral to it, or approximately at the level of the sigmoid notch. The incision is continued downward and forward from the anterior border of the ramus along the external oblique ridge. As the anterior incision is approached, the scalpel is directed medially to the crest of the ridge, so that the two incisions meet. This process is repeated on the contralateral side. The posterior flaps are reflected buccally to expose the external oblique ridges and lingually just to the mylohyoid ridge.

A point 18 mm distal to the end of the anterior osteotomy is measured and marked; this is the site where the posterior osteotomy begins (Fig. 13-6). It should be noted that the posterior try-in template has two marks on it, at 18 mm and at 30 mm.

The posterior template is placed on the crest of the ridge with the 30-mm mark on the ramus at the posterior end of the projected osteotomy and the anterior mark at the 18-mm point. The template

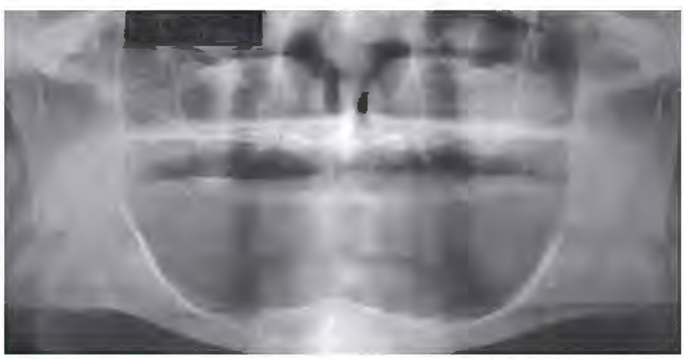


FIGURE 13-1. Panoramic radiograph of a mandible suitable for a ramus frame implant. Dimensions must be adequate for the anterior component (foot), as well as for the posterior or ramus segments.

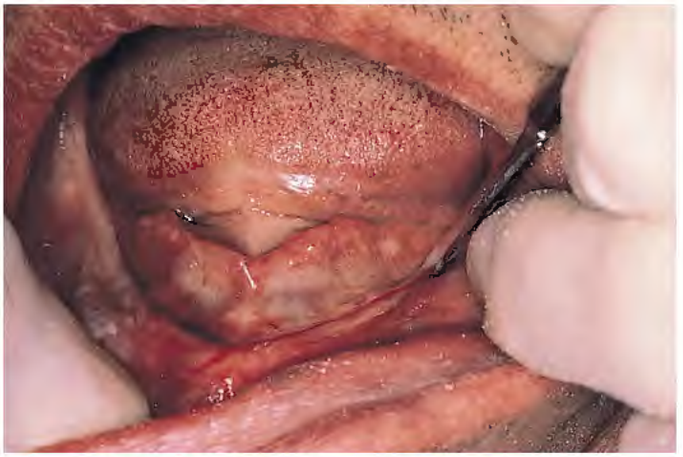


FIGURE 13-2. For the RA-2 ramus frame, the anterior incision is made at the crest of the ridge from mental foramen to mental foramen.

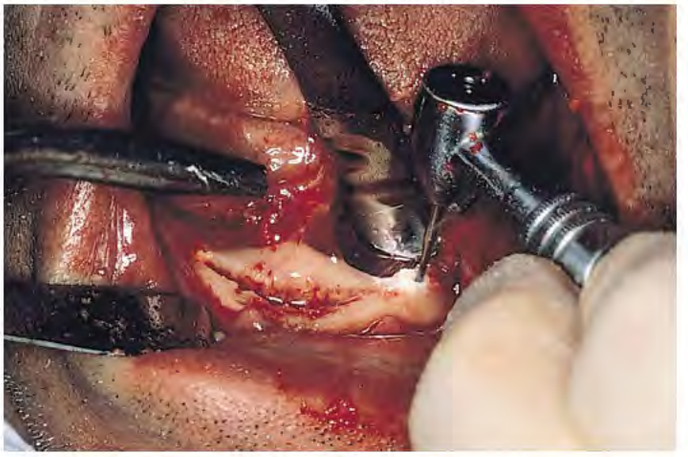


FIGURE 13-5. Before a transcortical osteotomy is made, a small, saline-cooled, round bur in the high-speed handpiece is used to form its outline. The initial effort is made in the form of shallow perforations about 3 mm apart.

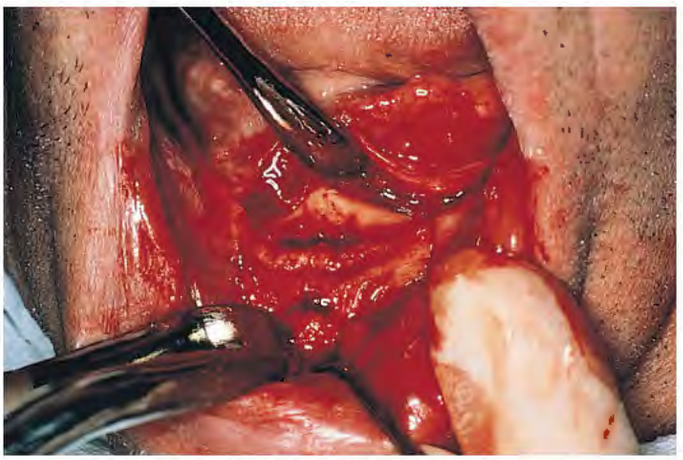


FIGURE 13-3. The symphyseal flaps must be reflected with care. The exposed anterior ridge should demonstrate the crest, its curvature, and the angle of anterior inclination.

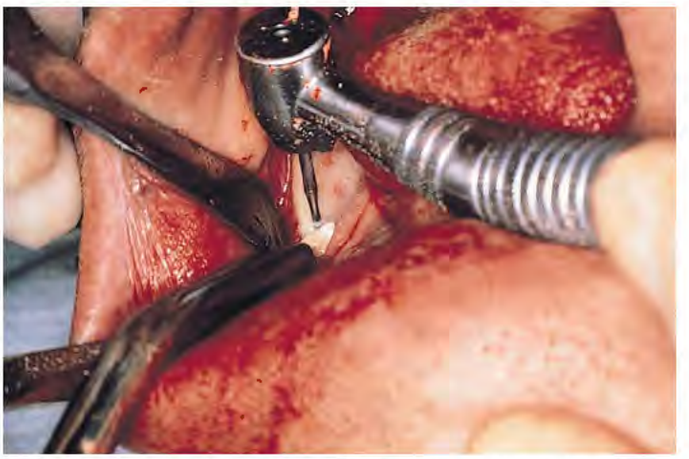


FIGURE 13-6. An alveolar crestal incision is made into fixed gingivae in each ramus retromolar area and then carried forward to meet the anterior incisions. The ridge must be exposed from the ramus anteriorly to the mental foramen. The posterior (ramus) osteotomies are made most easily with a straight (Hall) handpiece or an obtusely angled Impactair, although a conventional handpiece can be used if the patient can open sufficiently. The osteotomies should be created by first making transcortical bur holes in a perforated pattern.

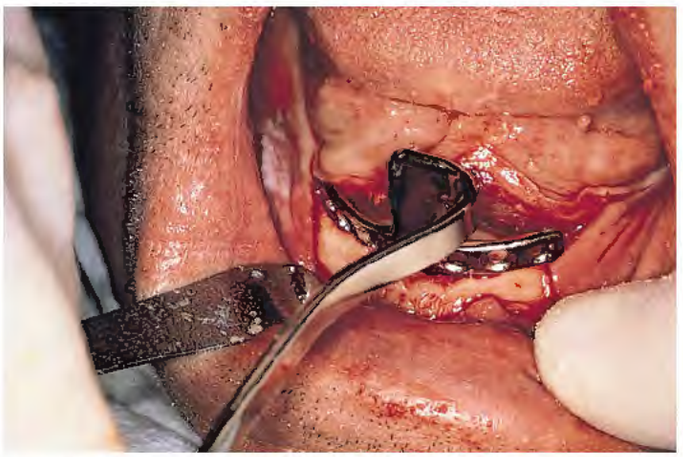


FIGURE 13-4. After the flaps have been reflected, the template is held with its large, curved border over the bony ridge to outline the shape of the osteotomy for the anterior component (foot). The template must be bent to conform to the shape of the ridge.

is placed at the angulation of the long axis of the ramus and 2 mm medial to the lateral cortical plate. It acts as a guide for the osteotomy, which should be as close to a straight line as is possible.

With a No. 1 round bur, a series of perforations is made just through the cortical plate. They should be 1.5 to 2 mm apart along this line, beginning at 30 mm and working forward to 18 mm (Fig. 13-7). The surgeon's tactile sense indicates when the cortex has been perforated and the marrow cavity reached. The template must guide the placement of the dots. When they have been completed, the surgeon evaluates their alignment and accuracy and makes corrections, if necessary. A 701L surgical bur then is used to connect and deepen the dots. The resultant groove is completed when it reaches a depth of 6 mm, which is 1 mm deeper than the flutes of the bur.

The distal end of the template is placed in the posterior part of the osteotomy and forced under the anterior cortical plate of the ascending ramus. The foot is brought down into place anteriorly. If the osteotomy requires a curve because of the anatomy of the ramus, the shape of the template must be modified accordingly

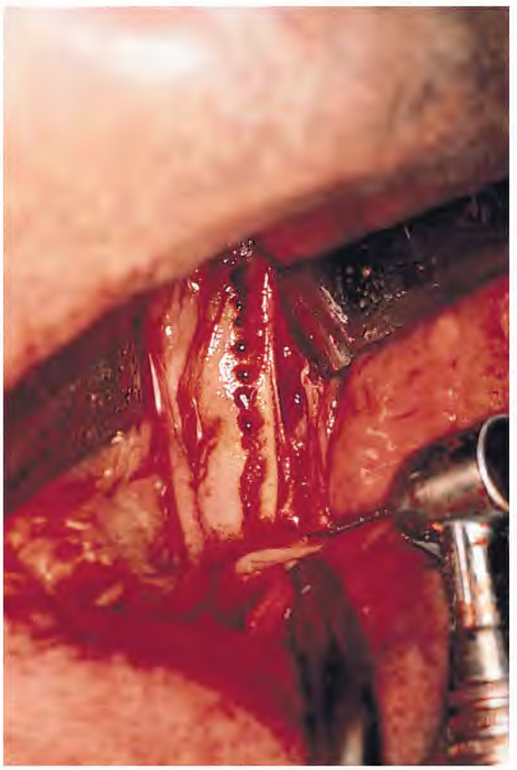


FIGURE 13-7. When the perforations are aligned satisfactorily, a long, tapered 701 fissure bur is used to connect them at a depth that can accommodate the posterior components of the ramus frame.

with the bending jig and pliers. Once the template fits satisfactorily, these modifications are transferred immediately to the implant while the reshaping procedure is fresh in the surgeon's mind (Figs. 13-8 and 13-9, *A* and *B*).

After one side has been completed, these same steps are performed on the contralateral side. If the patient has a Class II (retrusive) or a Class III (protrusive) mandible, the shape of the implant is modified. For the Class II mandible, the anterior center post is bent posteriorly up to 4 mm. For the Class III mandible, the center post is bent up to 4 mm anteriorly.

At this point, the implant is seated. First, its distal ends are placed in the posterior extents of the osteotomies. Because the implant is 2 mm too long for the anterior ramus border, the distal ends of the

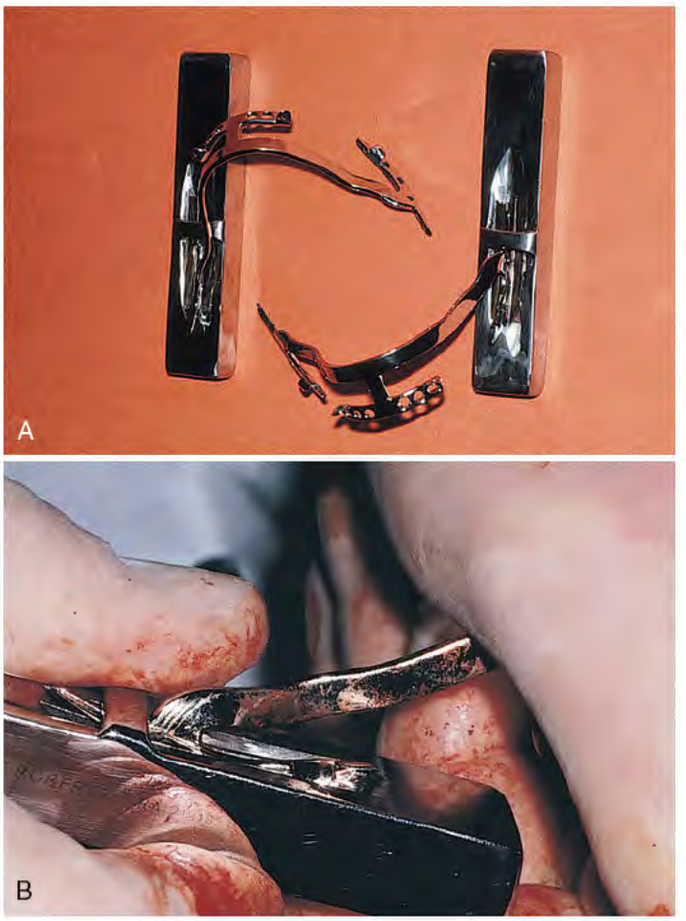


FIGURE 13-9. A, The posterior components of the RA-2 often need to be bent. Bending jigs facilitate these maneuvers. **B,** These handheld devices allow the surgeon to precisely adjust the angle or inclination.

implant must be placed posteriorly into the rami grooves with firm finger pressure until the 2-mm extensions are accommodated and the ramus frame fits passively into the osteotomies (Fig. 13-10).

The anterior foot of the implant is rotated downward toward the symphyseal osteotomy. Hand pressure is used first, and then a surgical mallet is used to tap the implant into the anterior groove. Any additional bending adjustments needed for more accurate accommodations are made.

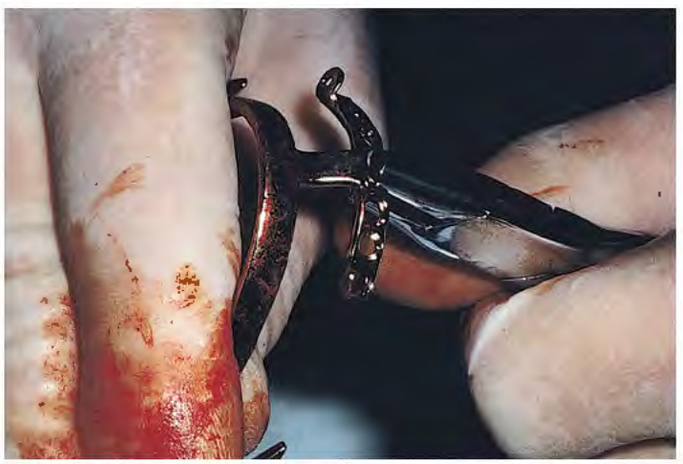


FIGURE 13-8. The anterior foot must be bent into a pattern that replicates the template. Roberts pliers can help accomplish this.

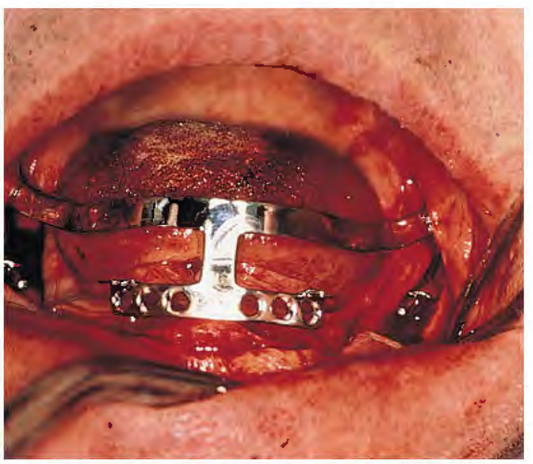


FIGURE 13-10. The posterior components are placed and seated first. Then, the anterior foot should be tapped into its osteotomy.

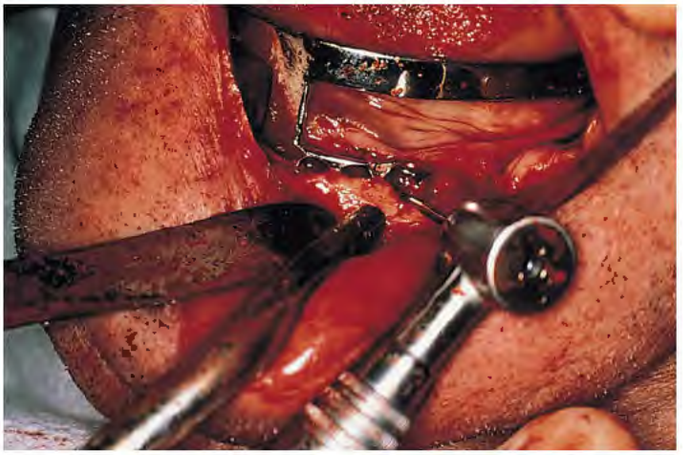


FIGURE 13-11. Small grooves are cut into the cortex to accommodate the seating tabs.

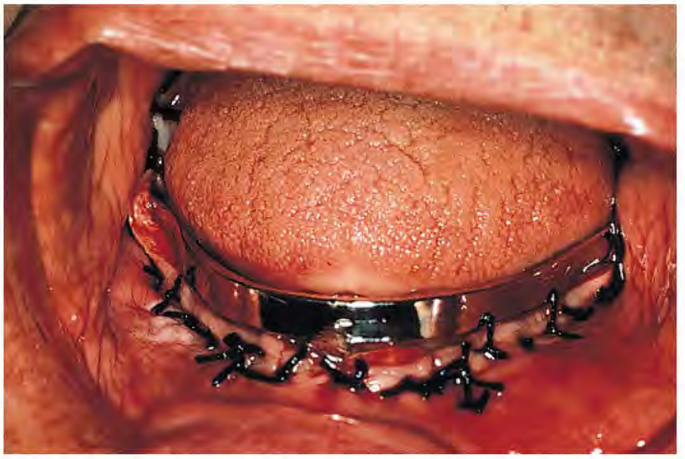


FIGURE 13-12. Closure is complete with mattress or interrupted sutures.

The three infrastructures of these implants have seating tabs. When the anterior foot is seated, the posterior tabs on the posterior feet are inspected. If they are already seated, the anterior foot will not seat unless tension is placed on the arc of the implant. To rectify this, the implant is removed and its arc is opened or closed by using the bending instrument as required.

The implant then is reseated and checked for accurate passive seating of the posterior tabs. If they continue to move into place before the anterior foot is seated, remove 2 mm of additional bone from beneath the sites of the posterior tabs. Some anterior bone also may need to be removed from beneath the tab site.

Only reasonable force should be used to seat these implants. If excessive force is required, the osteotomies are inadequate or nonconforming, or the implant is improperly aligned in relation to them.

When the alignment and osteotomy sizes appear to be correct, the anterior and then the posterior feet of the implant are tapped into place. When bone height permits, the shoulder of the anterior foot is buried 2 mm below the crest of the ridge. This can be accomplished by removing 2 mm of bone from beneath the anterior seating tabs (Fig. 13-11). Seating is performed with the bayonet instrument, which should be tapped with a mallet over the anterior center post. The seating instrument then is placed on the posterior tabs and tapped to deliver the posterior feet into place. Finally, the anterior tabs are bent by inserting the seating chisel into their small holes and tapping down until they hug the bone.

All areas are irrigated, and closure is performed with a continuous horizontal mattress suture using purple dyed 4-0 Vicryl (Fig. 13-12). The procedure with a panoramic radiograph (Fig. 13-13).

The patient's denture may be relined with soft, self-curing Durabase Soft, Coe-Conditioner, or Viscogel, and it can be worn immediately. Normal postoperative recommendations for analgesics, antibiotics, antiinflammatory agents, and postoperative care are as described in appendixes G through J. After a healing period of 6 weeks, a new overdenture may be made for the patient (see Chapter 25) (Fig. 13-14).

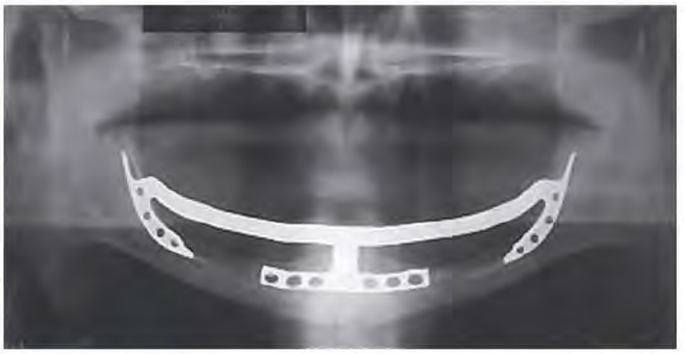


FIGURE 13-13. The postoperative panoramic radiograph should show the three components of the ramus frame completely seated in bone. Also, evidence of canal clearance, as well as generous use of the anterior osseous structure, should be seen.

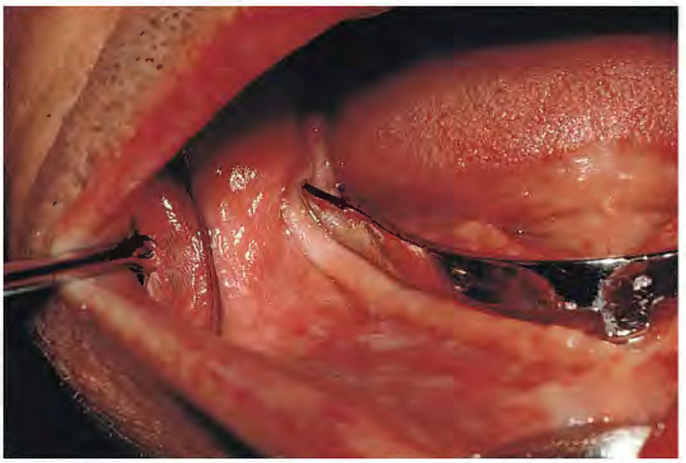


FIGURE 13-14. Healing should show a high level of tissue health, good keratinization, and the emergence of the posterior components through fixed gingivae.

RA-1 RAMUS FRAME (PACIFIC IMPLANT COMPANY)

The RA-1 implant is available in four sizes, and the size chosen depends on the dimensions of the patient's jaw. The implant is selected by measuring from the midline of the mandible to the posterior entry site into the ramus. Then, depending on the measurement, one of the following sizes is chosen.

No.	Size
4	45 to 52 mm
5	53 to 55 mm
6	56 to 62 mm
7	63 to 68 mm

Most patients require the No. 5 implant.

Surgery

The first incision is started 5 mm lateral and 5 to 8 mm superior to the retromolar pad and against the anterior border of the coronoid process. The incision is continued anteriorly against the bone, passing the retromolar pad on its lateral side and up to the crest of the ridge in the first molar area. From this point, the incision is extended on the crest anteriorly to the first premolar region. The buccal and lingual flaps are reflected with care so as not to disturb the mental neurovascular bundles.

The appropriate position for the posterior rail is determined. The rail is placed at the superior portion of the retromolar pad and midway between the inner and outer borders of the ascending ramus. A high-speed, water-cooled, Impactair handpiece with a No. 2L round surgical bur is used to perforate the cortical plate and make a series of separate transcortical holes that ascend the ramus 6 to 7 mm to the predetermined site. If the perforations appear to be located correctly, a 700XL can be used to connect them, creating a groove. A 701XL bur and then a 702 XL bur are used to widen this groove to 2 mm.

The trial template is placed in the osteotomy and forced back through the cancellous bone to a depth of 11 mm. In many cases the handpiece must be used to deepen the osteotomy to the required dimension.

If the first trial template fits properly, the 702XL fissure bur is used to make a horizontal osteotomy from the anterior base of the vertical groove laterally just to the external oblique ridge. The bur should not be allowed to pass through this hard cortical layer.

The second posterior try-in template, which has a wing on its side, is fitted into the osteotomy. When it is seated properly, the winged portion of the template is submerged completely.

These steps are repeated for the contralateral side. Finally, the anterior incision and osteotomy are prepared as described for the RA-2 model.

When all three osteotomies have been completed, the implant is fitted first into the ramus areas. The frame is compressed toward the midline, if necessary, to align the posterior extensions so that they can slip passively into the osteotomies.

The implant is coaxed into place posteriorly by gentle rocking. When it is seated, the foot is rotated downward into the anterior osteotomy.

At this point, a 557XL bur is used to remove 2 mm of bone from beneath the anterior seating tabs; this allows the foot to be seated below the crest of the ridge.

To complete the operation, the surgeon places the long bayonet seating instrument over the implant center post and taps gently with a surgical mallet. The seating instrument or chisel then is inserted into the holes in the anterior tabs and gently tapped, bending them over the crest. If the implant's accommodation to its host site is not satisfactory, one or two of the following alterations are made to help seat it.

1. The center post of the implant may need to be bent more labially or lingually to seat the anterior foot successfully. If so, this can be done with a Roberts anterior bending pliers.
2. If one or both of the lateral posterior tabs do not fit within the confines of the patient's rami, one or several of them can be removed to allow the posterior components to be buried.

Before final seating of the ramus frame, all bony and other debris must be irrigated from beneath the flaps and from within the bone grooves. The three wounds are closed with a continuous horizontal mattress suture, and a postoperative panoramic radiograph is taken.

Postoperative recommendations for analgesics, antibiotics, antiinflammatory agents, and follow-up care are as described in appendixes G through J.

The patient's denture should be reamed and relined with a soft, self-curing liner. The patient may be dismissed with it in position. After a healing period of 6 weeks, a new denture superstructure is constructed, which may be used with a soft liner (i.e., Durabase) to give it a "sloppy fit."

The ramus blade has been designed to serve as a distal abutment for fixed bridge prostheses in atrophic mandibles in which insufficient bone is available in the more anterior conventional areas. It can be used when as little as 5 mm of bone is available above the inferior alveolar canal.

RAMUS BLADE

The ramus blade is available in both standard (Fig. 13-15) and relief (Fig. 13-16) designs. The latter is used when minimal bone is present above the inferior alveolar canal. Ramus blades are made of commercially pure titanium and are placed in the second molar areas with the infrastructures extending upward and backward into the ramus. They are available in several lengths and three different abutment angulations.

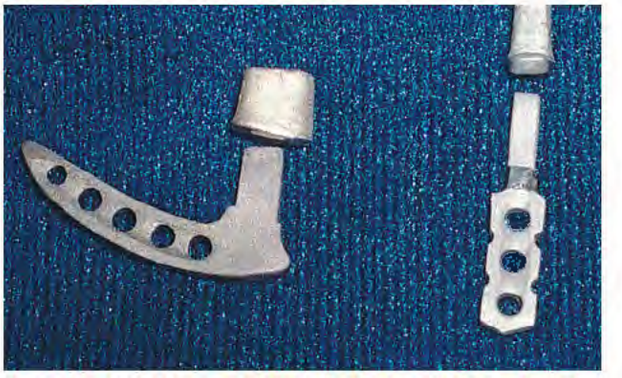


FIGURE 13-15. The standard ramus blade is available with three different angles of the abutment head. Copings must be custom-cast.

FIGURE 13-16. Relief design ramus blades may be placed in regions that require a shallow implant without injuring the mandibular neurovascular bundle.

Implant designs are selected by superimposing a clear plastic ramus blade template over a periapical radiograph of the area to be implanted. The head of the implant template must be aligned so that it is parallel to the long axes of the more anterior natural teeth with which it shares the roles of abutments. Each template design should be tested until the correctly angled implant is discovered. Ideally, it should occupy all of the usable bony space.

Surgery

When possible, only local infiltration should be used to anesthetize the patient. A full-thickness incision is started against bone 3 mm lateral to and 8 to 10 mm above the retromolar pad. The external oblique ridge is palpated for guidance in making the incision directly on it (Fig. 13-17). The incision is continued downward and forward, lateral to the retromolar pad, and then anteriorly to the premolar area. After the retromolar pad has been passed, the incision is directed onto the crest of the ridge.

The buccal and lingual flaps are reflected to expose the external oblique ridge and the anterior border of the ramus. The mental bundles are protected.

The surgeon then locates the desired position of the implant abutment, which should emerge through keratinized epithelium, and then uses a No. 2 round bur to place a bone dot at this site. The surgeon then creates a mental image as to the projected position of the implant. The posterior extension of the osteotomy must be directed along the center of the exposed anterior ramus or slightly lateral to it, with the lateral cortical plate used as a guide. The anterior, or abutment end, should emerge from a zone of fixed gingiva on the ridge at the spot previously marked.

With these requirements in mind, the surgeon starts at the anterior dot and uses a high-speed, water-cooled, Impactair handpiece with a No. 1 round bur to penetrate the cortical plate. Repeated penetrations are made, 3 mm apart, for 15 to 18 mm distal to the starting point until the full length of the selected implant has been accommodated. The implant is placed over the outline, and if it conforms, the dots are connected to create a grooved osteotomy. The bur is changed to a 701XL and then to a 702XL, if necessary, to widen the osteotomy to 2 mm and deepen it to 4 to 6 mm, depending on the dimensions of the selected implant design (Fig. 13-18).

FIGURE 13-17. A suitable operative site for a ramus blade must be evaluated by thorough palpation and confirmed by radiography.

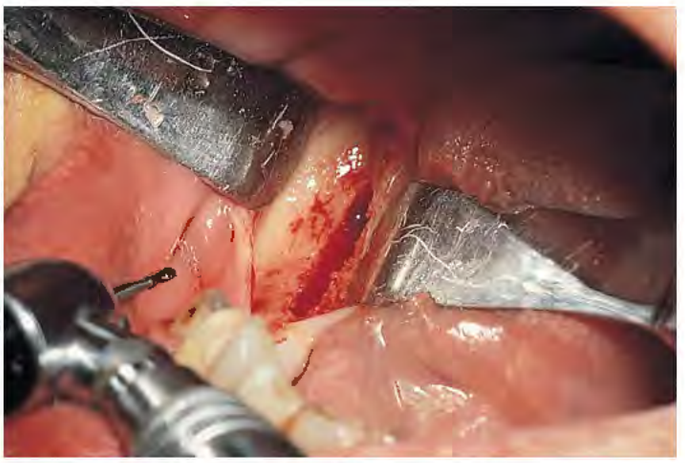


FIGURE 13-18. The posterior osteotomy should be long enough to accommodate the ramus blade infrastructure, and it should be located centrally so that neither cortex is perforated and the implant is located within the marrow cavity.

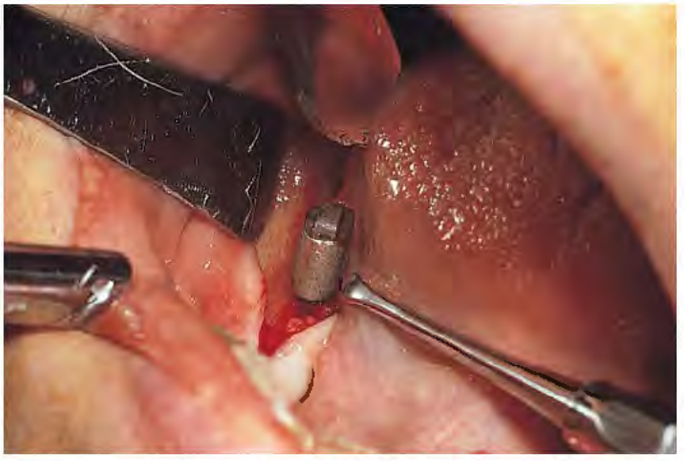


FIGURE 13-19. The seating technique requires that the posterior end be slipped into the osteotomy until the anterior abutment portion of the blade can be tapped inferiorly, where it will be surrounded completely by bone.

The posterior point of the implant is placed in the distal end of the osteotomy, and the bayonet seating instrument is placed on top of the anteriorly located abutment. The implant's infrastructure is seated by gentle tapping with a mallet. When correctly seated, the implant should be firm, and its shoulder should be 1 mm below the cortex of bone. If either labial or lingual inclination of the implant abutment is required, this is done before final seating. The slot of the bending jig is used to hold the implant while the abutment is angled with Roberts pliers.

After acceptable parallelism has been achieved, the implant is tapped firmly into place with mallet taps directly to its shoulder (Fig. 13-19). The wound is closed with 4-0 Polysorb continuous horizontal mattress sutures.

The postoperative regimen is as described in appendixes G through J. After a 3-month healing period, prosthodontic rehabilitation can begin, with the use of a classic fixed bridge technique. Sanitary pontics are recommended whenever possible.

Mandibular Subperiosteal Implant Surgery

14 CHAPTER

ARMAMENTARIUM

Acrylic: self-curing (Formatray)
Diamond drill: Atwood 473 diamond for the straight (Hall) handpiece
Drill: Hall
EZ Tray material
Forceps: Gerald (toothed)
Hemostats: long, curved hemostats (i.e., tonsillar); mosquito
Impression material and adhesive: Surgident Neoplex regular body polysulfide
Mortise mesh: titanium (TiMesh)
Needles: hypodermic, 20 gauge, 1½ inch
Orangewood sticks
Pliers: crimping
Retractors: beaver tails (Henahan), Army/Navy
Scissors: Mayo
Screwdriver: Vitallium, titanium tipped
Screws: 5 or 7 mm Vitallium; 5 and 6 mm titanium
Scalpel: long handle
Scalpel blades: Bard-Parker (BP) No. 15 and No. 12
Surveyor
Suture: 2-0 black silk; 4-0 dyed Vicryl
Tissue conditioner: Coe-Comfort, Viscogel
Tubes: 0.045-inch (inner diameter) orthodontic
Water: thermostatically controlled bath (to 178° F)

CAVEATS

The exposed operative site requires the surgeon's absolute respect. The bone that supports the subperiosteal implant must be treated with the highest level of care, and its response to the simple trauma of mucoperiosteal reflection is responsible for some level of resorption, as evidenced by radiographic signs of change about 3 months after insertion.

Some clinicians maintain that grooves can be cut into the crest of the ridge (i.e., "witness marks") to allow countersinking of primary struts. However, this should never be done, because it may threaten the prognosis of the implant. Bone has plastic memory, and if it is altered by cutting a groove or mortise form to seat a component of the infrastructure, it almost immediately begins to undergo resorption. Within weeks, what might begin as an intimate metal to bone relationship can become a growing, rounded radiolucency. This phenomenon, which takes place beneath the abutments, can be the first sign of a cascade of events leading to implant failure (Fig. 14-1).

COMPLETELY EDENTULOUS DESIGNS

Preventing injury to mental or dehiscent mandibular nerves is important. The implant design should be selected with care in advance (Fig. 14-2), and if any question of dehiscence arises, a tripodal infrastructure (discussed later in the chapter) should be planned.

The more complex impressions are made in several parts. The surgeon, therefore, should have the materials and equipment on hand to make an index so that the segments of the impression can be assembled accurately. Tissue thickness measurements are obtained so that the laboratory can construct a casting with abutments that have accurate cervical height.

The laboratory also must receive a good surgical centric recording that relates the bony mandible to the cranial base, or the implant abutments may be placed in incorrect and unusable positions. Complete mandibular implants should not be made in opposition to natural maxillary dentition.

Procedure

Before beginning surgery, the surgeon should examine the intact mucosa that covers the mandible. The sublingual adnexa are palpated (i.e., sublingual glands, mylohyoid and genioglossus muscles, plicae sublinguales, Wharton's ducts). These adnexa usually lie above the ridge crest. The vestibules often are ill defined, and a mucosal linea alba is seen at the ridge crest (Fig. 14-3).

Bilateral mandibular block anesthesia is used. Local infiltrations in the form of long buccal blocks and infiltrations deeply into the anterior area also should be used. These infiltrations create profound anesthesia, so that aggressively made flaps can be reflected fully for properly designed implants. The limit for the average adult is eight ampules of 2% lidocaine for the first hour. Subsequent injections are administered only after the solutions given at the outset have been absorbed.

After administering the anesthetic but before making an incision, the surgeon uses a sharpened periodontal millimeter probe to measure the thickness of the mucoperiosteum at the four to six potential permucosal sites (points of implant after emergence) on the linea alba. These measurements are recorded on a chart.

Incision

A Bard-Parker (BP) No. 15 blade is used to trace the linea alba, a fine white scar on the crest of the ridge that results from the trauma of past extractions and denture wearing. The incision starts at one retromolar pad and proceeds around the arch to the contralateral side (Fig. 14-4). If the radiograph shows that the mental foramina are at or near the crest of the ridge, the incisions are curved slightly lingually to avoid injuring the emerging neurovascular bundles. In addition, a vertical relieving incision is made just lateral to the labial frenulum. Incisions are made directly to bone so that they need not be retraced.

Reflection

A sharp periosteal elevator is used to reflect the mucoperiosteum. Full-thickness flaps are elevated carefully. If the flaps resist reflection, a BP No. 12 blade is used, hugging the bone, to cut scar adhesions. The following structures must be exposed and visualized:

1. The external oblique ridges and beyond, inferiorly to the angle, anteriorly to the inferior border for the full width of the ramus.
2. The mental foramina, superior rims only (the neurovascular bundles should not be dissected from their fibrous sheaths).
3. The symphysis to the inferior border of the mandible for a width from canine to canine.

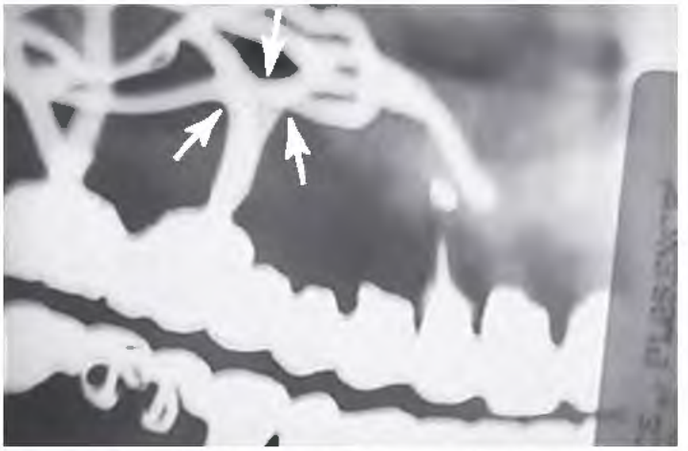


FIGURE 14-1. Witness marks are grooves cut across the crest of the ridge to allow flush seating of the primary struts of subperiosteal implants. However, these marks should never be used, because geometric patterns cut into bone do not retain their sharp line angles. This radiograph shows the pathologic downfall of an implant under which such grooves had been cut and subsequently were resorbed into rounded troughs *(arrows)*.

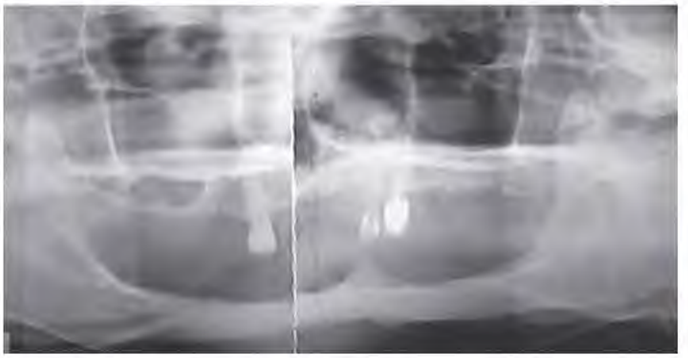


FIGURE 14-2. Severe mandibular atrophy is managed well with a subperiosteal implant. Dehiscence of the neurovascular bundle can be a significant complication.

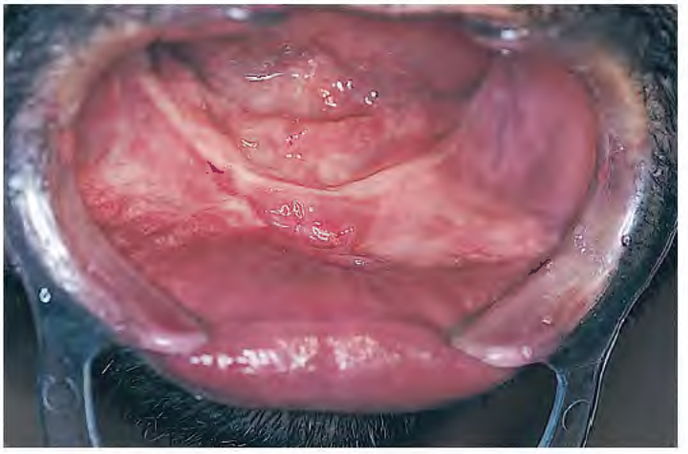


FIGURE 14-3. Absence of vestibular morphology and knife-edged ridges are aspects of an atrophied ridge that work well with a mandibular subperiosteal implant.

4. The genial tubercles, superior surfaces only (the genioglossus muscle attachments must not be released).
5. The lingual cortex from the anterior ends of the mylohyoid ridges forward to the genial tubercles; the reflections are carried down lingually to the inferior borders in the canine areas.

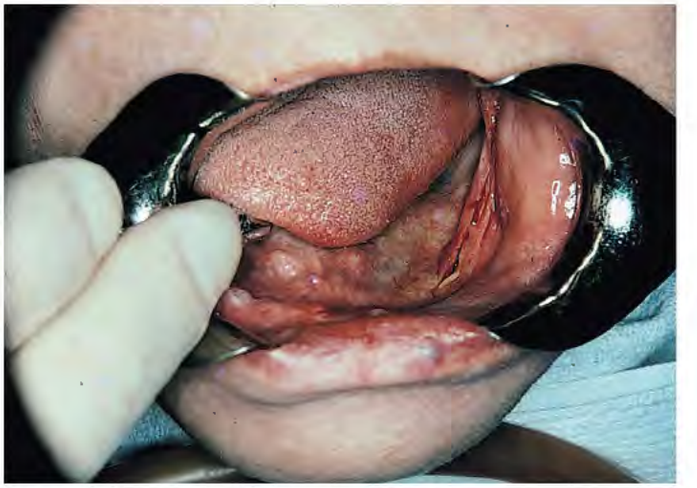


FIGURE 14-4. Surgery begins with a crestal incision. It should be made from retromolar pad to retromolar pad. An anterior vertical relieving incision is required.

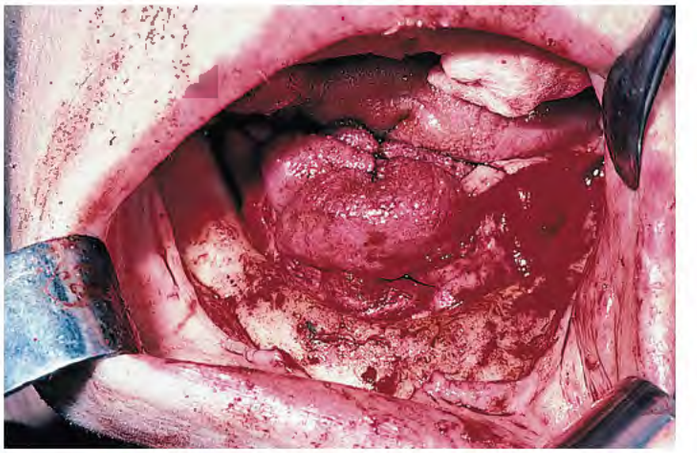


FIGURE 14-5. Suturing the lingual flaps to each other across the dorsum of the tongue facilitates complete exposure of host bone. The genial tubercles, mylohyoid muscles, external oblique ridges, mental foramina, and symphysis should be seen.

Often finger dissection is the simplest and least traumatic means of performing this procedure. The implant periphery is extended into these areas to compensate for the potential facial structural weakness caused by the scallops designed to circumvent the mental foramina. The mylohyoid muscles are not elevated from their attachments.

After vital anatomic structures have been exposed, the two lingual flaps are sutured to each other with 2-0 black silk sutures, which are brought across the dorsum of the tongue. If the tongue slips from beneath these shoestring ties, its lateral border is included on either side in the suturing process. These sutures are tied tightly so that the tongue, floor of the mouth, and lingual flaps are bundled compactly together in the midline and the mandible is well exposed for impression making (Fig. 14-5). The exposed bone is protected with saline-moistened sponges; this creates hemostasis and prevents dehydration of the tissues.

Impression Making

1. The EZ Tray material is heated to 178° F in an electric water bath. When it is soft, one cake is removed and compressed over the bone immediately after the surgical assistant removes the sponges. It is molded so that it extends to all significant

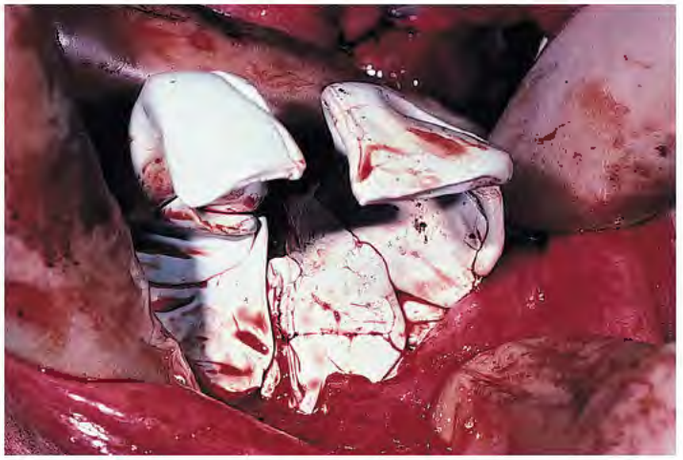


FIGURE 14-6. Shaping thermolabile EZ Tray segments directly on the bone aids impression making, because the segments can be seated separately if necessary.

peripheral regions (Fig. 14-6). The molded piece (tray) then is irrigated until it hardens.

2. An extra piece of material is fashioned into a handle and attached to the tray. Drying is not necessary, because the material is quite cohesive. The tray then is removed; if it is shy in any area, it is augmented with newly softened material until the entire planned bony host site is covered. The surgical assistant should use a beaver tail (Henahan) retractor beneath one buccal flap, and the surgeon should retract the other, to perform enough rehearsal seatings to ensure efficient, rapid tray placement at the time of the final impression. If manipulation of the buccal flaps presents a problem, several 2-0 black silk sutures are passed through the flaps. The ends of the sutures can be tied in loops after the needle is removed, and they can be used as retractor handles. The wound is repacked with moistened sponges while adhesive is applied to the tray.
3. Impression material (Surgident's Neoplex regular) is mixed thoroughly, the tray is loaded with the material, and the implant is seated per rehearsal (Fig. 14-7). It is held firmly in position for 8 minutes. A valuable handling characteristic of this material is that it need not be used until after it passes through its sticky or stringy stages. A puttylike consistency is proper for manipulation.
4. The impression is removed and examined for the following landmarks:
   - The mylohyoid muscle, in the form of ruffled borders
   - The genial tubercles, as two indentations
   - The symphysis, which is smooth and curved inwardly as it represents the inferior border of the mandible
   - The mental foramina, which may be seen only as semilunar indications of their superior borders, along with the fan-shaped representations of the neurovascular bundles
   - The external oblique ridges, which should be clearly demarcated with extensions beneath them down to the inferior borders, when possible (Fig. 14-8)

If the impression is accurate and has a smooth texture, it is set aside while copious saline is used to irrigate and thoroughly debride the host site. If the tray is unsatisfactory, making a new impression best solves the problem; the surgeon should not try to correct the faulty impression. A panoramic radiograph should be taken postoperatively to detect fragments of residual impression material, which are radiopaque. These fragments can be removed during second-stage surgery.

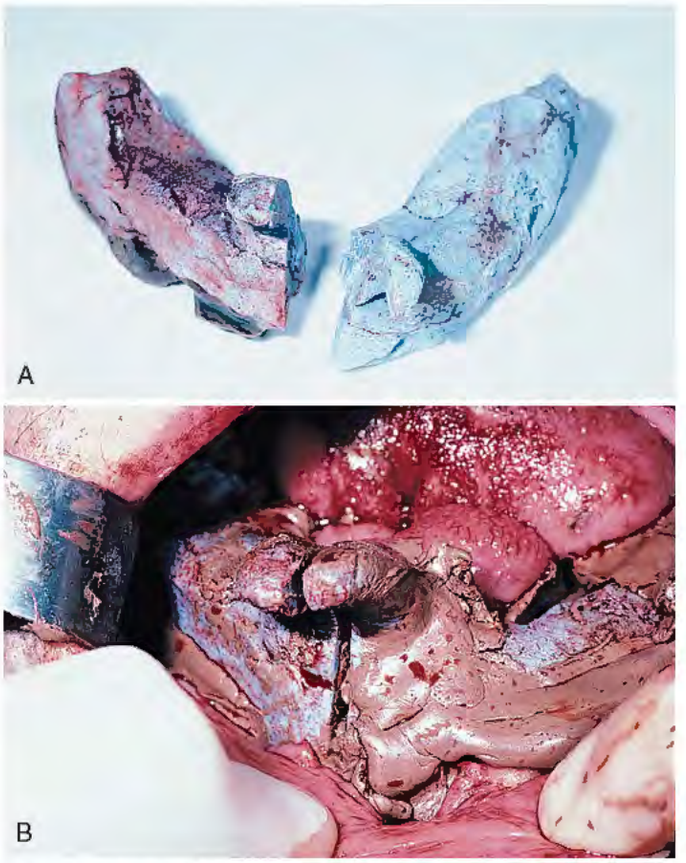


FIGURE 14-7. **A,** When undercuts are present in the rami area and a tripodal implant is planned, the tray can be made in two or three segments. **B,** Each tray portion is filled with an elastomeric impression material and can be seated and removed separately if no satisfactory path of insertion can be found. An index, made while the tray halves are in position, is used after removal for reassembly.

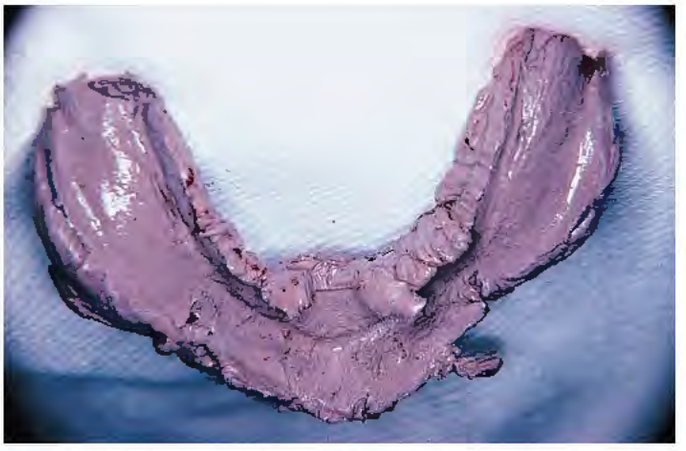


FIGURE 14-8. The completed rubber base impression should have a dull homogeneous surface, mental bundles, genial tubercles, the turned border of the symphysis, both external oblique ridges, and the ruffled border of the mylohyoid muscles.

Surgical Jaw Relationship: Centric Recording

The patient's acceptable maxillary denture prosthesis or a prefabricated, properly adjusted wax rim is placed on a base plate, and a thick roll of Optosil putty or a prefabricated bite rim is used to establish centric and vertical relationships. The elastomer is pressed and molded to the bone while the patient is guided to closure in a

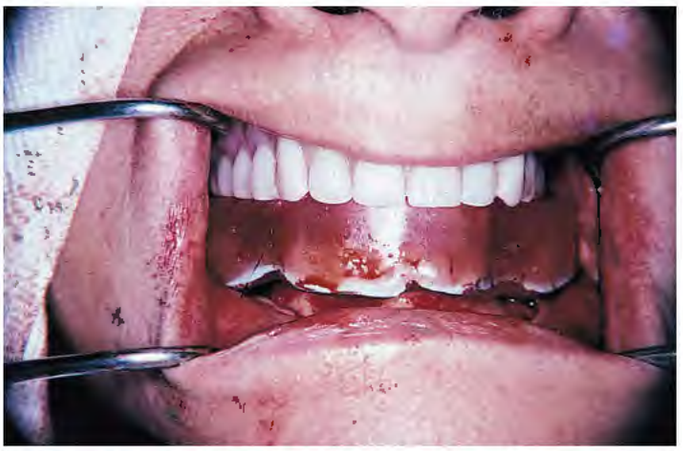


FIGURE 14-9. After the impression has been made, vertical and centric relationships are established with an Optosil-lined wax rim resting directly on the bony surface of the mandible.

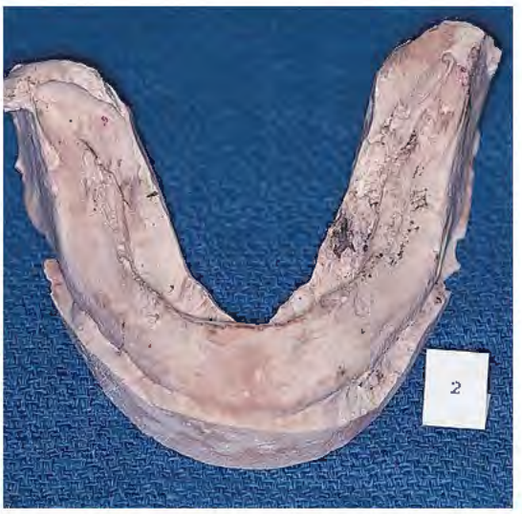


FIGURE 14-11. The separated cast is checked for the vital structures (see Fig. 14-8).

natural mandibular position (Fig. 14-9). The Optosil is removed after it has set; the wound is reinspected and irrigated again with saline, and the retraction sutures are removed from the tongue and buccal flaps. An impression of the upper denture, which should have been made previously, serves as a countermodel.

Closure

1. The flaps are coapted and compressed firmly with a surgical sponge grasped with the thumb and forefinger.
2. The buccal flap is grasped at the right posterior end of the incision with a Gerald forceps. Closure is performed using 3-0 black silk suture on a FS 2 or C-13 cutting needle (Fig. 14-10) in a continuous box-lock suture (see Chapter 6). The routine postoperative regimen is used (see Appendix G). The patient's original mandibular denture may be adapted for use as a transitional appliance after it is lined with a tissue conditioner, such as Coe-Comfort or Viscogel.

Implant Design

1. The model is boxed and poured in pink Vel Mix stone.
2. After the Vel Mix has set, the cast is separated and checked for the landmarks listed previously (Fig. 14-11). It then is articulated with the countercast.
3. The designated places for primary, secondary, and peripheral struts are marked with a sharp pencil. An X is used to mark the position of permucosal cervices or posts. The peripheral struts are placed to the fullest extent of dissection, but undercuts are respected. Undercuts can be established by surveying the cast before design. Only primary struts (those that bear the abutments) should cross the ridge crest. Each must have only one cervix. The secondary struts should be plentiful so as to incorporate strength and rigidity, but they must never be placed less than 7 mm apart, otherwise strong periosteal reattachment to bone is discouraged.
4. Three screw holes are placed in each casting and delineated as small circles. The casting, which is waxed slightly below some of the undercuts, still may not achieve primary retention. If this is the case and the implant fails to snap into position, one to three screws are required. One hole is made just lateral to the symphysis (which is too dense to allow entry directly into the midline), and the other two holes, if needed, are made facing anteriorly (to allow direct screwdriver use) entering the lateral oblique ridges.
5. To establish cervical lengths and the height of the bar over the mucosa, 3 mm are added to the tissue thickness measurements. Sufficient space is allowed for cleaning, placement of retention clips or devices, and some implant settling and soft tissue hypertrophy (Fig. 14-12). The laboratory should be instructed to articulate the models and wax and cast an implant of surgical Vitallium in accordance with the outlined design. Bar configurations to accommodate internal clips, Hader clips, O-rings, or other retentive devices must be requested at the time of casting (see Chapter 26). Individual abutments, rather than a bar, may be used if the patient's prosthetic requirements are best suited by this approach. In such cases, a sturdier infrastructure must be designed to substitute for the rigidity offered by the Brookdale bar.

The patient is recalled for second-stage surgery after 36 hours or in 4 to 6 weeks. Any period between these times results in poor healing.

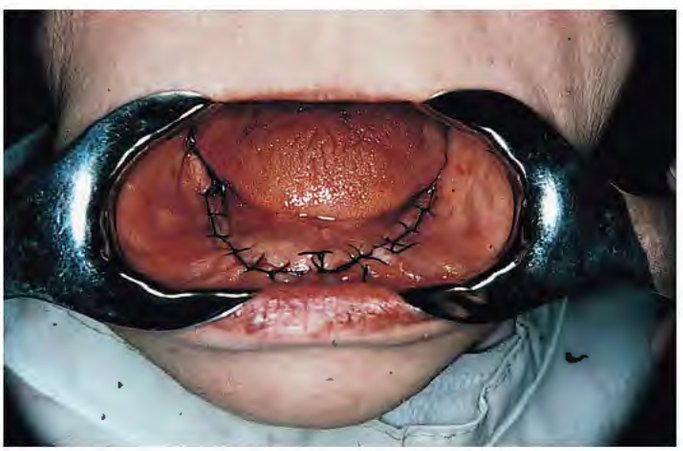


FIGURE 14-10. Closure is accomplished with a box-lock suture.

Implant Insertion

If a two-stage "immediate" 12- to 24-hour insertion is planned, regional anesthesia is more difficult to achieve. When the silk sutures are removed, the tissues fall open with ease (which is an advantage of the 1-day procedure). The host site is irrigated with care, and all residual clots and debris are removed. A Poole or Frazier plastic suction tip is used rather than a metal one. The sterilized, passivated implant

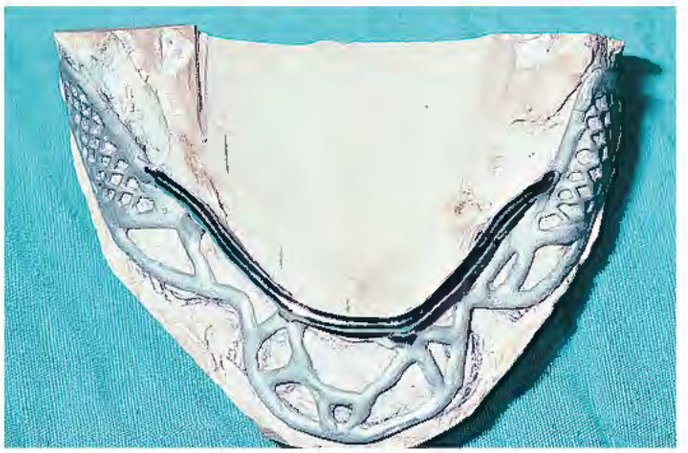


FIGURE 14-12. Vitallium casting of the lateral ramus design of Dr. Robert James. The peripheral struts should avoid the mental foramina and extend to the symphysis. The Brookdale bar, which is highly polished, has six points of permucosal penetration, and the ramus extensions should curve laterally to allow them to exit from fixed gingivae. The bar's height is determined by tissue thickness measurements, with additional consideration given to hygiene measures, hypertrophy of the mucosa, and manipulation of retention clips or other extension devices.

(see Appendix E) is seated in the host site. It is tapped firmly into place with an orangewood stick and a mallet, with care taken that the flaps are not caught beneath the peripheral struts. Accurate adaptation and primary retention must be verified (Fig. 14-13).

If retention is not positive, the anterior or all three of the fixation screws are used to establish primary retention. With the assistant holding the implant firmly in place, the surgeon uses an Atwood 473, tapered, diamond drill in a Hall handpiece in the anterior receptacle to make a concentrically placed screw hole to its full depth. The most superficial 5 mm is beveled to the 2-mm diameter of the casting's hole. A 7-mm long Vitallium screw is introduced, and a Vitallium screwdriver is used to turn it one revolution clockwise, then a half revolution counterclockwise (to allow the blood to act as a lubricant) until the screw is seated fully (Fig. 14-14). If three screws are required, none should be fully placed until all are within two turns of complete seating. However, each screw hole must be drilled and the screw partly seated before the subsequent holes or hole is made.

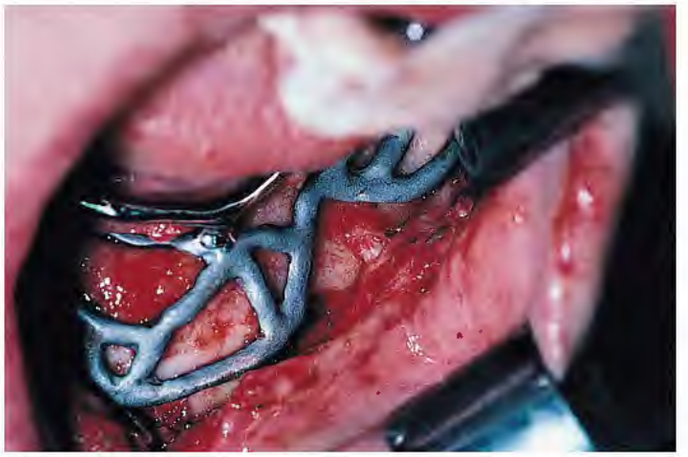


FIGURE 14-13. The second-stage operation involves a soft tissue reflection that can be somewhat less aggressive than the first. Protection of the mental neurovascular bundle must be an integral part of the operation and the implant design.

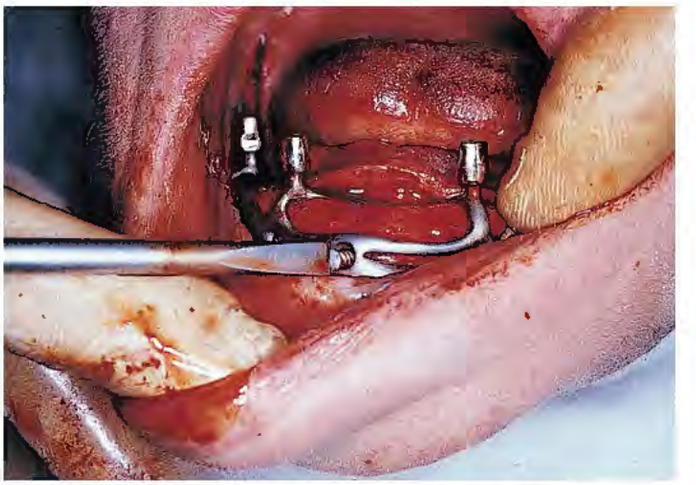


FIGURE 14-14. If positive retention cannot be achieved by simple placement of the infrastructure, screw fixation is recommended. This anterior screw is introduced into the bone just lateral to the midline.

The final fastening should take place in the same way that lugs on a spare tire are tightened: half a turn of each until all three are fully in place and all are resting passively in their countersunk holes. If places of improper fit of metal to bone are found but the implant is stable (does not rock), these deficiencies may be managed using 20-mesh hydroxyapatite (HA) particles, which are tamped beneath and around the errant strut with a moistened cotton applicator (Fig. 14-15). After thorough irrigation, closure is performed with 3-0 violet-dyed Vicryl in a horizontal mattress configuration (Fig. 14-16). In addition, a single purse-string suture is tied around each cervix. The patient is dismissed with instructions to follow the routine postoperative regimen (see Appendix G).

The postoperative course should be less complex than after the first stage of surgery. The sutures need not be removed because they are resorbable, and the existing denture may be hollow ground and lined with tissue conditioner immediately after insertion of the implant. The postoperative appearance 6 weeks after insertion should indicate maturation of the supporting tissues (Figs. 14-17 and 14-18).

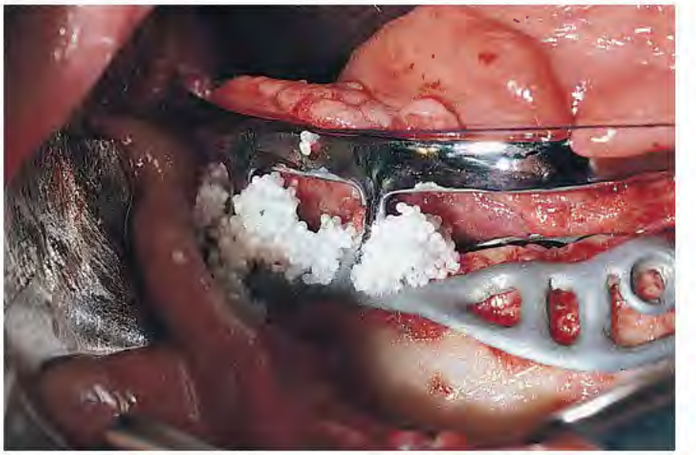


FIGURE 14-15. If discrepancies are found beneath the casting, synthetic particulate bone substitutes, such as hydroxyapatite or hard tissue replacement (HTR), may be used as a grout.

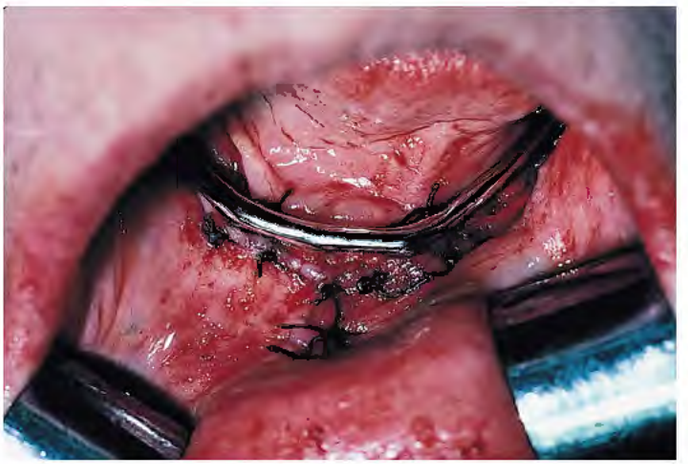


FIGURE 14-16. Closure with a resorbable suture (dyed Vicryl) is completed in a continuous horizontal mattress configuration.

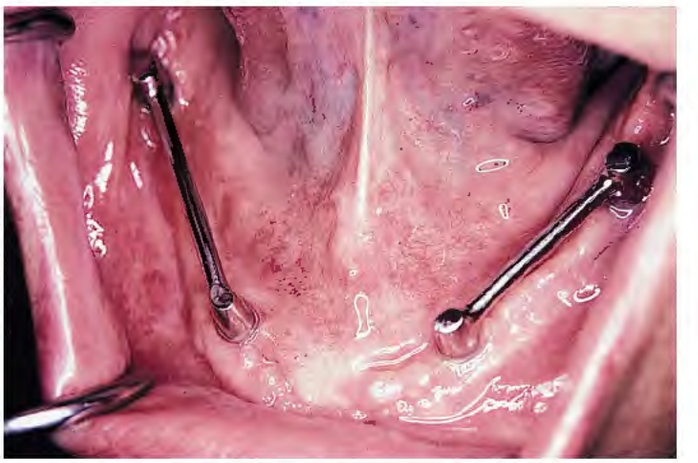


FIGURE 14-18. If the mandible flexes during opening, the bilateral Brookdale bar is preferable.

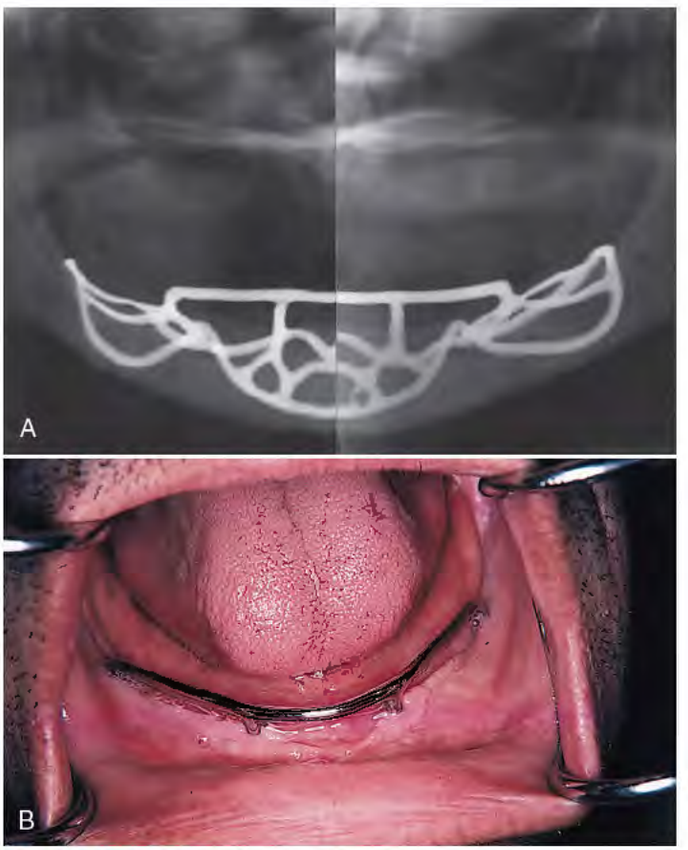


FIGURE 14-17. **A,** A Panorex radiograph of a completed implant shows good extension, a Brookdale bar configuration, and proper adaptation. **B,** Six weeks after insertion, the implant is firm, and the gingival cuffs are pink and well keratinized. Impression making may begin at this point.

EDENTULOUS TRIPODAL DESIGN: BROOKDALE BAR

Procedure

Incisions

The tripodal implant requires three incisions. The first is made anteriorly in the linea alba at the crest of the ridge from a point just anterior to one mental foramen and around to the same position on the contralateral side, with an additional parafrenular vertical relieving incision. The second incision is made on one side in the region extending from a point halfway down the ramus and forward to a second point 1 cm posterior to the mental foramen. The third incision is made in a like manner on the contralateral side. The incisions are made through the mucosa and directly down to bone. When planning and making the ramus components, the surgeon must make sure to palpate the ramus' anterior border (review chapters 4 and 13). The anterior border of the ramus is quite far laterally from the ridge crest. The surgeon must anticipate its location and flare. At the distal end of each of these posterior incisions, a lateral relieving incision 1 cm long is required. Some brisk bleeding is encountered, but firm tamponade controls it.

Reflection

A sharp periosteal elevator is used to reflect the anterior flaps labially and lingually to expose the entire symphysis to its inferior border. The crest of the ridge is revealed almost to the mental foraminal areas and the superolingual aspect to the genial tubercles. On either side of the tubercles, blunt finger dissection is used to approach the inferior border. These exposed bone areas are packed with saline-moistened sponges.

The posterior reflections take more time and patience to complete. The elevation is started anteriorly at the ridge crest, and the keratinized gingivae is lifted away to the buccal and lingual sides. Once the elevator reaches a point below this zone on the buccal side, it slides more easily downward, lifting the investing tissues with ease. A sponge can be used ahead of the elevator, exposing the entire lateral surface of the ramus from the mandibular angle along the inferior border forward to a point just beneath the anterior extent of the incision. Blunt finger dissection also is effective. The crestal tissues are lifted lingually over the crest of the ridge and down to the mylohyoid ridge, and these wounds are packed with saline-soaked sponges. The safest size is 4×4 (2×2s should never be used, because they may be left behind). Ray-Tec sponges, with built-in radiopaque markers, are preferred (Fig. 14-19).

The zones of bone exposed with the three islets of the tripodal implant are covered. Incisions have not been made in the dangerous premolar and molar areas, which pose a risk of mandibular or mental nerve dehiscence.

CAVEATS

The same precautions apply for this section as were listed previously, as well as some others.

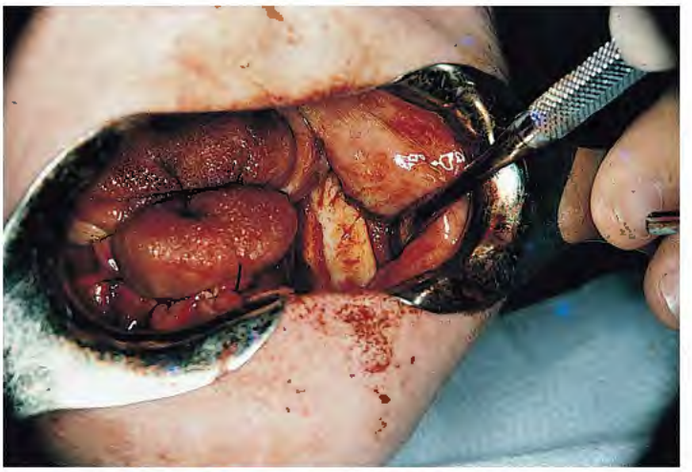


FIGURE 14-19. If dehiscence occurs, the tripodal implant design preserves the mentomandibular canal by allowing three separate incisions, one over each anterior ramus and one anterior to the mental foramina.

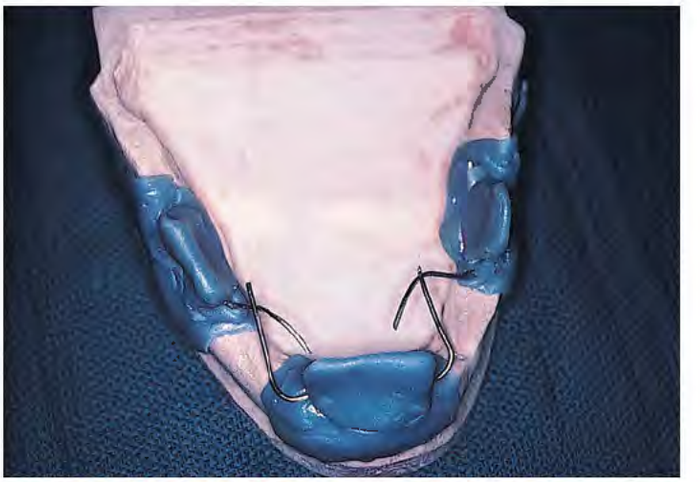


FIGURE 14-20. Impression making with three separate islets, each of which is seated individually, facilitates fabrication of the tripodal implant. The metal loops are used to connect the segments.

If evaluation of the host site indicates a dehiscent neurovascular bundle, either mandibular or mental, a three islet (tripodal) implant may be planned. The basic armamentarium, principles of surgery, placement, closure, and postoperative care are the same as for implants of the traditional design; these elements should be reviewed before proceeding.

The only connection of the three islet components that coordinates the infrastructure of a tripodal implant is the Brookdale bar (either complete or in bilateral segments). Such bars may be designed to accept the superstructure retentive devices of choice (see Chapter 26). The bar, therefore, is a structural element that serves as a mandatory part of the planned device.

Impression

Retraction sutures of 2-0 black silk are placed for the buccal and lingual flaps as described previously. To make a tray, the surgeon molds three polymethylmethacrylate (PMMA) segments to the bone or heats three pieces of EZ Tray. As each segment or piece softens, it is cut with a Mayo scissors to the approximate shape of each of the three exposed bone areas and pressed over the cortex while the assistant retracts the flaps. Each of the three tray elements is extended to the inferior border of the mandible. The anterior component should extend over the ridge crest to the superior surfaces of the genial tubercles and posteriorly to a point 2 mm anterior to the mental foramina. The posterior components should rise from the inferior border of the rami, over the ridge crests, and extend anteriorly to a point just short of the extent of the incision.

An extended retention device is attached to each of the outside tray surfaces. The device can be 0.059 flanged orthodontic buccal tubes, copper bands, or pieces of right-angled 0.045 stainless steel orthodontic wire staples. After each of these retentive devices has been placed and fused to the tray with a hot spatula and then cooled with irrigant, they are dried and seared to achieve more reliable retention (Fig. 14-20). The host sites are irrigated, and each of them is kept moist at all times before the impression is made. Adhesive lining is applied to each of the three trays.

The Neoplex polysulfide material is mixed separately for each of the three components. The first posterior segment is lined with the impression material, seated, and held for 8 minutes until setting is complete. Meanwhile, the other two surgical sites are kept moist. This first islet is allowed to remain in place while the second, contralateral segment is seated and held until it sets. The anterior portion is completed last. The impression material must not block out the wires or tubes that have been placed as tray assembly devices.

After each of the three impressions has set, a roll of autopolymerizing Formatray acrylic, at least 1 cm in diameter, is placed so that it engages the three tray retention wire loops or tubes. The resin is sprayed with coolant to counteract exothermic heat as it sets. The entire complex is gently lifted out as a unit, without dislodging or displacing any of the three components.

A surgical centric recording is taken (as described previously) with a polyvinylsiloxane putty, and a counterimpression is made with alginate. The wounds are debrided and irrigated, and the transdorsal retention sutures are removed. Closure is performed with 3-0 black silk suture. The cast should be boxed, poured in Vel Mix, separated, and articulated.

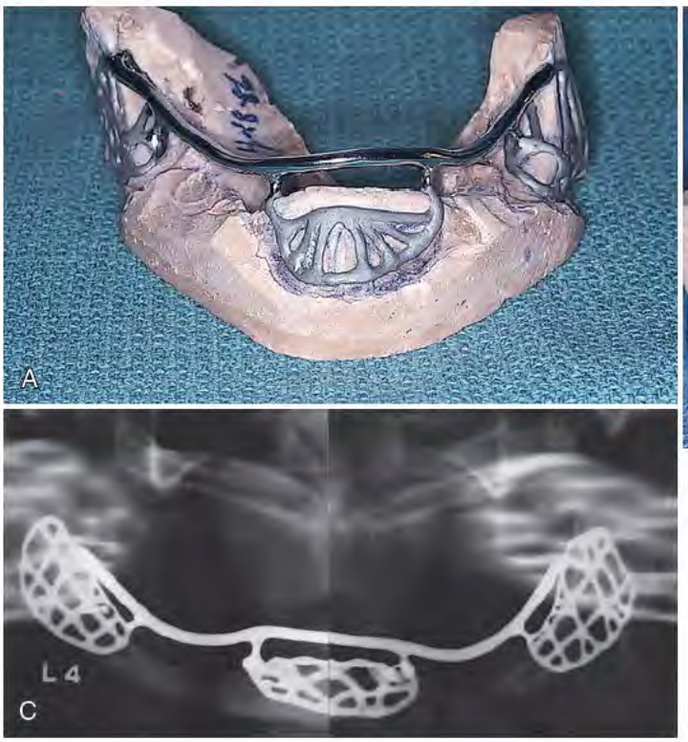
Design of Casting

The design of each islet is determined after the cast has been surveyed. Barring undercuts, the peripheral struts of each segment should cover as much area as was included in the impression. Secondary struts should be 7 mm apart and numerous.

The Brookdale bar, of a shape that serves as an overdenture retainer, should be connected at two points to each islet; this means that the patient has an implant with six sites of permucosal penetration. Two should be placed (by making an X on the cast in the designated positions) on the anterior islet in each of the canine positions. On the posterior islets, one each is located at the anterior ends, at the ridge crest. The most posterior cervix on either side should be a horizontal extension of the Brookdale bar directly through the tissues and connecting with the highest extent of the posterior islet's peripheral strut. Because the bar should exit through fixed gingiva, it must course laterally backward in an S configuration to become joined at the lateral aspect of the ramus (Fig. 14-21, *A* and *B*).

Insertion

Tripodal implants are placed by retracing the original incisions. The implant is put into position and tapped for final seating. Closure is performed using the classic suture techniques as described previously (Fig. 14-21, *C*). (Resolutions for rocking or instability of the infrastructure that cannot be solved by firm tapping with an orangewood stick are presented in Chapter 28.)



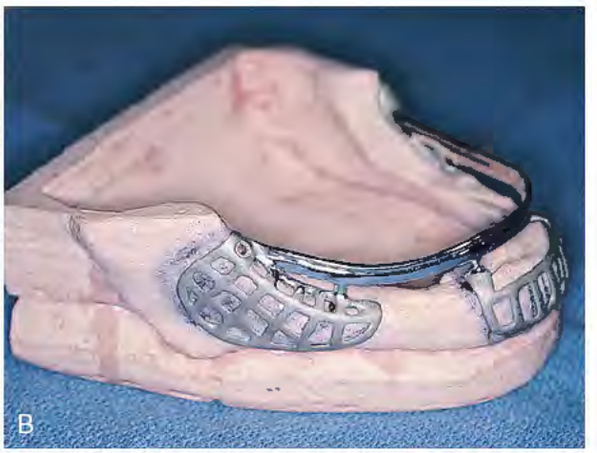


FIGURE 14-21. **A,** The tripodal design has few crestal elements and a significant symphyseal component. **B,** The rami are sites of vital support. As they come closer together during jaw opening, tension that stimulates a dynamic osseous environment and ongoing bone remineralization is created. Two points of permucosal penetration are found at each posterior end: the first is horizontal to the ramus, the second is vertical to the retromolar pad. Either of these may be resected if the need arises. **C,** A Panorex radiograph demonstrates the dramatic extension of the tripodal islets and the bar configuration.

PARTIALLY EDENTULOUS DESIGNS

Implants for partially edentulous jaws are rarely used for an atrophied mandible, because ramus blades usually are more appropriate, less costly, and far less complicated to seat. With an atrophied mandible, implants for partially edentulous jaws are used only as posterior abutments for fixed bridge prostheses, and one or two abutments are placed in the most desirable locations to receive fixed retainers (Fig. 14-22). Their abutments should be shaped like crown preparations.

The impression technique, design, and placement of such implants, either as paired unilaterals or as a universal implant that circumvents the remaining anterior natural teeth, should follow the steps outlined in this chapter for the tripodal implant.

The universal implant must be designed with bilateral islets similar to those of the tripodal implant. The islets are connected by lingual supragenial tubercle and labial juxtasymphyseal struts, which allow the anterior teeth to remain untouched; this arrangement also allows them to be connected in a fixed, stress-broken prosthesis or mesostructure bar to the implant's abutments. The steps in making a universal implant are the same as for the classic, fully edentulous implant. However, the natural teeth must be included in the impression. The design, which does not allow bar construction in the areas of natural teeth, must have stronger peripheral and secondary struts to offer better rigidity in these cutout areas. Placement follows the standard techniques, and guidance for prosthetic options is given in chapters 20 and 21 (Fig. 14-23).

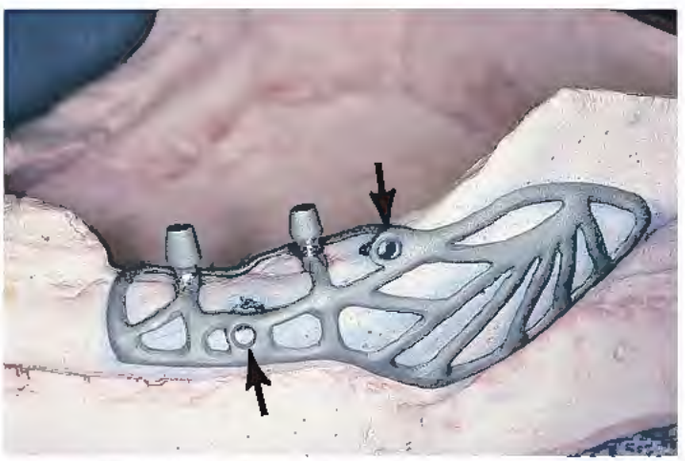


FIGURE 14-22. This unilateral subperiosteal implant with two abutments is designed for reception of a fixed bridge prosthesis. Two screw holes are required to achieve primary retention *(arrows)*.

SUBPERIOSTEAL IMPLANT PROSTHODONTICS

Universal and unilateral subperiosteal implants are cast with their abutments attached and as such are considered one-stage implants. They can be, and often are, restored with fixed prostheses. Care must be taken so that the natural teeth do not become carious as a result of cement failure (caused by the differences of support mechanisms between natural teeth and implants). The implant abutments should have been cast parallel to the natural teeth (Fig. 14-24, *A*); if they were not, corrective telescopic castings solve the problem. The abutments should be matte finished for the creation of a more lasting cement seal. Each natural tooth should have a separate gold coping cemented to it. Upon completion of this step, a bridge of high-percentage precious metal alloy is made using a standard elastomeric impression technique. Acceptable crown and bridge procedures are followed, including the use of a custom tray and syringe. Polyether (e.g., Impregum) or polyvinylsiloxane (e.g., Reprosil) materials are recommended for single-stage implant impression making.

Implant abutments are treated as if they were natural teeth, including the use of retraction cord. All small fins of impression material that may have become wedged beneath the gingivae at the implant cervices must be removed after completion of the impression. Crown margins (except in areas that require a high level

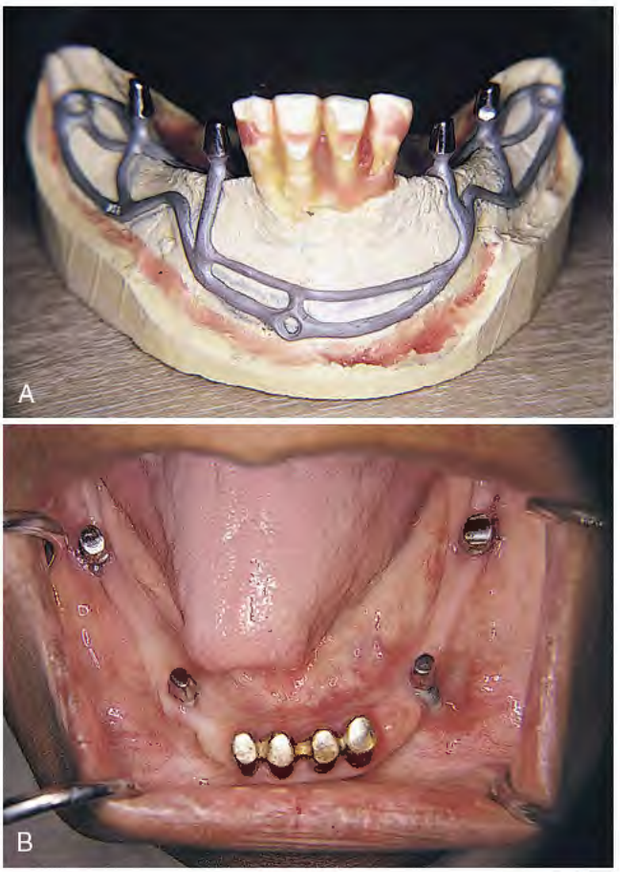


FIGURE 14-23. **A,** The universal subperiosteal implant (Samuel Weber design) circumvents natural teeth. The abutments must be made parallel to the natural dentition. **B,** After the universal subperiosteal implant has been inserted and the protective copings on the incisors have been cemented, an overdenture prosthesis may be made.

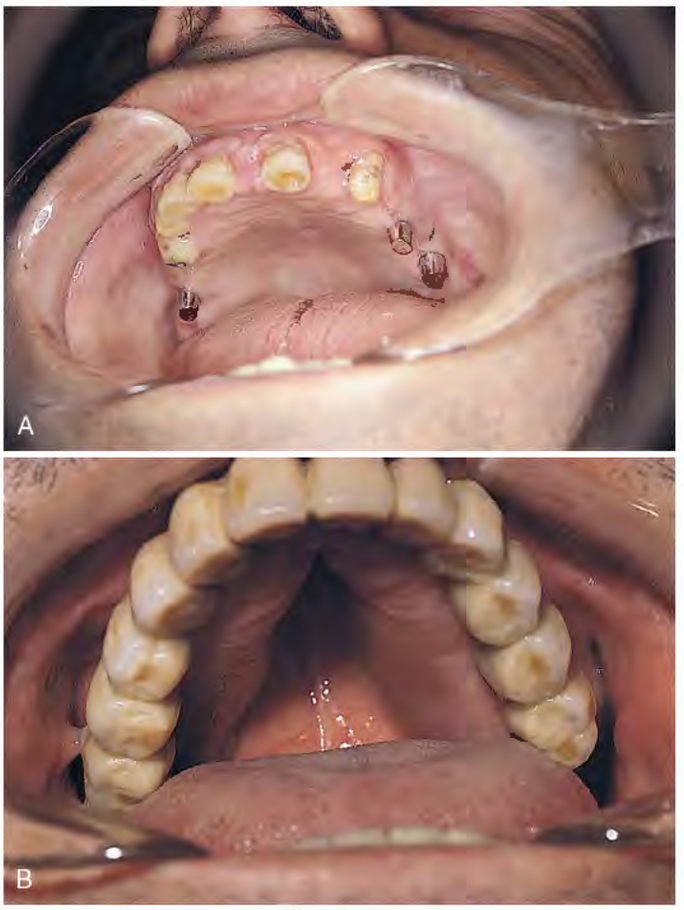


FIGURE 14-24. **A,** A fixed prosthesis sometimes is desirable for restoration of a universal subperiosteal implant combined with natural abutments. **B,** This composite veneered gold coping bridge serves both functionally and esthetically as a final prosthesis. If temporary cement is to be used, the natural teeth are given gold copings.

of esthetics) should be supragingival. Designs should include canine-protected occlusion free of lateral excursive interferences. The buccolingual occlusal tables over implants should be narrow and approximate the width of premolar teeth. Laboratory-quality composite restorative material processed to the metal castings completes the process of fabrication (Fig. 14-24, *B*).

Final prostheses for unilateral and universal implants may be cemented with temporary cement, because the underlying natural teeth have been protected with gold copings. This allows for repairs, hygiene treatments, and simple troubleshooting procedures (see chapters 27 and 28). When retrievability is desired or if the abutments are short and poorly retentive, lingual retention screws (Howmedica) can be used (Fig. 14-25). Final prosthesis construction for complete subperiosteal implants follows the instructions presented in Chapter 26.

COMPUTER-ASSISTED DESIGN/ COMPUTER-ASSISTED MANUFACTURE (CAD/CAM) TECHNIQUE

ARMAMENTARIUM

CAD/CAM company for stereolithographic laser model fabrication
Jaw-positioning splint
Particulate grafting material: 20 mesh or 200 -500 micron size
Resorbable membrane
Membrane tacks
Titanium bone screws
Cone Beam machine (CBVT)
Radiologist with GE 9800 CT scanner or its equivalent

CAVEAT

The implantologist must be experienced with subperiosteal implant bone impression techniques before attempting this method, to be able to manage situations in which the CAD/CAM-generated casting does not fit and a traditional impression must be taken.

Use of an advanced computer can eliminate the first-stage bone impression surgery and radiographic technology, replacing it with a program known as *computer-assisted design/computer-assisted manufacture* (CAD/CAM). If a diagnostic computed tomography (CT) scan was performed for analysis of the placement of the endosteal implant (see Chapter 4), in most cases the head position was not correct for use by the CAD/CAM company. A new head orientation may have to be used, depending on the software (but using the same immobilization jigs, without the original gutta percha points).

Basically, the CT scan data are transferred to a magnetic tape, which subsequently is loaded into a computer. The computer interfaces with a three-point milling machine to generate a model of the bony maxilla or mandible. This model is used as the master cast

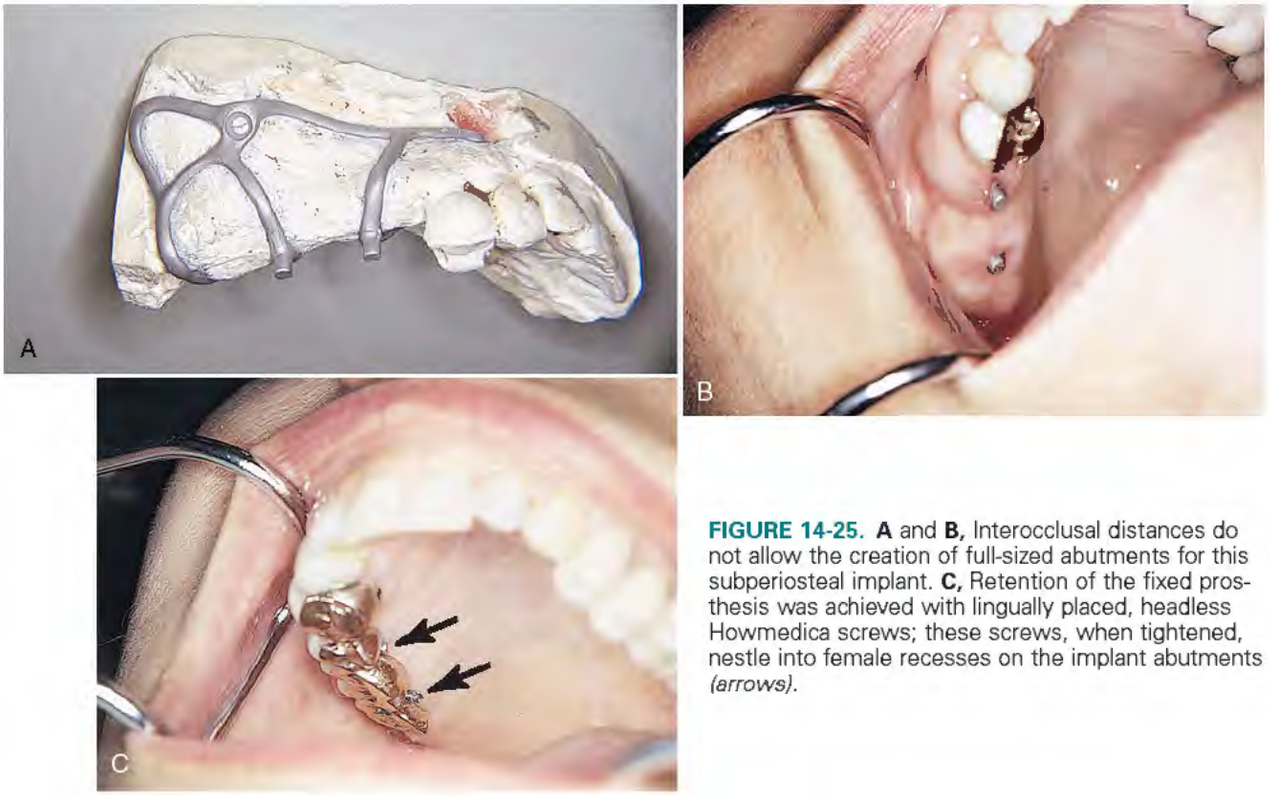


FIGURE 14-25. **A** and **B,** Interocclusal distances do not allow the creation of full-sized abutments for this subperiosteal implant. **C,** Retention of the fixed prosthesis was achieved with lingually placed, headless Howmedica screws; these screws, when tightened, nestle into female recesses on the implant abutments *(arrows)*.

when an implant casting is designed. Recently, technology has been introduced that produces bone models from CT scan magnetic tapes by means of laser sculpture; this is called *stereolithography.* Particular advantages of this method are the excellent accuracy achieved and the liberal requirements allowed by the imaging process. Records are acceptable from virtually any scanner, and the specific head angulation plays no role in the process.

CAD/CAM techniques have significant benefits. First, the patient is spared the lengthy first-stage surgical procedure. Second, because only one surgical procedure is performed, the mucosal tissue is less traumatized and, consequently, heals more readily. Third, greater extension of the implant can be achieved on bearing bone sites than is possible with a two-stage impression technique.

Because this technique allows the design of an implant that can extend much farther peripherally, the dissection for seating has to be more aggressive than ordinarily is required. If the casting is not acceptable at the time of surgery, however, a direct bone impression may be required to make a satisfactory implant. As mentioned elsewhere in this chapter, accuracy of fit alone should not mean rejection of an implant. Stability, on the other hand, is mandatory. If innovative adjustments can achieve three or more point contact stability, screw fixation and particulate 20-mesh HA augmentation are useful for completing the operation. The patient must always be informed that a two-stage procedure may become necessary (see Appendix F).

The patient also should be told that the total radiation exposure of the CT scan is equivalent to about that of a chest radiograph, and that the individual will be on the gurney for about 20 minutes unless the unit is a helical scanner, which completes the process in 50 seconds. The patient must remove all metal from the head and shoulders (e.g., earrings, necklaces, and metal-based dentures) before the scan. Metallic restorations must be removed from the jaw to be scanned.

Preparing for the Scan

The following essential steps must be performed in preparation for the CT scan procedure.

1. The radiologist must be consulted to determine that this individual has been trained in these techniques.
2. The practitioner must ensure that no metal is present in the arch to be scanned (it causes an obliteration of adjacent structures). If metal does exist, it must be replaced, at least temporarily, with a nonmetallic restoration. Titanium, however, may be left in position because it does not cause the "starburst" or scatter effect.
3. The patient should be provided with an intraoral jig or jaw-stabilizing device, which is to be worn during the scanning process. This prevents jaw movement during the scan. This is accomplished by fabricating base plates with wax occlusal rims for both arches and, using standard prosthodontic techniques, luting them in a proper centric relationship and at the correct vertical dimension. After the casts are mounted on a semiadjustable articulator (Hanau or Whip-Mix), all wax and bite paste material are removed, and the upper and lower base plates are locked together with self-curing acrylic rims. They should be supraoccluded with 3-mm-high shims. One vertically placed No. 50 gutta percha point should be processed into each canine area of the lower rim. On the images, this helps establish the locations of the mental foramina. Denture adhesive may be used to help stabilize this jig during the scan procedure. If a question arises about retention, the appliances can be relined with Viscogel (Fig. 14-26). (More details about appliance fabrication are presented in chapters 4 and 20.)

A clear acrylic duplicate of the patient's own denture, with the denture base made of 25% barium sulfate and radiopaque markers

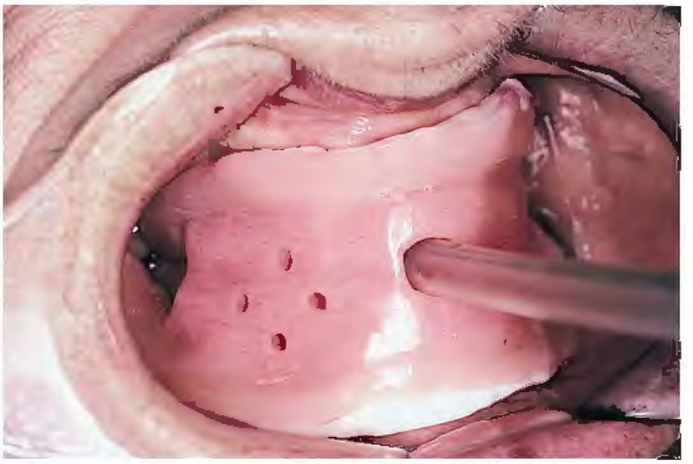


FIGURE 14-26. The computed tomography (CT) scan intraoral stabilizing device is in position. The four small holes are for breathing, and the metal-free, plastic tube is for aspiration of saliva.

for orientation mounting on the stereolithographic model of the jaw bone with soft tissue made from the data from a CT or CBVT scan.

4. A nonmetal saliva ejector and a source of suction must be available in the radiologist's office. It should be operated at minimal force so that it does not injure the tongue or the floor of the mouth. An antihistamine (e.g., diphenhydramine [Benadryl], 50 mg, given intravenously) helps reduce salivation and allay anxiety.
5. The radiologist should be given a recent panoramic x-ray film of the patient. This aids explanation of the perimeters of the scan field.
6. Calibration rods, which are taped to the patient's face over the zygomas, should accompany the individual; they are used to detect patient movement. The CAD/CAM company supplies them, and the rods can be reused for subsequent patients.

Role of the Radiologist

The following are essential steps for the radiologist in preparation for the CAD/CAM procedure.

1. The panoramic x-ray film must be reviewed so that the total area included in the scan is recognized (the perimeters).
2. Patient movement must be minimized. The x-ray slices must be acquired in rapid sequence, from inferior to superior, in one direction, over a period of about 20 minutes. The patient must be instructed not to swallow during the scan. Salivary evacuation and diphenhydramine can help achieve this goal.
3. The technician must take a lateral skull film (scout view) with the maxilla or mandible at a 15- to 20-degree angle to the x-ray beam for the Calcitek protocol or a 0-degree angle to the alveolar crest for the Techmedica protocol (Fig. 14-27). In total, 30 to 50 slices are needed (see Appendix C for scanner settings). Laser (stereolithographic) fabrication has no such angulation requirements (see Appendix C).
4. The radiologist should load the image data and image heading into a new magnetic tape in the uncompressed form and label it with the following information: CT scanner used; radiologist's name, address, and telephone number; patient's name; surgeon's name; jaw studied; and date.
5. The radiologist must understand that 1 to 2 mm of movement is the maximum that is acceptable. The calibration rods taped to each of the patient's cheeks parallel to the table top and perpendicular to the x-ray beam indicate by the clarity of their reproduction on the completed images whether the results are free of distortion.
6. The first slice should start below the inferior border of the mandible, and the last should end at the sigmoid notch level. This constitutes a complete mandibular model. For the maxillae, the perimetric boundaries should extend from below the residual ridge or occlusal surfaces of the teeth and extend superiorly to the infraorbital rims.

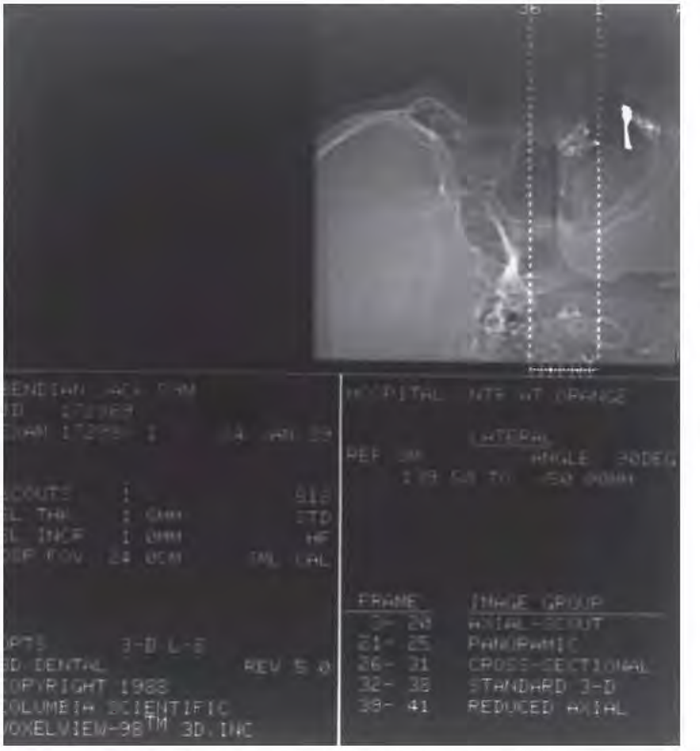


FIGURE 14-27. The first, or scout, film for preimplant CT scanning has two dotted lines, which indicate the inferior and superior extents of the scan. They must be parallel to the occlusal plane or the crest of the ridge.

Stereolithography (Laser-Forming Technology)

As services available for CAD/CAM technology wane, an accurate technique that requires far less rigid protocols on the part of the implantologist and radiologist has been introduced. Innova is one such laboratory that presents a simple protocol. It instructs the radiologist to use a 0-degree gantry tilt and scan the supine patient with the nasomental line at right angles to the table. They recommend 1-mm slices. To ensure that the patient remains still throughout the scan, opaque positioning or calibration rods are affixed to the patient's face.

The technology for model manufacture is different from the milling machine fabrication formerly used. Stereolithography is an additive process of creating physical replicas from the electronic data produced by CT scanning. The apparatus consists of a computer-guided laser that creates a layer by layer augmentation using a photosensitive liquid that solidifies, on completion, into an anatomic model. Other companies that offer similar services are Medical Modeling Corporation and 3D SLA Bio-tec Systems. (The protocols for these companies are given in the Appendix C.) These technologies can use magnetic resonance imaging (MRI) as well as CT scans to fabricate models and are less demanding about CT scanners and patient head position.

Fabrication of the Cast

Once the CT scan tape has been given to the company of choice, the company fabricates a model of the jaw (Fig. 14-28). A detailed laboratory prescription must be written; the implant is designed on the final model according to the recommendations made in this chapter. If both maxillary and mandibular subperiosteal implants are planned using this technique, the patient must be passed through the scanner twice, with the head orientation altered for each jaw. Stereolithography, however, requires only one cycle large enough to include cuts for both jaws.

Implant Fabrication

Until recently, the dental surgeon and the laboratory personnel had to make an educated guess at abutment or bar locations, because the generated model could not be related to the opposing jaw. Soft tissue occlusal records have been shown to be very inaccurate, causing extreme misplacement of abutments or bars (Fig. 14-29). To solve this problem, using a cast returned from the CAD/CAM laboratory, the surgeon can use the tube and stylus technique.

FIGURE 14-28. A cast produced by stereolithography shows the extensive exposure of peripheral structures.

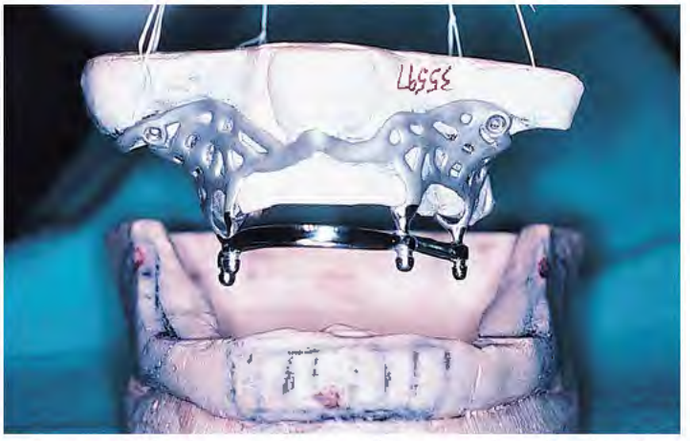


FIGURE 14-29. The completed casting cannot be related to the opposing jaw, nor can abutments and bars be placed in appropriate positions; it is essentially "hanging in space."

Tube and Stylus Technique for Establishing Centric Relationships

1. A preoperative cast of the ridge to be implanted is made. An acrylic base plate and wax rim are used for accurate centric and vertical measurements, using a conventional prosthetic technique. An alginate counterimpression (of natural teeth or a prosthesis) completes this step.
2. At each of five sites in the peripheral flange of the acrylic base plate (right and left first molars, canines, and in the midline), a hole ¼-inch in diameter is cut.
3. An orthodontic tube (0.045-inch inside diameter) with a welding flange is luted into each of the holes cut into the base plate and locked into place with acrylic (Fig. 14-30, *A*). Each tube is placed in an oblique direction aimed toward the ridge crest. The deep end of each tube must be placed directly against the tissue surface of the rim. Access to each tube must be available from the buccal side when the rim is seated and the lips and cheeks are retracted.
4. A 20-gauge, 1½-inch long, disposable hypodermic needle is used for each of the orthodontic tubes (Fig. 14-30, *B*). The needles will fit passively but snugly into the tubes.
5. The acrylic rim is placed in the patient's mouth to confirm that a correct occlusal plane has been established and that it offers the proper vertical dimension and centric relationship.
6. The buccal vestibule is anesthetized at the locations of each of the five tubes.
7. The patient is asked to close into centric occlusion, which stabilizes the rim. One of the hypodermic needles is placed through each of the orthodontic tubes. (Retraction of the lips or cheeks elevates the tissues of the vestibule.) A needle holder is used to push each needle through its tube until bone stops it (Fig. 14-30, *C*). The patient keeps the rim stabilized by continuing to bite while these simple needle seating procedures are complete (Fig. 14-30, *D*).
8. To stabilize the needles, each is fixed by crimping the orthodontic tube with a pliers (Fig. 14-30, *E*). The rim then can be removed by gentle manipulation after the patient opens the mouth.
9. The model of the opposing arch is affixed on a simple articulator.
10. The operative wax rim is occluded to the countermodel with needle positioners and luted with sticky wax.
11. The CAD/CAM model is placed in the base plate (Fig. 14-30, *F*). The points of the needle will strike the bone model at the five sites, yielding accurate seating. The model is fixed to the articulator with quick-setting plaster, which completes the mounting (Fig. 14-30, *G*).

At this point, the mounted models accurately reflect the relationship between the bony operative jaw and its opposing dentition (Fig. 14-31). This allows accurate height and placement of the implant bar or abutment. In this fashion, an implant can be constructed with accuracy and precision following the designs described in this chapter (Fig. 14-32). After it is returned from the laboratory, the implant should be passivated, treated, and sterilized as described in Appendix C.

Surgery for Insertion of the Implant

Surgery for placement of the CAD/CAM implant is the same as that described in the first part of this chapter. Every precaution must be taken. Regional block anesthesia is more effective for

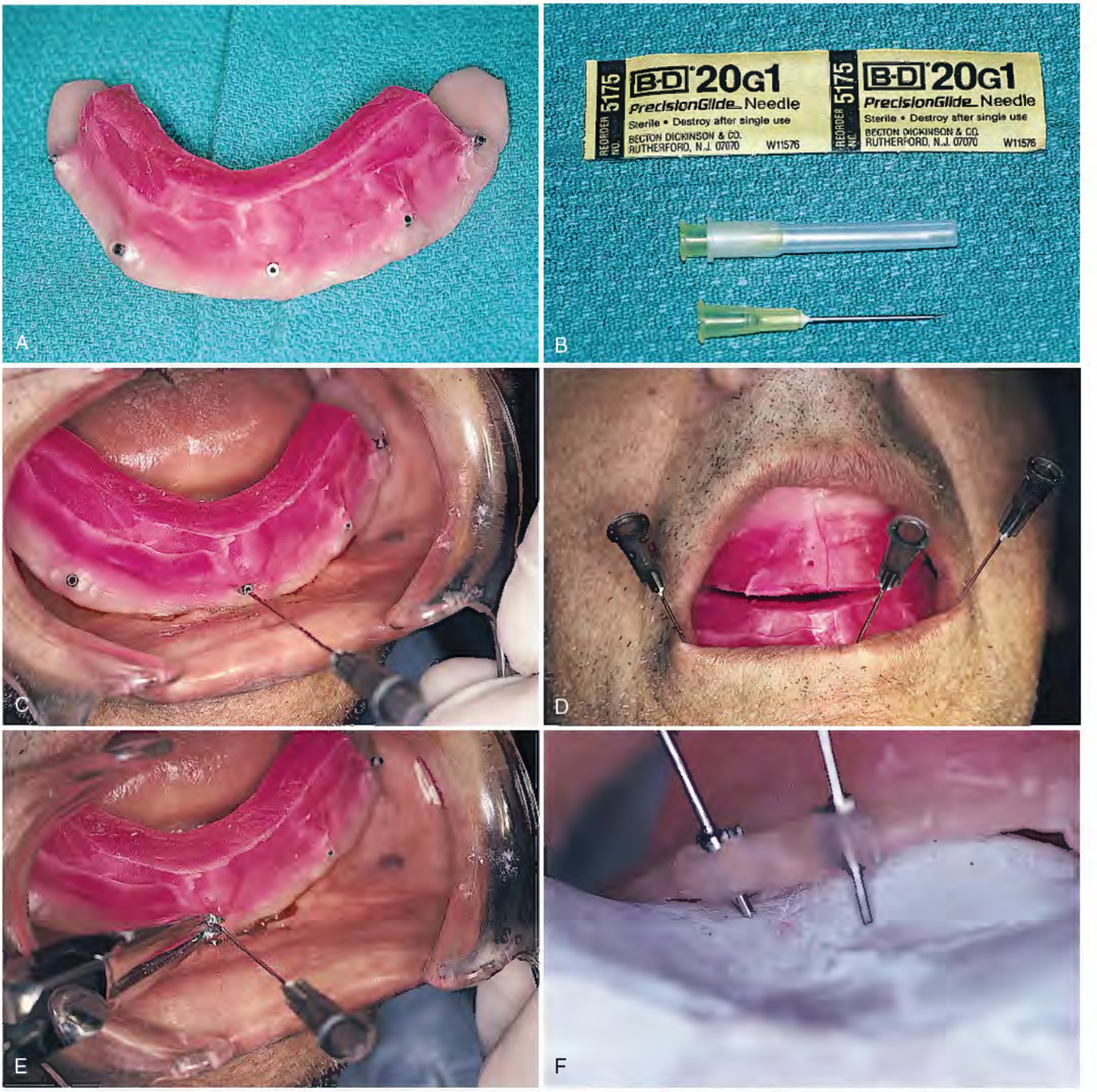


FIGURE 14-30. Tube and stylus technique. **A,** To establish an accurate relationship between a CAD/CAM cast and the opposing dentition, the surgeon processes five orthodontic tubes (0.045-inch internal diameter) into the flanges of an acrylic-based wax rim. **B,** The tubes accommodate 20-gauge, 1½-inch sterile hypodermic needles. **C,** An infiltration anesthetic is administered, and the rim is put in place. A needle is passed through each tube, piercing the mucosa and contacting bone. **D,** The patient keeps the rim in place by maintaining firm centric position. After each of the five needles has been placed, the patient may open the mouth. **E,** The position of each pin or needle is maintained by crimping each tube against its needle. **F,** The base plate is removed. The five extended points have established a direct relationship between the bone model and the bite rim, precisely the same as the relationship against the patient's own bone. **G,** Centric and vertical relationships are transferred to the casts. After articulation, the bone model will be positioned accurately in relation to the opposing dentition.

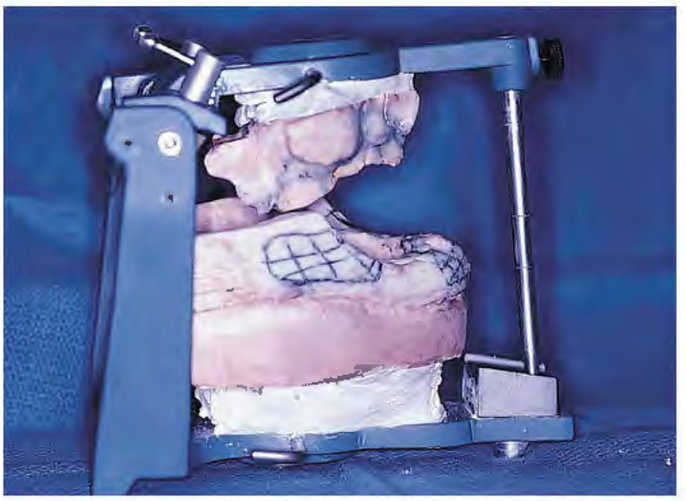


FIGURE 14-31. Articulation with the tube and stylus technique accurately relates even the most unusually related bone models.

placing CAD/CAM implants than for conventionally made ones, because the anesthetic will be given for the first time.

After the bone has been exposed, it must be inspected carefully. Minor areas of irregularity, as well as spinous and irregular structures that might not have been detected by the scan, must be eliminated. With proper retraction, the implant is seated. The experienced implantologist may be moderately disappointed to note the lack of expected accuracy of metal to bone adaptation. After several cases, a new set of standards is acquired for acceptability. Instability or rocking, however, is not permissible. If three or more points of good bone contact allow a stable or firm seating, liberal amounts of 20-mesh particulate HA graft material should be used under and around all struts that demonstrate deficiencies (Figs. 14-33).

Closure should follow in the routine manner described earlier (Figs. 14-34 and 14-35).

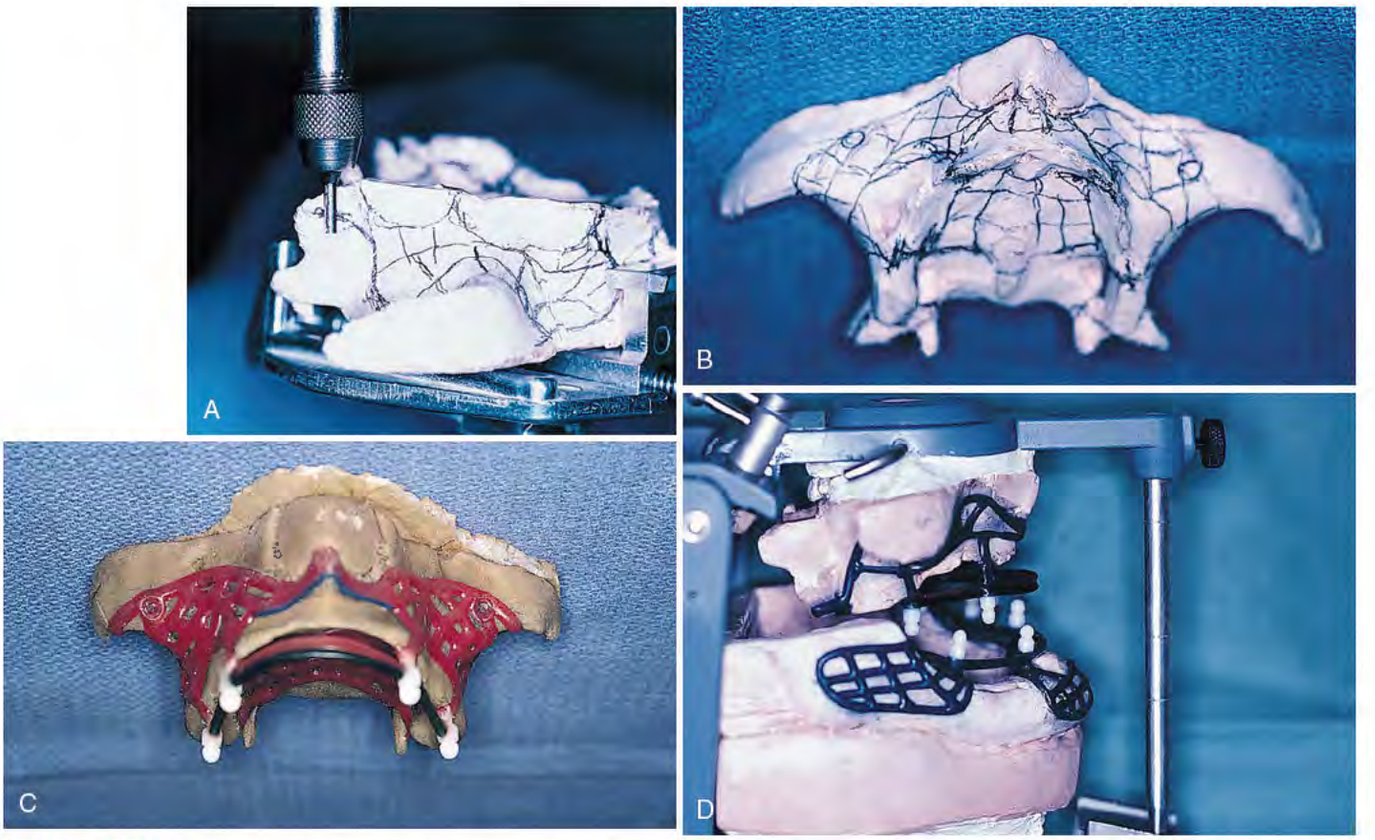


FIGURE 14-32. **A,** Positive, screw-free retention can be achieved by surveying a stereolithographic cast and marking the points of widest dimension. **B,** An infrastructure should extend slightly into undercut zones. Screw holes are included for elective use. **C,** The wax-up with bar and O-ring attachments, when cast, will move into place only if tapped with a mallet and orangewood stick. It then fits quite firmly. **D,** Waxed implants must be related to each other or to the opposing denture so that occlusal forces are directed optimally through their infrastructures. For the CT scan method, these relationships are achieved only by using the tube and stylus technique.

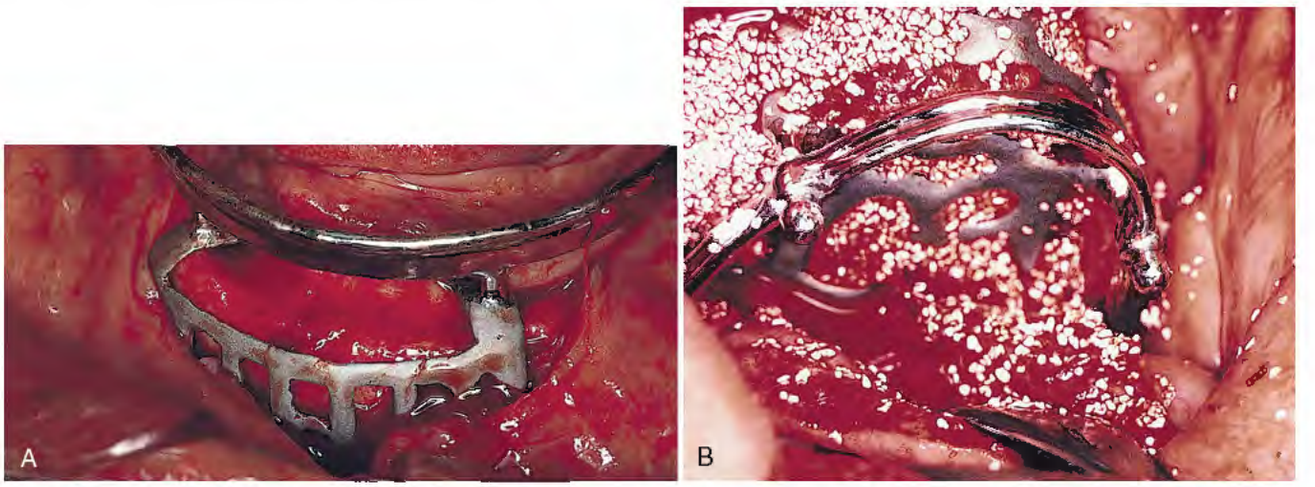


FIGURE 14-33. **A,** After castings have been placed, each strut is checked for accuracy of fit. **B,** In case of an inaccurate fit, if the casting is stable, the discrepancies may be managed successfully by adding graft materials.

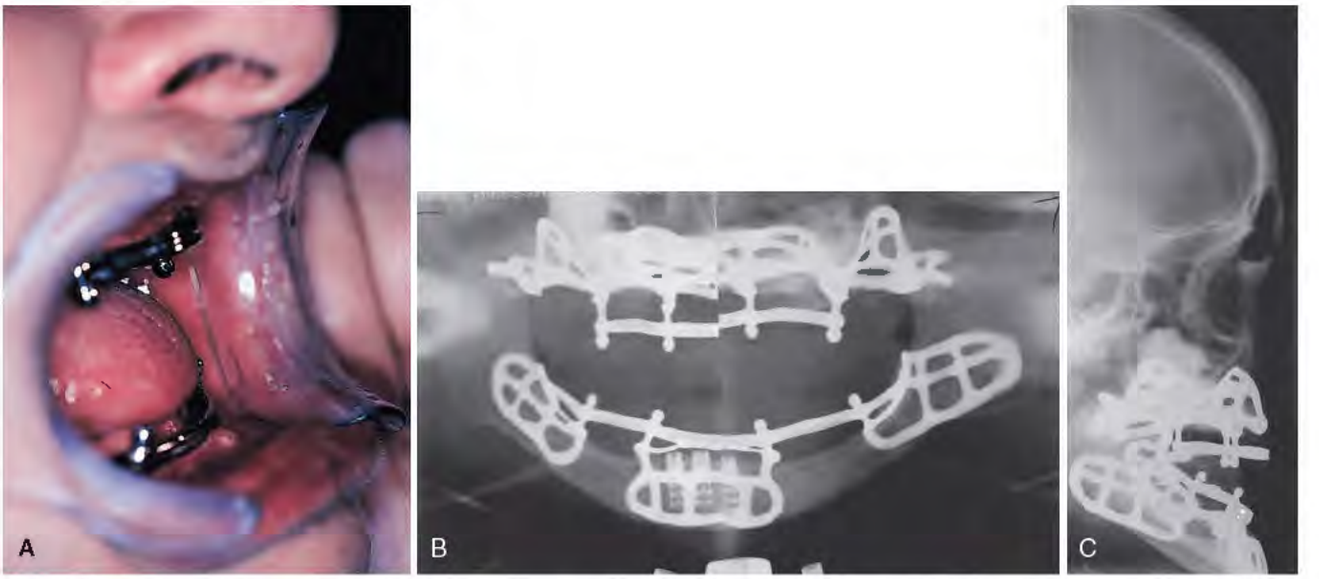


FIGURE 14-34. **A,** Careful presurgical and prosthetic planning eliminates guesswork in bar and abutment placement. This makes prosthetic techniques simple and accurate. **B,** CT scan technology allows for fabrication and placement of two subperiosteal implants in one operative session (with the patient under general anesthesia). Because the osseointegrated Core-Vent implants, which were allowed to remain in the symphysis, are made of titanium, scatter did not blemish the scans. **C,** Direct bone impressions do not allow the kind of peripheral extension that computer generation does.

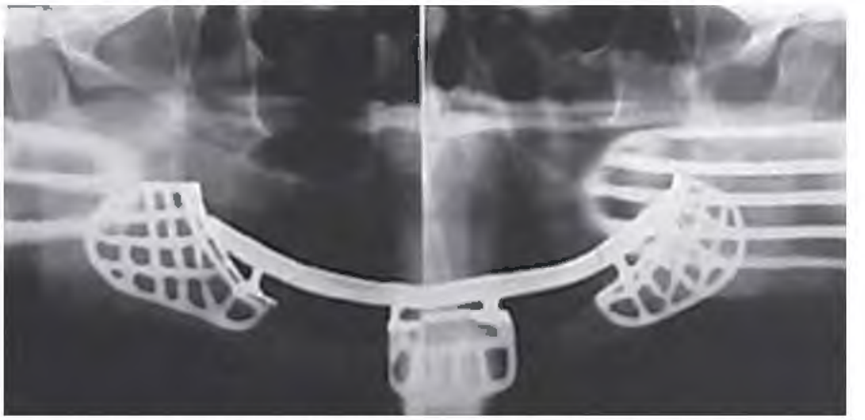


FIGURE 14-35. The CAD/CAM technique allows fabrication of tripodal implants, which allows islet placement in zones best designed to resist stress and sometimes too inaccessible for direct bone impression maneuvers.

Maxillary Pterygohamular Subperiosteal Implant Surgery

15
CHAPTER

ARMAMENTARIUM

Acrylic: self-curing (Formatray)
Articulator, Whip-Mix
Coe-Comfort soft tissue conditioner
Diamond drill: Atwood 347 for the straight handpiece
EZ Tray material
Forceps: Gerald
Hall drill
Hemostats: long curved (i.e., tonsil hemostats) and mosquito
Impression material and adhesive: Neoplex regular
Mallet
Needle holder
Needles: sterile hypodermic, 20 gauge, 1½ inch
Orangewood sticks
Orthodontic tubes: 0.045 inch (inner diameter [ID])
Pliers: crimping
Scalpel: long handle
Scalpel blades: Bard-Parker (BP) No. 12 and No. 15
Scissors: Mayo and Dean
Screws: 7-mm Vitallium
Screwdriver: Vitallium
Surveyor
Suture: 2-0, 3-0 black silk; 4-0 dyed Vicryl
Thermostatically controlled hot water bath (180° F)

CAVEATS

When the lateral posterior mucoperiosteum is reflected, either below or just adjacent to the zygomatic buttress, care must be taken not to perforate the maxillary sinus. Some eggshell bone may come away, but if it is allowed to remain attached to the periosteum, it serves a viable reconstructive role. Antral openings must be protected from becoming filled with impression materials.

An overenthusiastic periosteal elevator or long needle in the posterosuperior area may cause pterygoid plexus hemorrhage. If this should occur (as evidenced by considerable venous bleeding or rapid swelling of the face), the forefinger is used to apply firm tamponade upward and inward in the posterior vestibular area for a full 10 minutes.

A periosteal elevator may injure or tear the infraorbital or greater palatine neurovascular bundles. Care must be taken when approaching these foramina.

The buccal fat pad is always beneath the retractor. If it prolapses, as it often does, it should not be cut or resected, because this may change the patient's facial symmetry markedly. When the surgery is complete, the pad should be tucked back in and the flaps should be sutured over it.

If the pterygoid plate or raphe dissections are bilateral and are performed vigorously in a susceptible patient, edema from each side may compromise the airway. The surgeon must be aware of this possibility and must be prepared to (1) use steroids (dexamethasone, 10 mg given orally or 20 mg given intravenously, followed by 5 mg four times daily); or (2) institute surgical airway management (e.g., orotracheal or nasopharyngeal tubes or airways or tracheostomy).

Hydroxyapatite (HA) coatings may be beneficial at interface areas, but they do not allow the implant to be flexed or malleted into place, nor do they offer assurance of the classic suspension mechanism required for implant success. Design considerations must play a role in prescribing HA coatings.

In addition, 12- to 36-hour, two-stage subperiosteal implant procedures cannot be performed if HA coatings are ordered, because the time frames are not correct for these procedures.

The surgery for pterygohamular subperiosteal implants requires experience and aggressiveness to expose the prospective bone-bearing areas.

COMPLETELY EDENTULOUS DESIGNS

Experience over the past 20 years has yielded unpredictable prognoses for maxillary unilateral and complete subperiosteal implants. Failure probably occurred because infrastructural components were placed on a bone foundation not well designed to withstand occlusal stresses. The resulting resorption led to failure of bony support, antral complications, and subsequent exteriorization of these devices. However, a design change took place, called the *pterygohamular extension.* With the addition of peripheral struts in the pterygohamular areas and on other, more reliable basal bone buttresses, a more predictable device was produced. This chapter outlines each step leading to the production of pterygohamular complete, universal, and unilateral maxillary subperiosteal implants. If surgeons are comfortable with other designs, the placement techniques are the same.

Procedure

For surgeons experienced in hospital procedures, this operation may best be performed in the operating room with the patient under general anesthesia. However, regional block with sedation is an alternate way to proceed.

Routine maxillary infiltration anesthesia is not sufficient. Second division (greater palatine), posterosuperior alveolar, and infraorbital blocks are necessary, in addition to considerable deep infiltration into the pterygomandibular raphe. After the tissues have been anesthetized, a sharpened millimeter probe is used to measure the tissue thickness at the sites of planned permucosal abutments, each of which should be placed in attached gingiva. These measurements are recorded on a preoperative study model or chart.

Incision

The incision is made at the crest of the ridge on the linea alba, from the distal incline of one tuberosity around the arch to the contralateral side. A midline relieving incision is required just lateral to the labial frenulum, which extends up to the nasal spine.

Reflection

A sharp periosteal elevator is used to lift the palatal flap cleanly from the bone. It is lifted as close posteriorly to the junction of the soft palate as can be managed (Fig. 15-1). This cannot be done without severing the incisive neurovascular bundle, but no significant harm results from doing so. The structures that prevent a complete soft

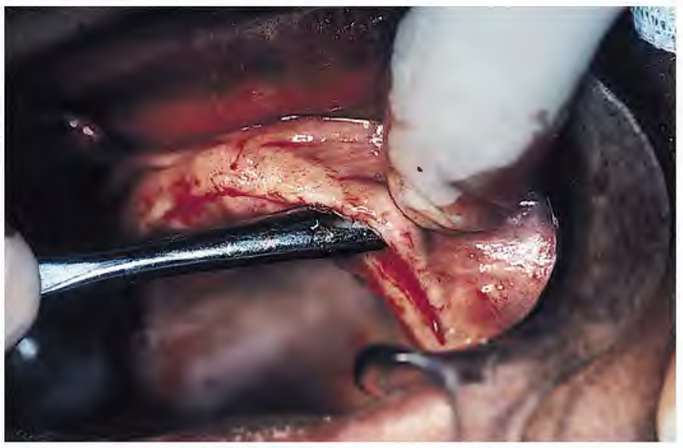


FIGURE 15-1. To obtain an impression for a pterygohamular implant, the surgeon makes a crestal incision from the base of the tuberosity forward to the midline of each side. Reflection must be completed with a sharp periosteal elevator.

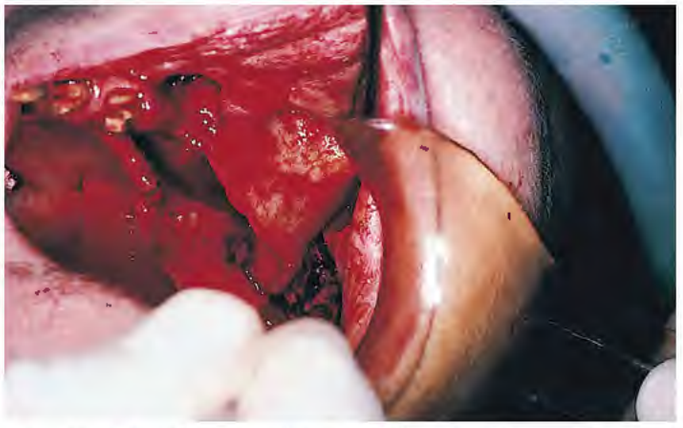


FIGURE 15-2. When complete, reflection should reveal the zygomatic buttresses, the greater palatine foramina, the canine fossae, the incisive foramen, the anterior nasal spine, and the pyriform apertures.

tissue reflection are the greater (anterior) palatine neurovascular bundles bilaterally, and they must be preserved. They may be seen clearly running anteriorly from their foramina (located just medial to the ridge crests in the second molar areas) in the periosteal surface of the reflected palatal flaps. The periosteal elevator is extended behind and lateral to these foramina, and the overlying tissues are lifted away from the hamulus bilaterally (the hamulus is found just at the anterior end of the medial pterygoid plate) (Fig. 15-2).

On the labiobuccal aspects, the mucoperiosteum is elevated beginning at the midline and proceeding posteriorly on both sides. In this way, the structures that are exposed and that may be identified clearly are the anterior nasal spine, pyriform apertures, canine fossae up to the lower rim of the infraorbital foramina, zygomatic buttresses (no less than 3 cm beyond their roots), posterolateral maxillae (to a height level with the superior surfaces of the zygomatic arches), and the entire bony tuberosity.

The remainder of the pterygohamular complex is the last structure to be exposed. A Bard-Parker (BP) No. 15 blade on a long handle is used to extend the original incision from the distal end of the tuberosity downward in the mucosa overlying the pterygomandibular raphe. As the mucosa falls open, the gleaming white fibers of the raphe become evident (Fig. 15-3). Blunt dissection with the forefinger on either side of the raphe reveals the attachment of these

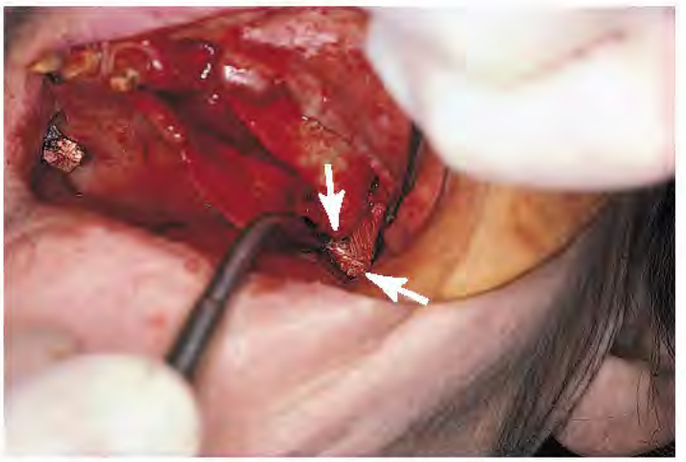


FIGURE 15-3. After completion of the primary reflection, a second incision is made from the base of the tuberosity downward over the pterygomandibular raphe for a distance of 2 cm. Blunt and sharp dissection beneath this incision exposes the gleaming white fibers of the raphe *(arrows)*. These fibers are dissected from the lateral and medial pterygoid plates and the hamulus. This can be done only by sharp dissection using long, pointed, curved surgical shears.

fibers to the pterygoid plates. The raphe is stretched with the periosteal elevator, and curved or angled, long-handled scissors (Dean) are used to snip away the fibrous attachments, with care taken to stay directly against bone. In most cases, the raphe is extensive, and considerable cutting is necessary. When it finally comes free, it is intact and easy to identify because of its glistening whiteness.

Beneath the raphe are the pterygoid plates, which the surgeon identifies with the fingers of the dissecting hand. Further vigorous blunt dissection of the overlying soft tissues pushes these tissues firmly from both plates. They are clearly palpable, even though they may not be visualized. The probing finger should be able to nestle into the fossa between them. The sharp dissection is complete only when this complex is exposed fully. A saline-soaked sponge is packed into the site to maintain hemostasis and prevent desiccation.

The periosteal elevator should lift the palatal tissues anteromedially from the base of the medial pterygoid plate forward to the hamulus, a small finger of bone. If the tissues are resistant to elevation, a BP No. 12 blade is used as if it were a periosteal elevator, stroking gently but firmly at the bone level until the hamulus is exposed. When the overlying mucosa is elevated, a tendinous structure is found at its lateral base. The hamulus serves as a pulley for this structure, the tendon of the levator veli palatini muscle. To expose the hamulus for the impression, the tendon is cut with a BP No. 12 blade.

The final bit of exposure is done on the lateral maxilla posterior to the zygomatic root and anterior to the lateral pterygoid plate. A periosteal elevator is used to elevate the tissues, starting at the distal attachment of the zygoma and proceeding posteriorly to the lateral surface of the lateral plate. The raphe fibers are resistant to elevation, and the plate comes free of these fibrous encumbrances only if curved, sharp scissors or a BP No. 12 blade is used to separate them. For this the surgeon must remove the original saline-soaked pack and replace it with a larger one that encompasses the entire pterygohamular plate complex.

Before making the impression, the surgeon should note the exposed structures: the anterior nasal spine, the pyriform apertures, the canine fossae up to the infraorbital foramina, the base of the zygomas (including a minimum of 3 cm of exposed arch), the

lateral maxillae, the lateral and medial pterygoid plates, the hamuli, the greater (anterior) palatine foramina, the palatal surfaces of the maxillae, and the incisive foramen. Sharp spicules of crestal bone and knife-edge ridges are rounded with burs, rongeur forceps, and bone files.

Not all patients have well-defined pterygoid plates, and in these individuals, even the most careful palpation fails to reveal their presence. Only one plate may be palpated or, in rare cases, neither may be palpated. Some rudiment of a plate is always present at the pterygomaxillary suture, however. Therefore the area must be uncovered, because it is important as a site for implant bearing.

Impression Making

The flaps are packed open with saline-soaked sponges, and the palate is sutured into a midline bundle.

An EZ Tray sheet (see Chapter 14) is placed in the hot water heater at 178° F until it softens. The surgeon lifts the material from the bath while the assistant removes the saline sponges from the wound. As the assistant retracts the flaps, the soft material is slipped beneath them and then teased, massaged, and pushed peripherally to the fullest extent of the dissection. The forefinger is used to press the compliant material over the pterygohamular structures. Before it sets completely, the material is lifted out and reseated several times so that it does not become locked into undercuts.

If not enough working time is available to fabricate the entire custom tray at once, the EZ Tray is augmented in its wet state by adding small, heated, supplementary peripheral pieces These "welds," even when wet, are reliable, as when handles are added to the trays. Upon each removal of the tray, however, the surgeon must be sure to dry the welded areas and reinforce them by using a heated wax spatula and, when indicated, sticky wax.

If the exposed bone appears to be geometrically complicated and numerous undercuts indicate difficulty creating an acceptable path of removal, two separate half trays should be made, each with its own handle. They are trimmed in the midline so that they seat together and fit snugly against each other from the anterior nasal spine all the way back to the posterior palate, as described for the mandibular implant in Chapter 14. The two halves are seated separately for the final impression. After an index is made with self-curing acrylic, the halves are removed either in one piece or separately and collated using the index. If the impression must be removed in two halves, indexing structures should be made on the outside surfaces of the trays. This can be done by cutting 4-mm cubes of EZ Tray and luting them to the outer surfaces of the tray halves.

When the impressions have been completed in two halves, excess impression material is removed from the attached cubes, a thin layer of lubricant is applied, and a U-shaped Formatray (acrylic polymer) index is placed over them (see Chapter 14).

If possible, the entire complex should be removed in one piece. If it is resistant, the index is removed first, then the tray halves separately. They are reassembled on the countertop with the indexing cubes used for accuracy.

After a satisfactory tray or pair of half trays has been completed, the wound is repacked with saline-soaked sponges. Elastomeric impression materials (e.g., Optosil, Reprosil, or Neoplex) do not displace fluids such as blood, mucus, or saliva, therefore the importance of creating a clean, dry host site cannot be overemphasized.

To place the trays efficiently after they have been filled with impression material, the surgeon and assistant should conduct tray-seating rehearsals with the palatal flap sutured together in the midline. In addition, the surgeon should pass 2-0 black silk sutures through the labiobuccal flap margins and remove the needles. The surgeon can attach each to a hemostat so that it serves as a retractor. Beaver tails (or Henahans) also work well for lifting the flaps.

The path of insertion of each tray should be practiced, with the flaps elevated and lifted in the appropriate sequence. When it becomes evident that this can be done with consistency, the final impression can be made.

Adhesive is applied to the trays, and even lengths of the white and brown accelerator and base of Neoplex regular are mixed and placed in the tray in modest amounts. If the tray fits accurately, the material serves merely as a wash.

The packing is removed, and the trays are seated following the rehearsal pattern: one tray and then the next. Each one is vibrated into place to eliminate entrapped air. Some impression material should extrude beyond the tray flanges. The handles must be aligned as they were during the practice seating. The trays are held firmly in position for 8 full minutes. Any material that may be covering the cubed indexing structures should be removed.

The retention cubes are lubricated; then, some autopolymerizing resin is mixed, molded into a sausage-shaped mass, and pressed over them. As the acrylic sets, coolant is used to control the temperature.

After polymerization, the index is removed and seated once again to make sure it serves as a reliable assembling device.

Each of the hemitrays is removed. Sometimes the rubber from each tray flows along the entire length of the seam, and the two halves can be removed as one. If that happens, they still must be supported by the index.

The impression is examined for all requisite details (Fig. 15-4). If any is missing, the impression is repeated. Wash techniques usually are unsuccessful and consume valuable operating time. If the impression is acceptable, the implant is beaded, boxed, and poured in Vel Mix pink die stone (Fig. 15-5).

Surgical Jaw Relationship: Centric Recording

A counterimpression of the lower teeth or denture is taken using alginate. Then, a large roll of Optosil putty is used to record the centric and vertical relationships between the bony maxillae and the opposing mandibular dentition using classic prosthodontic techniques.

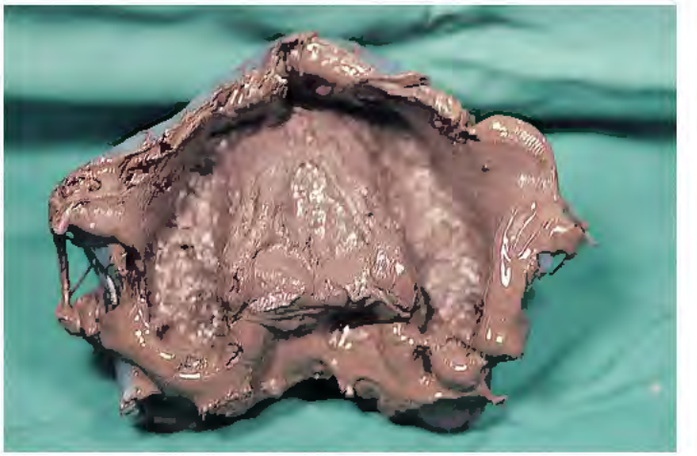


FIGURE 15-4. A tray, fabricated from the thermolabile polymeric EZ Tray material and molded directly onto the exposed maxillae, pterygoid plates, and hamuli, is coated with adhesive, and a Neoplex polysulfide impression is registered. It should demonstrate all the vital structures noted in Fig. 15-3 and elsewhere in this section of the chapter.

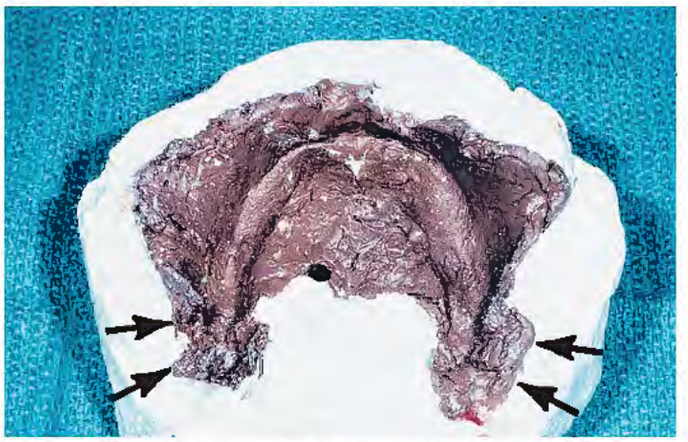


FIGURE 15-5. The impression should be boxed and art-bordered before pouring. Note the pterygoid extensions *(arrows)*.

Closure

The flaps are retracted widely, and the wound is inspected. It is debrided carefully, irrigated with saline from a syringe, and inspected again for impression material fragments; the retraction sutures are then removed. The wound margins are coapted, and blood and fluids are expressed from beneath the flaps. Closure is performed using a 3-0 black silk, continuous, horizontal mattress suture (see Chapter 6). Suturing begins at the posterior end of the incision on each side and proceeds no farther than the premolar area; otherwise, retracting the upper lip, which is necessary to close the contralateral side, will be difficult. After each posterior half has been closed, the bilateral sutures continue anteriorly until they meet in the midline. The right and left sutures are tied together in a final square knot, and the relieving incision is repaired separately.

The patient's denture is inserted immediately to prevent the formation of a hematoma or edema beneath the palatal flap. The pooled blood beneath the flap can cause fibrosis and an annoying permanent palatal thickening. A denture adhesive should be used if retention is lacking. The patient should be instructed to follow the postoperative regimen given in Appendixes G to I.

Implant Design

After the trimmed Vel Mix pink stone model is separated, the implant is designed using a freshly sharpened No. 4 hard lead pencil (Figs. 15-6 and 15-7).

FIGURE 15-6. The cast resulting from the poured impression must have the infrastructural struts and borders outlined for the technician's wax-up.

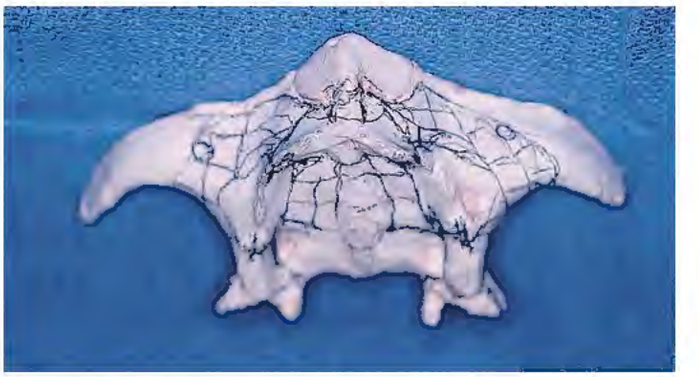


FIGURE 15-7. The computer-generated cast offers a more generous exposure of the prospective implant's support structures. When designing implants on these models, the surgeon must take care not to extend their peripheries beyond a point that would prevent them from being seated. Strategically placed screw holes should be included. The tube and stylus method of articulation (see Chapter 14) is required for casts produced in this manner.

The peripheral struts should rest on the structures noted previously. Only the primary struts should cross the ridge crest. Each of these struts should be in a canine or first molar area. The remaining secondary struts may be left somewhat to the designer's imagination, but an ample number should be placed, although no closer than 7 mm apart; this lends torque resistance to the infrastructure and distributes stresses more evenly throughout the casting.

The cervices should be long enough to allow for the premeasured tissue thicknesses, unless the thickness is to be thinned (particularly in the tuberosity areas) by a filleting procedure (see Chapter 6). The laboratory should be instructed to add 2 mm to the length of the cervices so that the Brookdale bar (which may be designed for Hader clips, custom-made clips, Lew attachments, O-ring attachments, or other retention devices) is placed above the mucosa at a distance sufficient to allow hygienic measures and a small degree of implant settling or gingival hypertrophy (Fig. 15-8).

The cast is marked by a surveyor stylus so that the peripheral struts can be placed in locations that lock them into slight undercuts. There need be no concern about this unless an HA coating is planned, because the bearing bones are compliant and resilient enough to allow a rigid casting to be snapped over them. If this

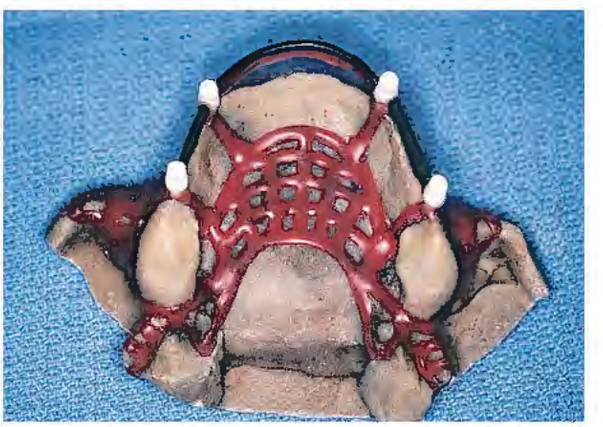


FIGURE 15-8. The wax-up is done on a refractory cast and should be checked by the surgeon to ensure that it conforms to the original prescribed design. Interstices must be made large enough to allow strong periosteal reattachment and viable revascularization. "Trailer-hitch" attachments for O-rings are a viable prosthetic option.

technique is used, screw fixation does not have to be incorporated into the operative design.

The laboratory should be instructed to supply an implant that presents a sandblasted or HA coated infrastructure and a highly polished Brookdale bar and cervices. The shape and size of the bar or abutments are designed so as to best serve the patient's prosthetic needs (see Chapter 26). The height required for each cervix should be noted on the prescription (Fig. 15-9). Three countersunk screw holes suitable to receive the standard 5- or 7-mm self-tapping Titanium implant screws should be designed in the peripheral struts of all implants: one just lateral to the midline and one on either side, in the zygomatic buttresses facing anteriorly. As an alternative, one or several vomeral screws may be placed palatally. Even if screws are not required, their use should be planned at the design stage.

Implant Insertion

If a 12-hour implant procedure is selected, the next steps are easier to perform. General anesthesia also makes the second stage simpler for the patient and staff. Regional anesthesia may be used, but problems can arise as a result of the changes in the pH of the tissues. When the sutures are removed, the flaps fall open almost spontaneously.

If, on the other hand, 4 to 6 weeks are allowed to elapse, the incision and reflection must be repeated as in the first stage. This is slightly more difficult, because the fibrosis of healing has made the tissues more resistant to reflection.

The implant should have been cleaned ultrasonically and passivated if the laboratory had not already done this (see Appendix E). It should not be touched by hands or gloves that contain talc. Gloves are rinsed in sterile saline after they have been donned. The implant is placed in a porcelain cup and autoclaved for 20 minutes at 370° F, or it can be treated with a radiofrequency glow discharge (RFGD) apparatus (Appendix E also offers details on the use of this equipment).

After the implant has been appropriately prepared for insertion, the flaps of the wounds are held with plastic retractors (plastic suction tips also should be used), and the casting is introduced, following the same rehearsal pattern as was used for making the impression. The flaps or other soft tissues must not become trapped beneath the peripheral struts during the seating procedure. The implant is tapped firmly into place with a mallet and an orangewood stick unless it is coated with HA (Fig. 15-10). When seating is complete, the wound is irrigated thoroughly with saline from a syringe. Each strut and component is checked to verify that the infrastructure is firmly and accurately seated (Fig. 15-11). In areas of deficiency or inaccuracies of strut to bone fit, 20-mesh (200 micron) particulate HA is firmly tamped beneath and around the metal (Fig. 15-12) (see Chapter 8).

When the pterygomandibular portion of the operative sites is viewed, the raphe on each side can be seen because of its stark, gleaming whiteness. It is somewhat withdrawn, but nevertheless present and easy to locate. A 3-0 Vicryl suture with a tapered needle is passed beneath the horizontal strut at the pterygomaxillary junction just before final seating. After full seating, the needle is passed into the most anterior portion of the raphe, which is stabilized with a Gerald forceps. A firm horizontal mattress surgical knot is tied, drawing the raphe to a point close to its original anatomic position. When screws are used (either zygomatic [Fig. 15-13] or midline [Fig. 15-14]), they are placed by pretapping with the Atwood 347 tapered diamond and then by self-tapping with a Vitallium screwdriver.

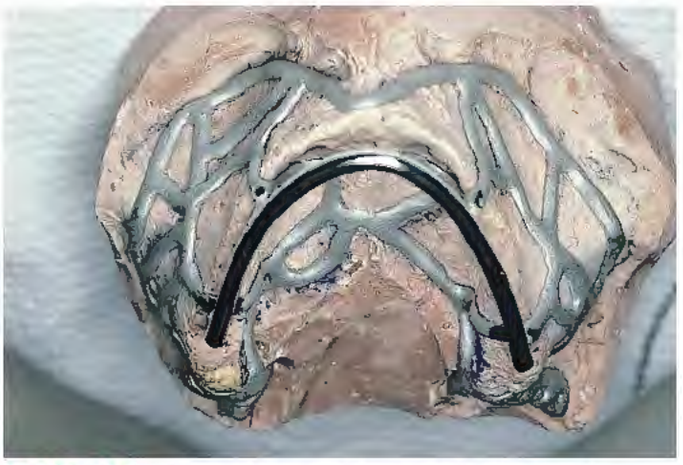


FIGURE 15-9. The casting should be matte finished and have a highly polished Brookdale bar and cervices. Adequate space for oral hygiene measures must be allowed beneath the bar. The centric vertical dimension and aesthetic demands of the reconstruction must govern bar placement. Peripheral struts extend to the anterior nasal spines, pyriform apertures, infraorbital foramina areas of the canine fossae, zygomatic buttresses, hamuli, greater palatine foramen regions, and pterygoid plates.

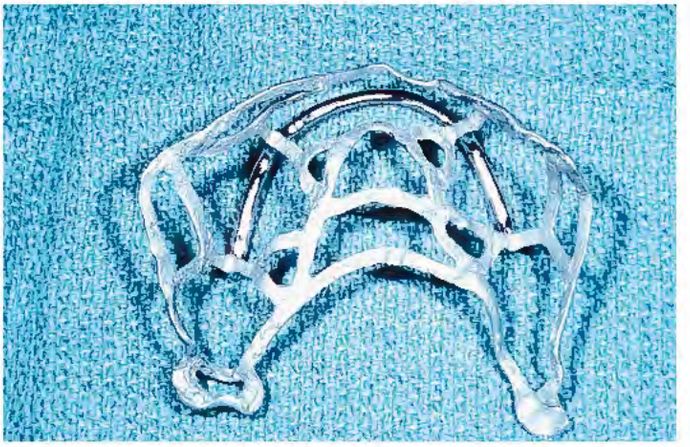


FIGURE 15-10. The undersurface of the casting should represent the matte-type host site morphology. Extensions onto the pterygoids are made aggressively.

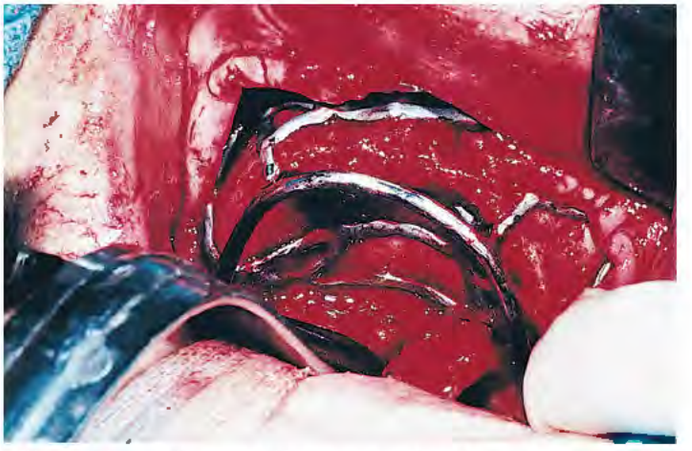


FIGURE 15-11. Second-stage surgery should reveal evidence of accurate fit of metal to bone, stability, positive retention (or the use of screws to achieve retention), and proper room for tissue beneath the bar.

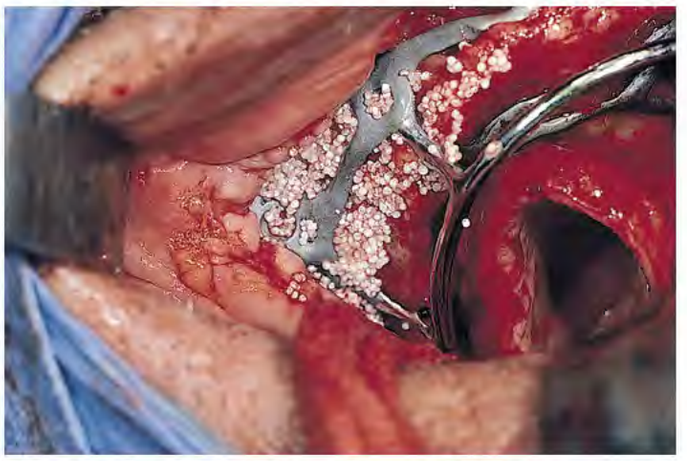


FIGURE 15-12. When discrepancies are noted between struts and bone, graft materials are used as a filler to encourage a dense fibrous tissue response.

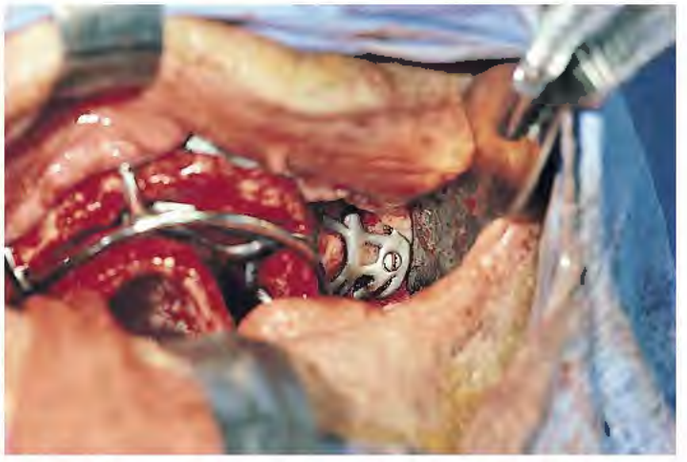


FIGURE 15-13. Zygomatic buttress fixation screws, when required, are 7-mm long, self-tapping Vitallium screws.

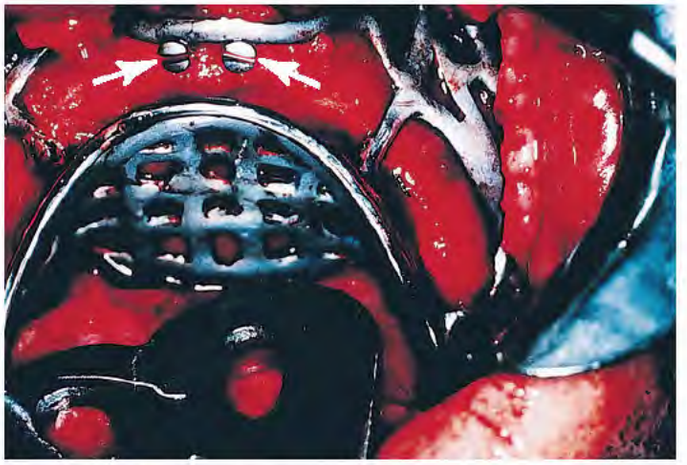


FIGURE 15-14. On occasion, midpalatine vomeral or labioalveolar screws *(arrows)* achieve primary retention. This is particularly beneficial if the malar buttresses are thin and the underlying antra are enlarged.

The flaps are coapted and then closed with 4-0 dyed Vicryl suture with a cutting needle (FSI) in a horizontal mattress configuration. Suturing starts at the tuberosities and moves forward to the premolar areas on both sides before proceeding more anteriorly. It then continues anteriorly beneath the bar. The two sutures that come together in the midline are used for the final knot. With 3 mm of clearance, the suturing is easy to complete once a rhythmic pattern has been established. The closure is concluded by making a separate horizontal mattress suture (drawstring type) around each of the four cervices (Fig. 15-15).

The wound is inspected to verify that it is well closed. If not, more sutures are added. When the closure is satisfactory and the mattress welt is clearly discernible, a piece of EZ Tray is heated in a water bath (178° F) and the pressed against the palatal tissues to discourage prolapse. When the palate has been compressed firmly against the underlying bone, a warmed plastic instrument is used to wedge and stabilize the stent material beneath the Brookdale bar from the palatal side (Fig. 15-16). This discourages the palatal tissues from becoming edematous, and it promotes healing in their normal arched configuration by preventing pooling of fluids in the

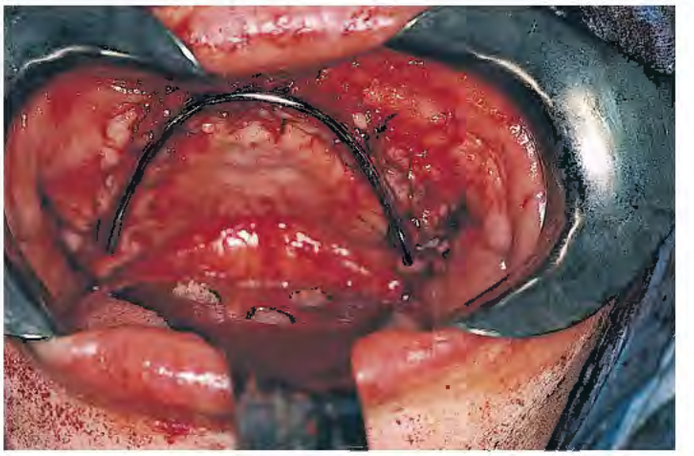


FIGURE 15-15. After satisfactory placement of the maxillary pterygohamular subperiosteal implant, primary closure is performed with a 4-0 dyed Vicryl continuous, horizontal mattress suture. The tissues should appear pink and well vascularized upon completion of the suturing.

FIGURE 15-16. To prevent prolapse of the large palatal flap, with subsequent permanent thickening of this tissue, an EZ Tray stent is placed against the palate and retained by wedging it beneath the bar. Stents are removed after the fourth day to prevent mucosal ischemia.

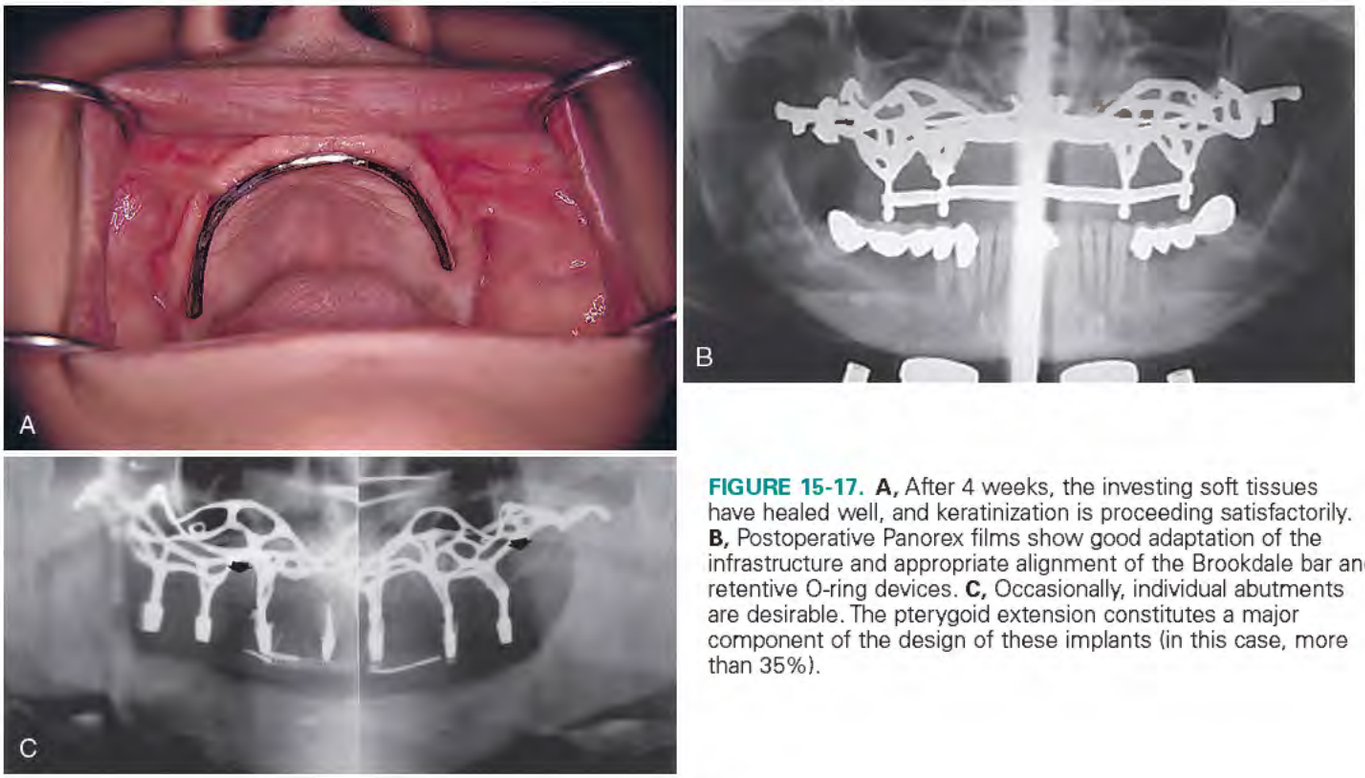


FIGURE 15-17. **A,** After 4 weeks, the investing soft tissues have healed well, and keratinization is proceeding satisfactorily. **B,** Postoperative Panorex films show good adaptation of the infrastructure and appropriate alignment of the Brookdale bar and retentive O-ring devices. **C,** Occasionally, individual abutments are desirable. The pterygoid extension constitutes a major component of the design of these implants (in this case, more than 35%).

subperiosteal compartment. The patient should again be given the appropriate postoperative regimen.

These sutures resorb, but long ends can be snipped if needed on the seventh postoperative day. After 7 to 10 days, the tissue-borne surface of the patient's denture is reamed and lined with a chairside soft material (e.g., Viscogel) so that the patient has the benefits of a prosthesis for the remaining 5 weeks. This can be done after the palatal stent has been removed (Fig. 15-17). Sometimes, a heated instrument is needed to soften the stent, facilitating its delivery. In 6 weeks, the prosthodontic phases may be started.

PARTIALLY EDENTULOUS UNIVERSAL DESIGNS

Construction of maxillary pterygohamular universal (bilateral) implants should follow the same plan as outlined for the totally edentulous case, except that all natural teeth have to be included in planning, impression making, design, and closure (Fig. 15-18).

Anatomic considerations may play a major role in the design and peripheral strut location of maxillary pterygohamular universal implants because of the maxilla's truncated cone shape. A design feature that allows the implant to pass over anterior teeth and a wide maxilla and come to rest at a superior and narrower location requires the addition of an adjustable labial strut. What otherwise might be an impossible maneuver is made possible by the presence of an anterior hinged strut using Howmedica's DE hinge, which may be closed and ligated with wire using two retention buttons for this purpose. When this ligation is complete, using Vitallium wire, the implant is snug in position (Fig. 15-19).

Most reconstructions using the universal design are planned for fixed crown and bridge-type cementable superstructures. As such, careful surveying is required to ensure that the implant abutments are placed in strategic positions and aligned in parallel relationships to the natural teeth.

Fixed prostheses are made by joining subperiosteal to natural abutments, without concern about their different support mechanisms. The design of such prostheses should take into consideration hygienic measures (large embrasures and sanitary pontics).

Natural teeth are protected with individually cemented cast gold copings so that temporary cements may be used for long-term superstructure fixation and retrieval.

PARTIALLY EDENTULOUS UNILATERAL MAXILLARY PTERYGOHAMULAR DESIGNS

The preprosthetic workup is extremely important for the unilateral pterygohamular subperiosteal implant. Because the final restoration is to be fixed, the buccolingual positions of the abutments must be predetermined to ensure that the fixed prosthesis is not overcontoured buccally or palatally. The positions of the abutments are also important to verify that they are placed in the positions of natural teeth and not in potential embrasure spaces, which would create esthetic and hygienic problems.

The procedures for fabrication of a unilateral pterygohamular implant are identical to those described in the previous sections, except that only one half of the maxilla need be exposed. Formatray or a self-curing acrylic is used for impression making (Fig. 15-20). All natural teeth are included in the operative quadrant, and the recordings are extended at least to the midline (Fig. 15-21). Surgical occlusal registrations with Optosil putty and alginate counterimpressions complete the requisite steps for implant fabrication.

Infrastructural design and sites of support follow the same rules as for the complete implant (Fig. 15-22). However, because unilateral implants are placed with the plan of making fixed prostheses, abutments must be designed that will be parallel to natural teeth (Fig. 15-23). This is why the adjacent natural teeth must be included in the impressions. After 6 to 8 weeks of healing, the fixed bridge prostheses are constructed, following classic techniques (Fig. 15-24).

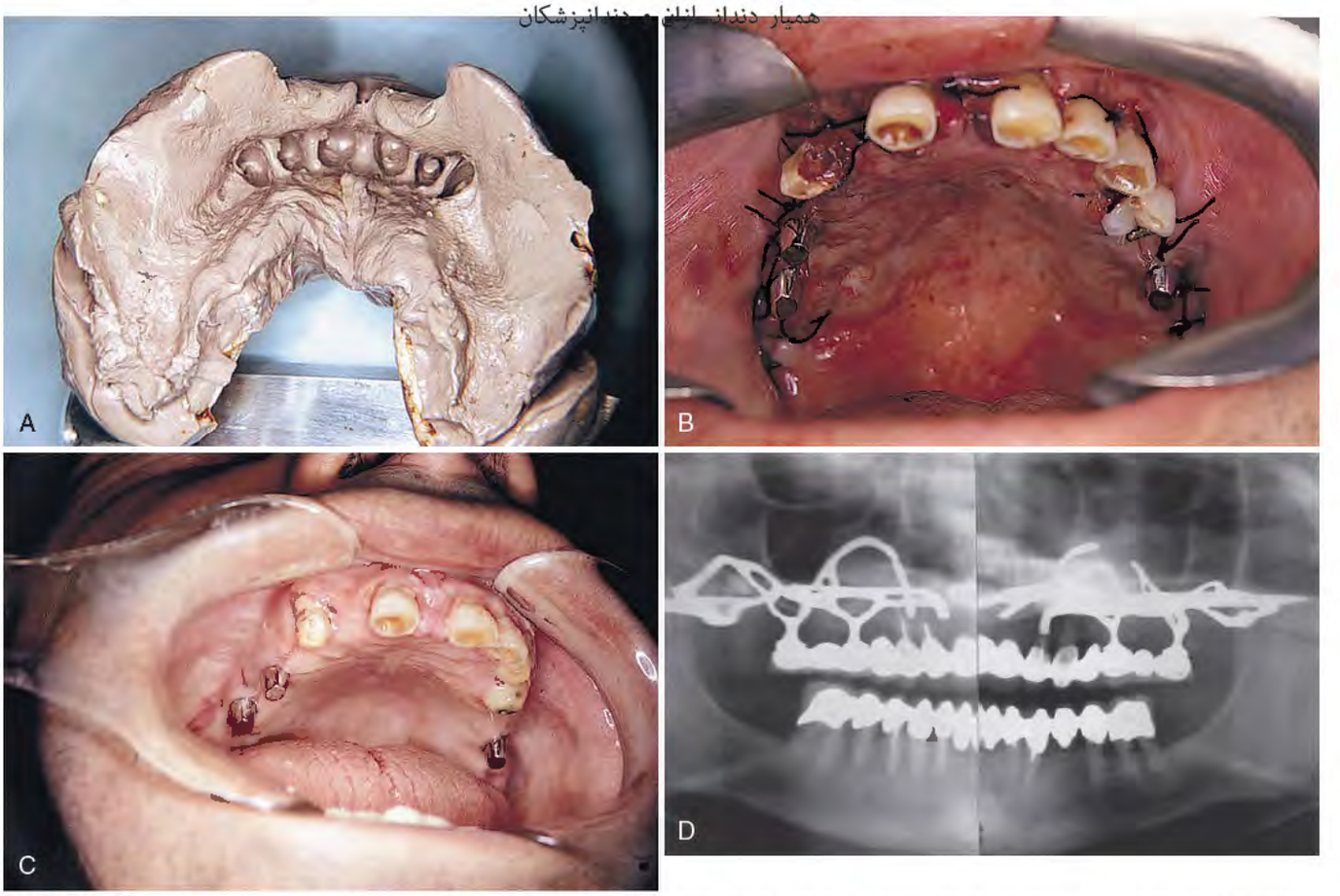


FIGURE 15-18. **A,** The universal implant is made with an impression that must include the natural dentition. **B,** Placement of a universal casting should include abutments made parallel to the patient's natural teeth. The integrity of the high palatal vault is maintained by using an EZ Tray stent. **C,** After healing, the implant abutments are seen to emerge from zones of fixed gingivae. After 6 to 8 weeks, prosthodontic reconstruction can be undertaken. **D,** A radiograph of a fully restored maxillary universal pterygohamular subperiosteal implant shows good peripheral extension and a functional relationship between natural and implant abutments.

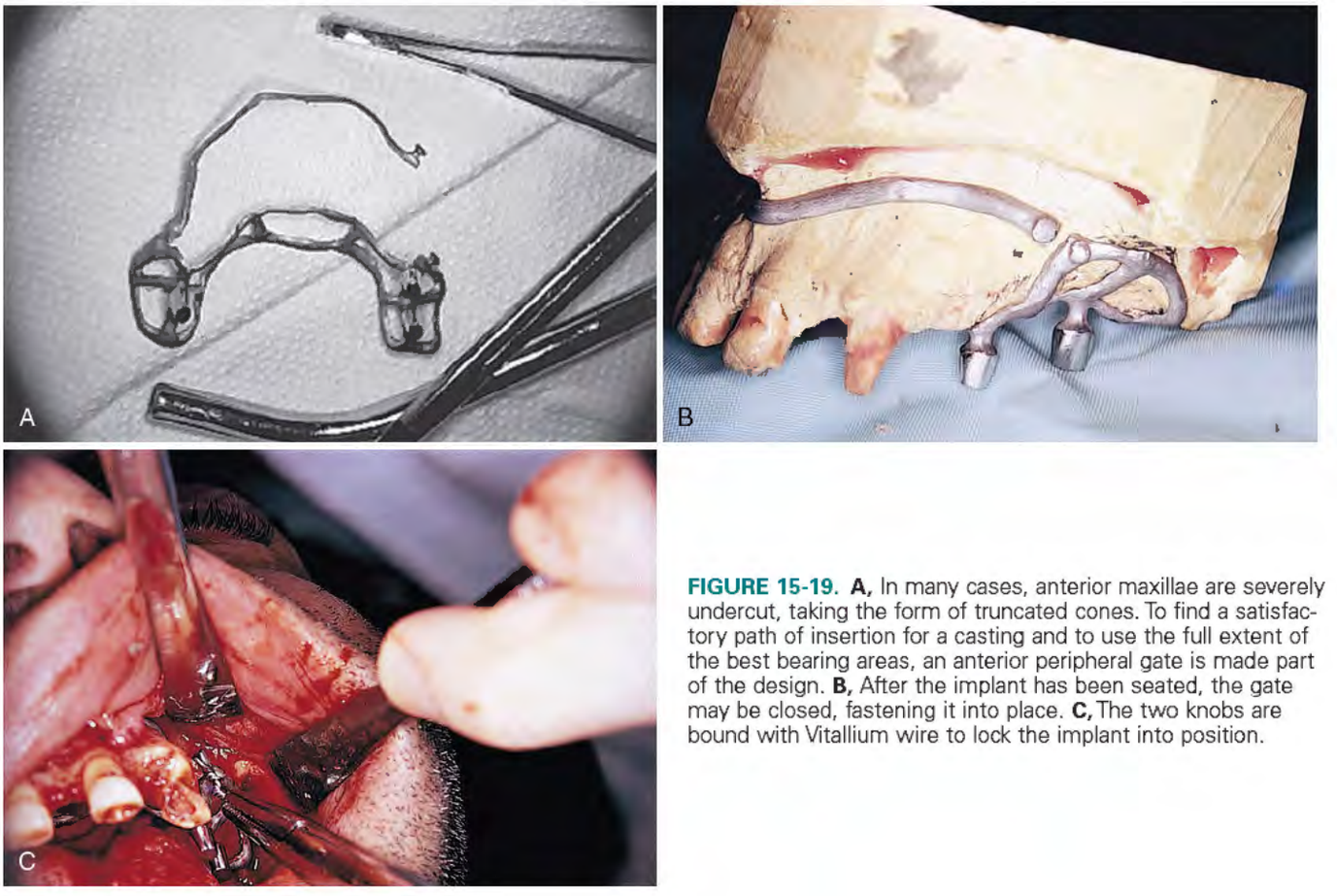


FIGURE 15-19. **A,** In many cases, anterior maxillae are severely undercut, taking the form of truncated cones. To find a satisfactory path of insertion for a casting and to use the full extent of the best bearing areas, an anterior peripheral gate is made part of the design. **B,** After the implant has been seated, the gate may be closed, fastening it into place. **C,** The two knobs are bound with Vitallium wire to lock the implant into position.

FIGURE 15-20. The unilateral pterygohamular implant impression tray may be made directly on the operative site with Formatray.

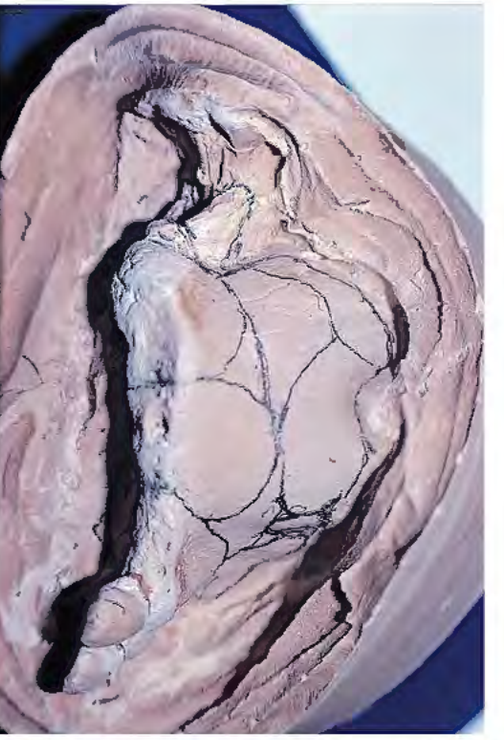


FIGURE 15-22. The cast that results from pouring the rubber base impression is used to design the unilateral implant. The surgeon should study the articulator relationships to designate the abutment locations and determine the tissue height information that is given to the technician.

FIGURE 15-21. After the tray is coated with adhesive, it can be used for a rubber base impression. It is inspected for accuracy in recording the pterygoid plates, hamuli, foramina, malar buttresses, and natural teeth.

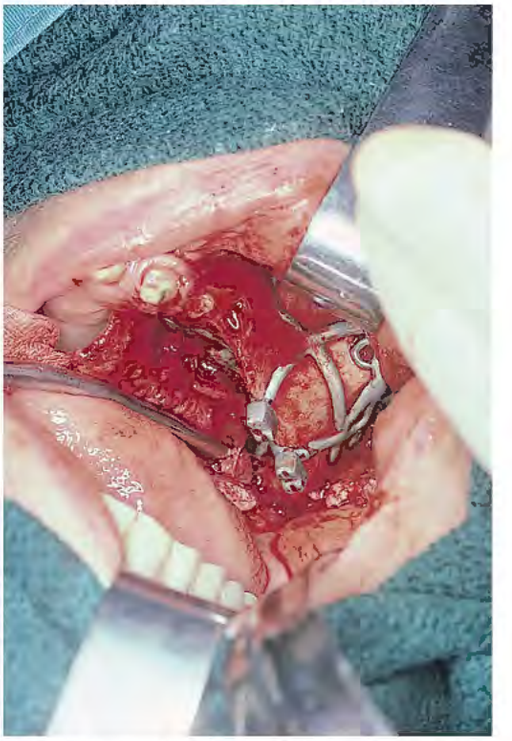


FIGURE 15-23. The casting that results from the poured model should fit accurately. Because the maxilla is compliant, slight inaccuracies can be eliminated by malleting the infrastructure into position with an orangewood stick. If positive retention cannot be achieved, screw fixation should be used.

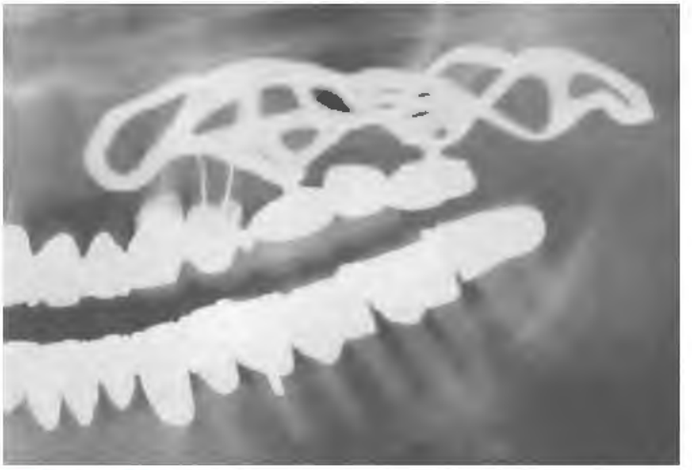


FIGURE 15-24. This pterygohamular casting extends over the pterygoid plates for almost 40% of its total length.

Maxillary unilateral and complete pterygohamular implant castings are made using the CAD/CAM-generated model system in exactly the same fashion as described for mandibular implants in Chapter 14 (see Fig. 15-7). Metal restorations are removed from all maxillary teeth before imaging. Counterimpressions and occlusal records are required, as if the models had been generated by direct bone impressions. Record taking for centric and vertical dimension cannot be done for CAD/CAM casts in the classic manner. To place the base model in an accurate relationship, the tube and stylus technique described in the CAD/CAM section of Chapter 14 must be followed.

Design considerations include making anatomic abutments parallel to natural teeth so that fixed prostheses can be fabricated. When implants on computer-generated casts are designed, the tendency is to allow them to extend far more aggressively onto peripheral bone. However, when such castings are being inserted, the practitioner may be faced with a much more extensive dissection than anticipated; therefore conservatism should be exercised in the extent of placement of peripheral struts.

Intramucosal Insert Surgery and Prosthodontics

16 CHAPTER

The intramucosal insert armamentarium consists of a base-preparing bur that prepares the denture with holes designed to receive the inserts; a surgical trephine to create the mucosal receptor sites; surgical indicator styli, which transfer the sites from denture to tissue; and the inserts themselves. Eight to 14 inserts must be used. Additional requirements include a scalpel with a BP No. 11 blade, pressure indicator paste (PIP), indelible pencil, college pliers, paintbrush, and autopolymerizing resin.

ARMAMENTARIUM

Anesthetic: local
Burs: base preparing; No. 4 and No. 6 round
Cotton pellets: Racellet
Dappen dishes: 2
Endodontic explorer: sharpened tip
Handpiece: high speed, water cooled
Hemostats: mosquito hemostats
Indelible pencil
Kerr Dycal ball-tipped applicator
Millimeter perioprobe
Needle holder
Paintbrush: sable, No. 00
Pliers: locking college
Polymethyl methacrylate powder and liquid: autopolymerizing
Pressure indicator paste
Scalpel: long handle
Scalpel blade: Bard-Parker (BP) No. 11
Surgical indicator styli
Suture: 1-0 black silk on curved cutting needles
T-burnisher
Titanium intramucosal inserts
Trephine

CAVEATS

The greater palatine and incisive neurovascular bundles must be avoided. Low-dipping antra should not be penetrated.

Inserts must be placed at least 1 cm apart. Insert bases are set in exact continuity with adjacent denture base material (neither too deep nor too shallow) and at absolute right angles to the tissue-borne denture surface at each site. Inserts need not be parallel to each other. In fact, it is best if they are not parallel, because this offers additional (interhead) clasping.

Proper patient selection is a requisite for success. This technique benefits only those who gag or have a lack of retention; it is not meant for patients who reject dentures because they "burn," are "too tight," or cause pressure.

INTRAMUCOSAL INSERT-SUPPORTED COMPLETE MAXILLARY DENTURES

Intramucosal inserts may be used for full upper dentures or unilateral partial dentures in either jaw. They are useful for patients who have problems with retention of a maxillary full denture. They are not for patients who claim that their dentures are too tight or for those who say their tissues burn from denture wearing. However, if the patient gags from denture wearing, these inserts can help by shortening postdam areas. However, U-shaped, or palateless, dentures work only for short periods; they slowly lose their retention as the healed receptor sites fill in with secondary-intention epithelium, which gradually reduces denture retention.

The technique must be followed carefully, and the inserts must be set into the denture base exactly flush with and perpendicular to the acrylic. If they are placed too deeply, they will fail to develop retention. If placement is too shallow, the protruding bases may cause ischemia and necrosis of the opposing mucosa, with subsequent chronic inflammation or loss of receptor sites.

The implantologist must start with a denture that satisfies the highest prosthodontic standards. The next step is to eliminate sore spots and decubitus ulcers.

Eight to 14 sites are selected on the surface of the maxillary mucosa, depending on the design of the insert head. The newer (Park) flatheads develop superior retentive qualities and succeed with as few as eight inserts. The traditional inserts, which are more of a rounded arrowhead shape, function best with 14 devices.

The tissues are dried, and then a Kerr Dycal applicator tipped with pressure indicator paste (Fig. 16-1) is used to mark the spots, which should be evenly placed at the crest. The first mark is made 5 mm lateral to the midline. The second mark is made in the center of the tuberosity, and the third is made halfway between them. The distance between these three marks is divided, and marks four and five are placed at the midway points. Repetition on the opposite side of the arch locates the first 10 marks. This is more than sufficient for the Park-type heads. For the earlier designs, the eleventh mark is placed 1 cm palatally from the ridge crest and midway between marks three and four. The twelfth mark is placed midway between marks four and five in line with the eleventh mark. These steps are repeated on the opposite side to locate the thirteenth and fourteenth marks. The surgeon should check the radiographs for low-dipping antra and should avoid the regions of major foramina and nerve bundles.

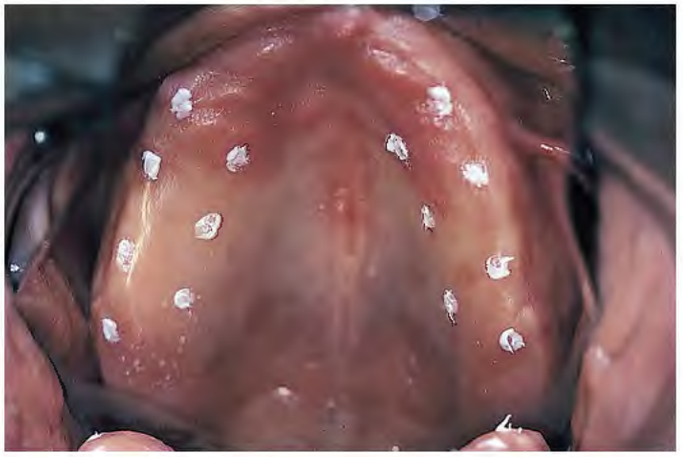


FIGURE 16-1. The potential host sites are marked on the mucosa with pressure indicator paste (PIP).

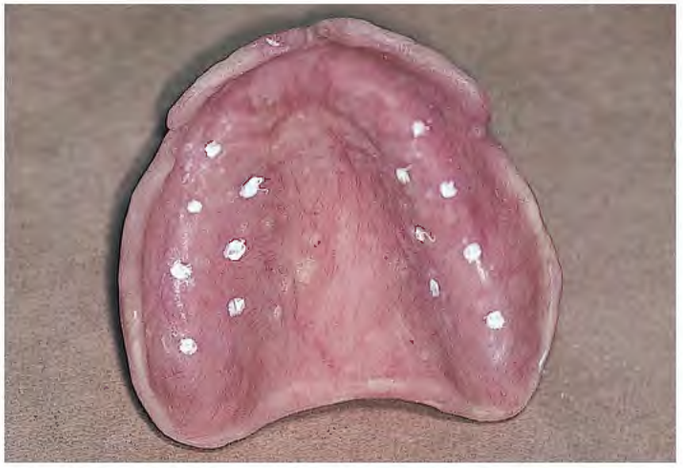


FIGURE 16-2. The denture is seated, and the marks are transferred to its tissue-borne surface.

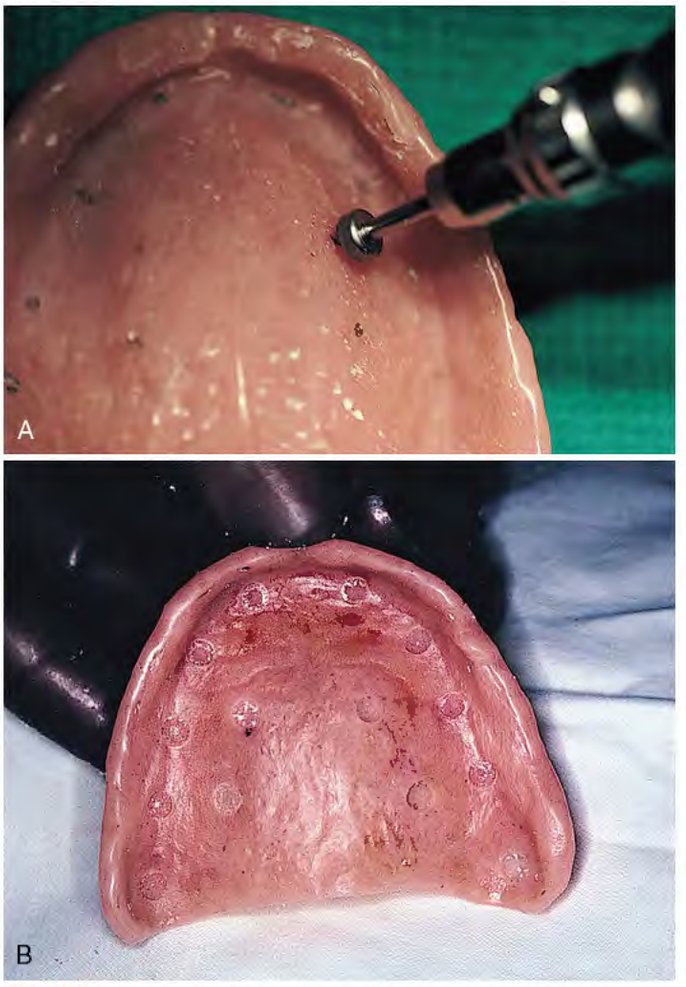


FIGURE 16-3. **A,** The base preparation is used to make an opening at each location marked by the pressure indicator paste. These apertures are drilled at right angles to the acrylic and to the full depth of the bur's blade. **B,** The 14 insert recesses have been completed with the base-preparing bur.

The denture is dried and seated directly upward, and the patient is guided into firm centric closure. When the denture is removed, the white marks will have transferred to it from the opposing tissues (Fig. 16-2). At the site of each white spot on the denture, the base-preparing bur is used to make an opening at an absolute right angle to the acrylic at each of the marks (Fig. 16-3). The bur is sunk precisely to the depth of the cutting blade to create holes into which the intramucosal insert bases will find flawless housing, exactly level with the acrylic.

A 30-gauge, short anesthetic needle is used to infiltrate a single drop of lidocaine 2% and 50,000 epinephrine into each of the 8 to 14 white marks in the tissues, assuming that these drugs are not contraindicated for the patient (Fig. 16-4).

A single arrowhead surgical indicator stylus is placed in each of the holes in the denture (Fig. 16-5), and each is tipped with a moistened, purple, indelible pencil. If the chosen system does not supply indicator styli, a somewhat less exacting technique can be used. The intramucosal inserts are processed into place with self-curing acrylic and tipped with indelible pencil to transfer their locations to surgical sites in the mucosa. Again, the denture is seated aggressively in a directly vertical maneuver so that each of the arrowheads or indelible pencil marks transfers to the tissues exactly opposite

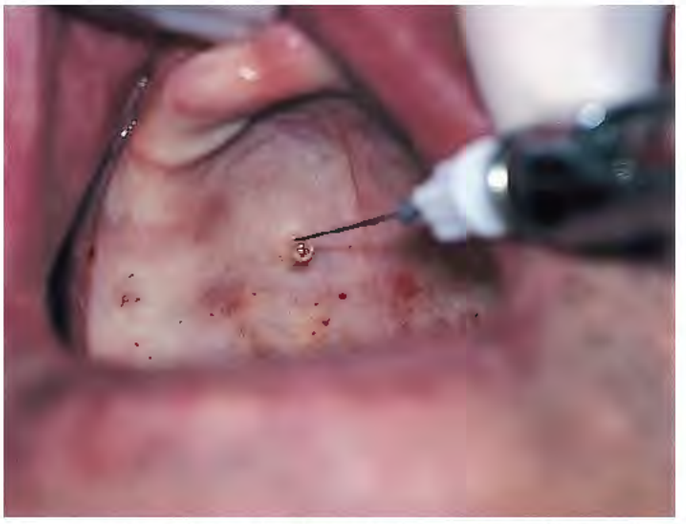


FIGURE 16-4. A drop of local anesthetic is infiltrated into each PIP-marked receptor site.

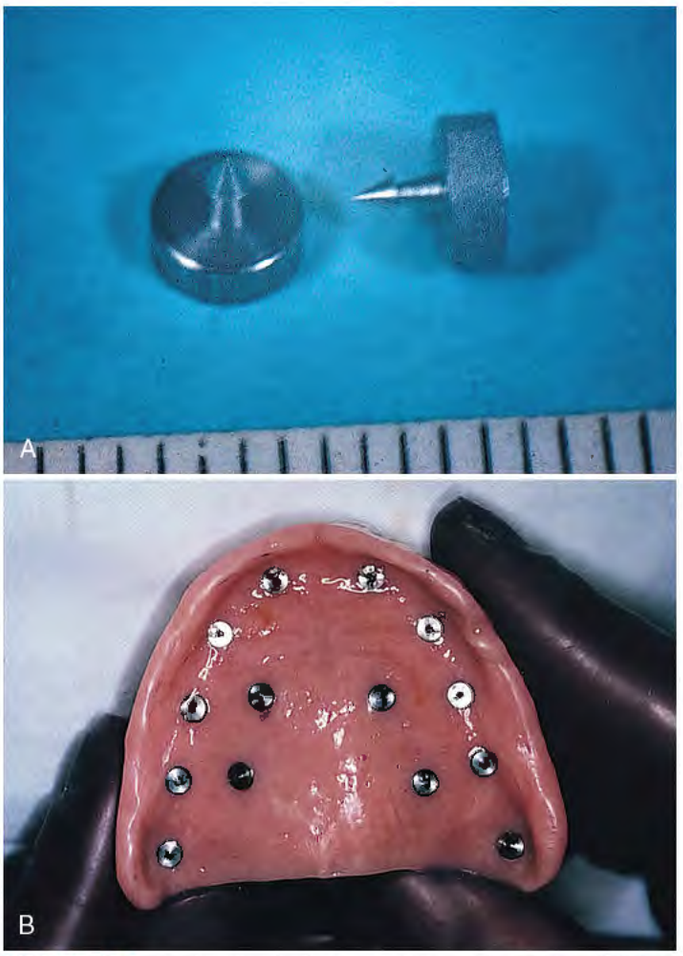


FIGURE 16-5. **A,** Surgical indicator styli have bases of a slightly smaller diameter than the inserts themselves. They are characterized by sharp, arrowhead-shaped tips. **B,** A surgical indicator stylus occupies each of the apertures.

the site of its denture hole. The denture is removed with care after a gauze throat curtain has been placed to catch any loosened styli.

About half of the styli will remain lodged in the tissues, and the other half will come away with the denture (Fig. 16-6). The latter group leaves the tissues tattooed with punctate purple spots.

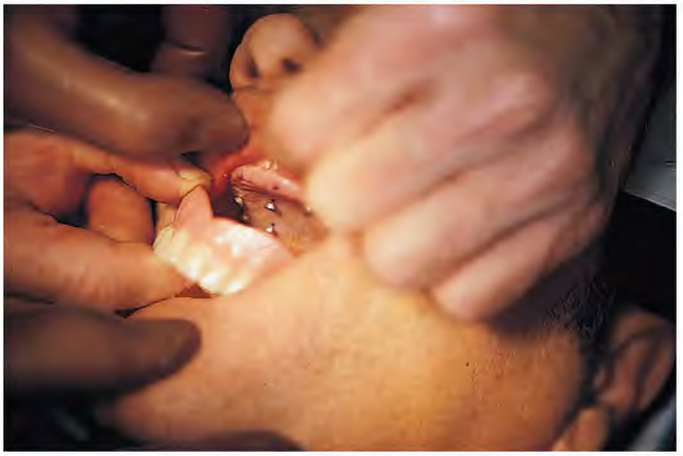


FIGURE 16-6. The denture is seated, and its position is checked for accuracy by having the patient close in centric. On removal of the denture, the styli remain embedded in the tissues, transferring the exact concentric relationship of each denture aperture to the tissue.

After the styli are removed, one by one, a round hole is cut into the tissues with the trephine, which should be forced through the tissues in a perpendicular direction. Its handle is pushed directly to bone and then rotated clockwise and counterclockwise several times (Fig. 16-7). Care must be taken not to press too hard in the premolar and molar areas, or the maxillary sinus may be penetrated. If this should happen, the site should be abandoned until it heals by secondary intention. (See Chapter 28 if healing by secondary intention fails to occur.) The trephine is removed, and its lumen is unplugged with the stylet; this should produce a small core of tissue. However, this core can be obtained only when the cutting end of the trephine is rotated against bone firmly enough to excise the tissue thoroughly. Each receptor site is created in the same fashion. Some brisk bleeding may occur, but tamponade solves this problem. Dramatic hemostasis also can be achieved by plugging a Racellet cotton pellet into the site.

Eight to 14 holes have been created, each the diameter of an insert cervix. At this point, none is wide enough to accommodate the

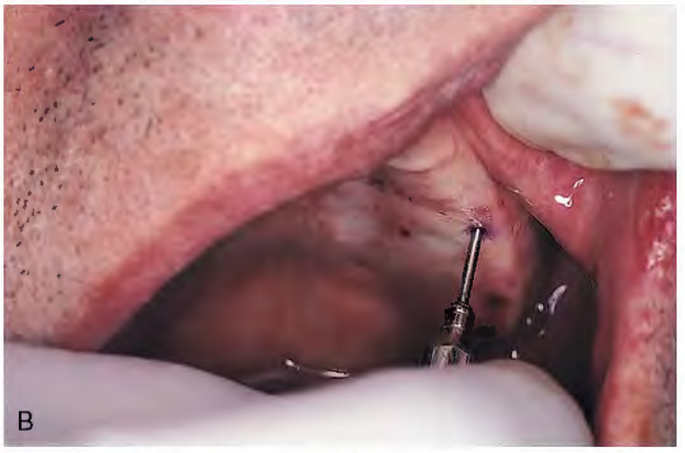


FIGURE 16-7. **A,** The trephine, a sharpened 18-gauge needle with Luer-Lok handle, and a stylet are used to remove a plug of tissue of sufficient diameter to accommodate the cervix of each insert. **B,** The trephine is placed at each stylus mark and forced into the mucosa with firm finger pressure until it strikes bone. At this point, it is rotated against the bone, which excises a full-thickness plug of tissue. The stylet is used to empty the lumen of this tissue.

insert head. To allow entry of these larger components, a Bard-Parker (BP) No. 11 blade in a long handle is used to make a cruciform or X incision is made at each site. Two 3-mm incisions at right angles to each other with the trephined hole at the center complete this operation (Fig. 16-8).

The depth of each hole is measured with a periodontal probe or with an actual insert that has been soldered to a broken instrument handle so that the measurements can be recorded on an anatomic chart. If any of the sites is less than the full depth of the insert head and cervix (usually 2.2 mm, but as much as 2.5 mm, depending on the system), the bone that lies at the base of the surgical site must be deepened. A sterilized No. 6 round bur in a high-speed handpiece should penetrate the bone to the bur head's full depth, which creates enough vertical depth to accommodate the head and cervix of the insert (Fig. 16-9). The patency of each X incision is checked one last time, and the patient is instructed to bite on a roll of saline-moistened surgical sponges.

The denture is washed and dried thoroughly, and a sable paintbrush is used to place a drop of monomer in the first receptor site (Fig. 16-10, *A*). This is followed with application of a thin slurry of acrylic powder and liquid into the retentive groove of the intramucosal insert base. The inserts are held at their necks with the beaks of locking college pliers forceps, and each is vibrated into its receptacle in the denture (Fig. 16-10, *B* and *C*). Care must be taken to ensure that its platform is perfectly level with the surrounding acrylic. Minimal amounts of acrylic should be used, to allow total seating of the insert base.

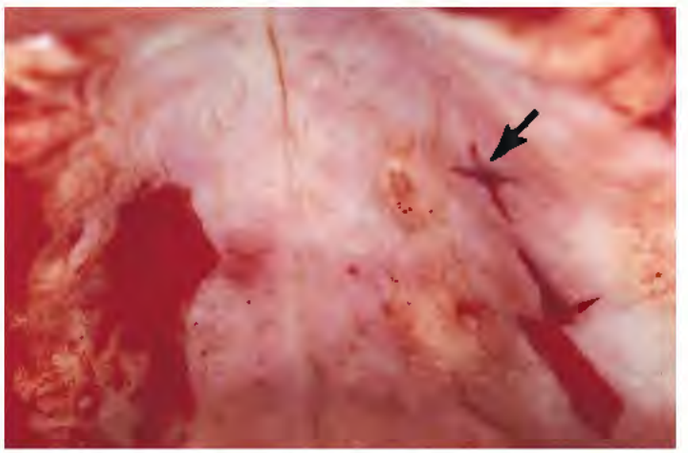


FIGURE 16-8. A BP No. 11 blade is used to make 3-mm cruciform incisions *(arrow)*. This completes the creation of the receptor sites and enlarges them to allow entry of the insert head.

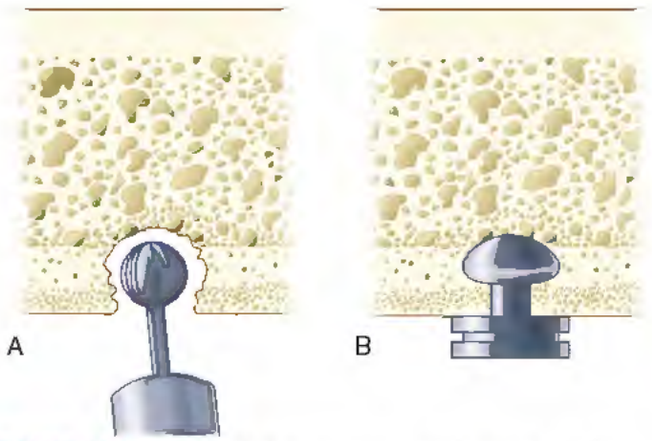


FIGURE 16-9. **A,** With shallow mucosae (as demonstrated by a millimeter probe), a No. 6 round bur is used to deepen the bone. Care must be taken not to enter the maxillary sinus. **B,** Within 72 hours, the deepened receptor site becomes lined with secondary-intention epithelium.

This operation is repeated until all inserts have been processed into the denture base. A cotton-tipped applicator is used to wipe any excess acrylic from the areas around the insert bases.

The sponges are removed from the patient's mouth, and the denture is seated. The inserts should move completely into place (Fig. 16-10, *D*). This can be verified if centric occlusion is correct and the postdam area is well seated. If this is not the case, each surgical site must be reassessed with a depth gauge as instructed previously, and those that need it must be deepened.

In theory, the procedure is now complete. However, practical experience has shown that the 14-day period after surgery, during which the denture must not be removed for even the shortest time, can be disappointing. Patients, particularly those who gag when uncomfortable, remove their dentures despite all warnings. To achieve the highest level of success, the denture must be ligated into place, which is done according to the following process.

First, the denture is removed. Moistened sponges are placed over the receptor sites, and a No. 4 round bur is used to drill three pairs of holes into the denture flanges. For the first pair, one hole is placed on either side of the labial frenulum, high in the flange and obliquely inward so that each is aimed at the other. For the second pair, one hole is made high in the buccal flange opposite the tuberosity, and its opposing mate is located palatally at a point 25 mm from the ridge crest and aimed obliquely toward the buccal. Finally, the same combination is completed on the contralateral side.

The sponges are removed, the denture is reseated, and the patient is asked to close into position. With the assistant holding the denture securely with a single finger placed on the palatal acrylic, the tissues are tattooed through each of the six new holes with an endodontic explorer tipped with a moistened indelible pencil (Fig. 16-11, *A* and *B*).

Next, the denture is removed, and a 1-0 black silk suture on an FS1 or C14 cutting needle is passed through the buccal surface of the tissue covering the tuberosity to the palatal tattoo. A deep bite of soft tissue is taken, both ends of the suture are directed out of the mouth, and the ends are clamped with a mosquito hemostat. The opposite side is managed with the same technique. Finally, the suture is passed from one anterior mark to the other, with care taken to ensure that the needle has grasped periosteum, thereby securing reliable fixation. At this point, three pairs of suture ends protrude from the mouth, each clamped in a mosquito hemostat.

The next step is to thread each suture end through its matching hole in the denture from the tissue-borne side outward. After this step, the three needles are removed and the hemostats are replaced, one to each pair of sutures. With the assistant holding the hemostats straight out, stretching the sutures taut, the denture is trolleyed up the sutures and into its final position (Fig. 16-11, *C* and *D*). To make sure no suture material has been trapped beneath the denture, the paired ends are pulled back and forth until they slide easily. The patient should close the denture into a firm centric position and maintain it in this fashion. When proper occlusion has been established, the anterior hemostat may be removed and this suture tied very tightly. The patient is asked to open the mouth, and with the assistant again supporting the denture firmly, the right and left posterior sutures are knotted behind the second

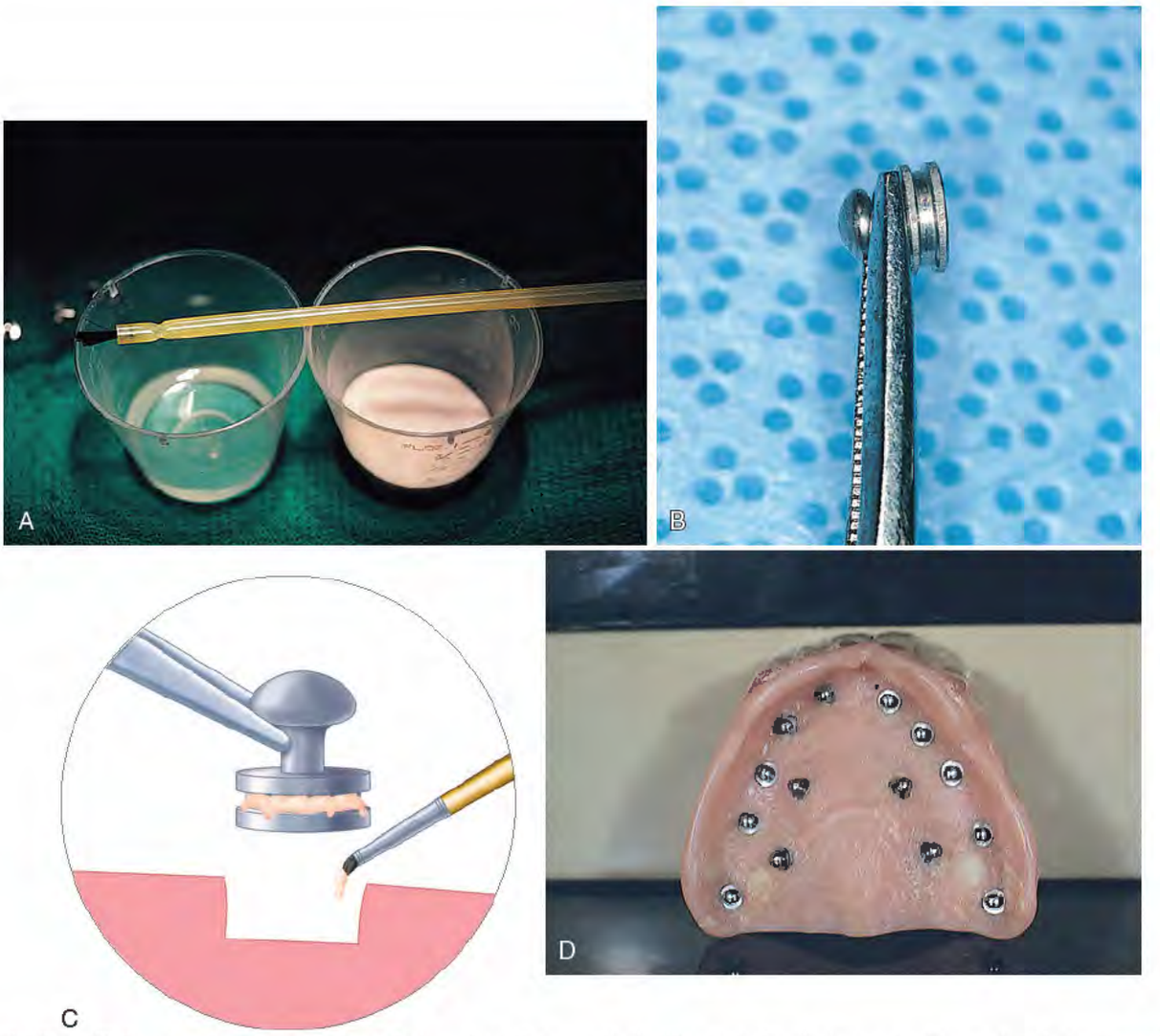


FIGURE 16-10. **A,** Pink autopolymerizing polymethyl methacrylate, applied with a paintbrush, is required to seal each two-tiered or textured (see Fig. 16-14) insert base into the denture. **B** and **C,** The inserts are held with the tips of pliers, and small amounts of acrylic are used to lute each into its assigned aperture. **D,** When placement of the intramucosal inserts is complete, the denture is seated and centric occlusion is confirmed.

molars and across the tuberosities. The denture now is fixed firmly in position.

A paintbrush is used to cover each suture with acrylic, and a final check is made to ensure that the occlusion has not been altered. If all is well, the patient is dismissed.

If no sore spots develop, the denture should remain ligated in position for 4 to 6 weeks. If a sore spot develops, a round bur is used to cut away the offending flange without removing the sutures or the denture.

At the end of the postoperative healing period, a No. 6 round bur is used to brush away the acrylic overlying the three sutures, the sutures are cut, and the denture is removed, revealing 14 well-epithelized receptor sites (Fig. 16-12).

Occasionally the patient may complain of tenderness at a receptor site, and it will be unclear which one is causing the problem. To test for this, the balled-end of a T-burnisher is inserted into each site (Fig. 16-13). If this pressure reproduces the patient's pain, the corresponding intramucosal insert cervix is grasped with the well-heated beaks of heavy laboratory pliers and, after the heat diffuses through the insert base, it is removed. The hole in the denture is filled with acrylic, and the receptor site is allowed to heal.

After the ligated denture has been removed, the suture holes are repaired with acrylic and polished, and the denture is reinserted. The patient should be asked not to remove the denture for 2 to 4 weeks. Adjustments are made as required, and a once a week removal and hygiene regimen is arranged. The patient should never be without the denture, because at any time, even after years of wearing, the surgically created receptor sites can fill in with epithelium in little more than 24 hours.

The instructions just presented apply to the intramucosal insert design that looks like a rounded arrowhead (i.e., Denserts). The benefit of these inserts is that soft tissue healing usually is uncomplicated, and the denture can be removed and reinserted easily and comfortably. However, because of their gentle slopes, no fewer than 14 of these devices are required for effective retention.

The newer, flattened heads of the Park Dental Research mucosal inserts (Fig. 16-14) have more acute undersurfaces. Although these inserts offer superior retention, their dentures are more resistant to insertion. In addition, more frequent instances of mucosal receptor site inflammation have been noted, and a longer postinsertion adjustment time is required to remove, manipulate, and replace such inserts.

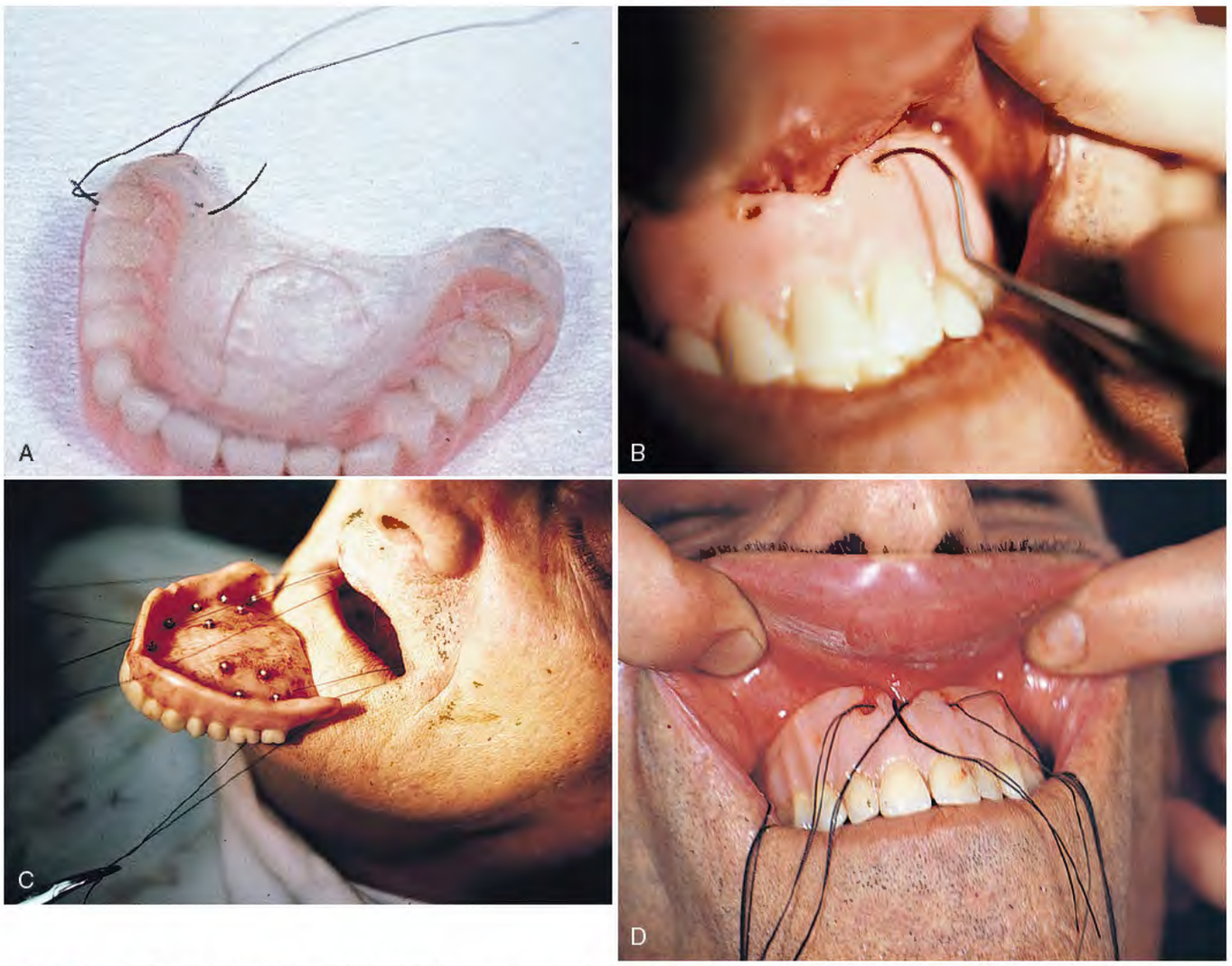


FIGURE 16-11. **A,** For suturing of a maxillary full-denture prosthesis into place, six holes are made in the prosthesis' flanges: buccal and palatal at each tuberosity and on either side of the labial frenulum. **B,** The newly made holes are transferred to the tissues by tattooing them with an explorer tipped with an indelible pencil. **C,** Each of the three 1-0 black silk sutures is placed, and the tattoo marks are used for guidance. The sutures are led out of the mouth and held taut by the assistant while the surgeon threads each suture through its matching denture hole. The denture then is trolleyed into position. **D,** On the denture's final seating, centric and vertical relationships are checked again. With the patient in closed position, knots are tied firmly at each site, and each is covered with acrylic.

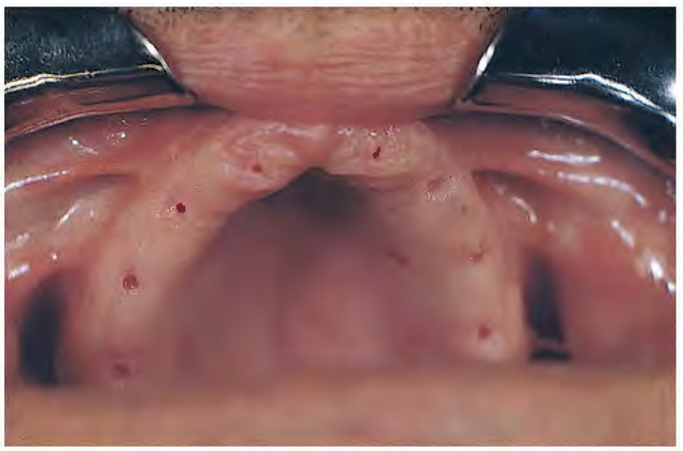


FIGURE 16-12. Six weeks after surgery, the patient returns, the sutures are removed, and the denture is cleaned. The receptor sites should be well epithelized, keratinized, and firm, and positive retention should be noted for each nestled insert head.

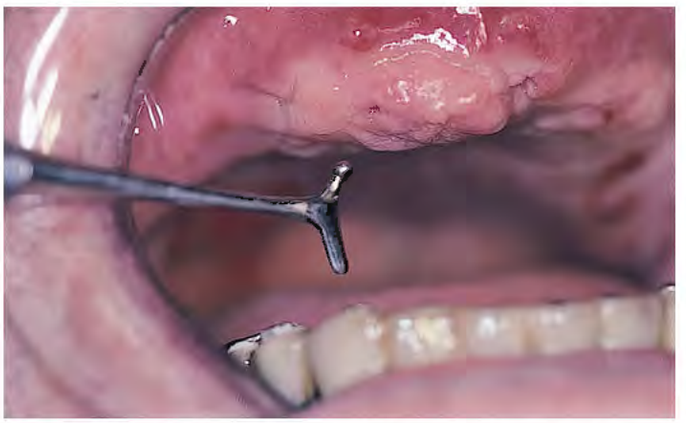


FIGURE 16-13. A T-burnisher is used to assess the integrity and status of each receptor site. Gentle pressure may indicate the presence of individual pain problems.

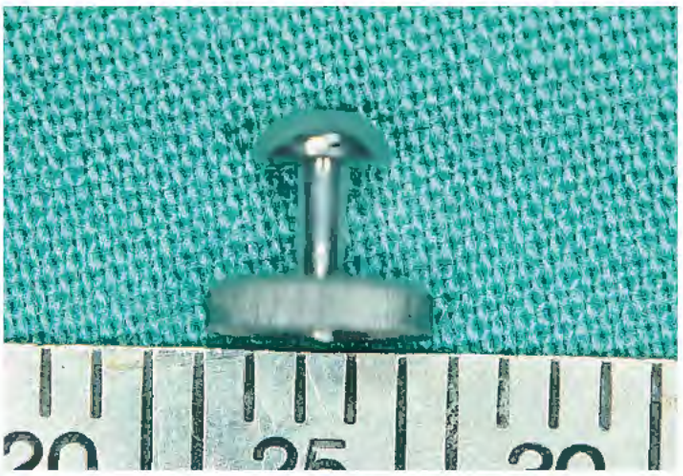


FIGURE 16-14. The more recently designed flattened insert heads (Park Dental Research) offer more resistance to removal. Because of their design, as few as eight of these devices may be used.

Because of the effectiveness of Park inserts, usually only 8 or 10 are needed, all placed at the ridge crest. The steps of placement, postoperative care, and maintenance are the same for both designs. In some cases, patients with less tolerance or poor manual capabilities have difficulty removing a denture with the flattened or Park insert. For these patients, judicious removal of the small devices must be done one at a time, over a period of weeks, until a balance of retention and comfort has been reached.

INTRAMUCOSAL INSERT-SUPPORTED UNILATERAL PARTIAL DENTURES

The value of inserts can be extended to partial lower and upper dentures (but not to full lowers). Three design features must be built into such unilateral partials:

1. A stress-broken saddle (e.g., DE hinge, Crismani, or Dalbo attachment).
2. An absolutely reliable retentive (clasping) device at the anterior end (e.g., precision attachment, Tach EZ clasp device, or reciprocating Bonwill clasps).
3. Fenestrations in the saddle casting large enough to allow entry of the base-preparing bur (because attempting to cut into a metal saddle to seat the insert bases is burdensome) (Fig. 16-15, *A*).

The technique for and placement of the inserts are similar to those for the full denture. As many inserts as can be used comfortably should be set into the saddle in at least two rows 1 cm apart. They should be located at the ridge crest, buccally in the mandible and palatally in the maxilla.

The partial denture must have an absolutely reliable clasping system for retention on the anterior abutment teeth. The saddle must be stress broken just distal to the last natural tooth. The laboratory should have prepared the metal casting of the saddle with sufficiently large, well-distributed spaces at the planned sites of insert placement to allow full entry of the base-preparing bur.

After the surgery has been completed and the inserts have been processed, the partial denture is seated and allowed to remain in position, untouched, for 1 month. If initial reliable retention is lacking, support can be gained by placing one transalveolar or circummandibular No. 1 stainless steel ligature wire at the distal end of the saddle (see Chapter 6). Sufficiently positive retention occurs after 6 to 8 weeks in a unilateral removable partial denture prosthesis to substitute for a palatal or lingual bar, contralateral clasps, or a posterior abutment tooth (Fig. 16-15, *B*).

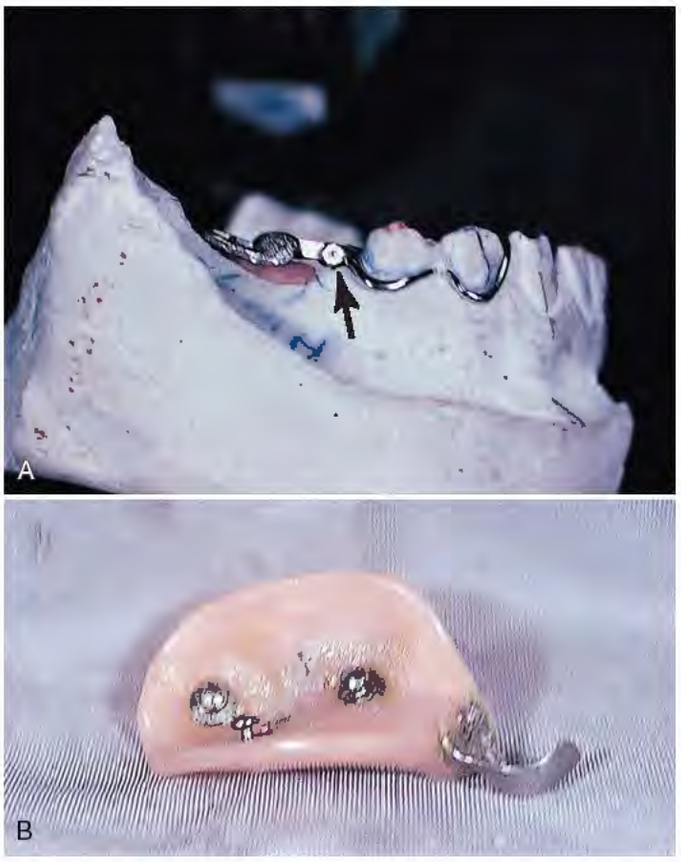


FIGURE 16-15. A, Unilateral maxillary or mandibular partial dentures are effective when coupled with intramucosal inserts. The integral components of such designs are a DE hinge or another stress breaker *(arrow)*, a reliable anterior clasping system, and a cast saddle with fenestrations of sufficient size to accommodate insert bases. **B,** The unilateral partial denture must be made to accommodate a sufficient number of intramucosal inserts to offer a self-sustaining, highly retentive saddle. This, in conjunction with the reliable clasping system, allows for successful functioning of unilateral partial dentures.

Kyocera, a Japanese company, makes a polycrystalline, alumina intramucosal insert that may be used in a manner similar to the techniques described for the devices in this chapter.

RELINING FULL UPPER DENTURES THAT HAVE LOST RETENTION AFTER HAVING HAD INTRAMUCOSAL INSERTS

If a patient complains of loss of retention of an intramucosal insert denture, the tissues supporting the denture should be examined. A loss of depth and undercut in some or all of the receptor sites may be noted.

The mucosal insert cervices are grasped one at a time with the beaks of heated heavy laboratory pliers; this allows them to be withdrawn easily. The inserts are then cleaned in an ultrasonic bath and sterilized in the autoclave.

The denture is treated with a chairside relining material (e.g., Durabase regular, Triad). Muscle molding is done with care, and after the relining material has set, the denture flanges are polished. Opposite each tissue receptor site, a small dimple of acrylic will be found that corresponds to it. At each of these elevations, a new site is cut with the base-preparing bur, and the original insert is reset with acrylic, as was done the first time the denture was thus equipped.

Each site is anesthetized, and the surgical steps are performed as described originally. However, the prosthesis need not be sutured into place this time, because the patient has achieved comfort as a denture wearer.

The patient is instructed not to remove the denture for 4 weeks, by which time a brand new prosthesis-mucosa relationship will have been established.

ENDODONTIC STABILIZER IMPLANT SURGERY

ARMAMENTARIUM

Cement: carboxylate
Complete endodontic armamentarium, including rubber dam and clamps
Diamond: discs, pear-shaped stone
Engine reamers: 28, 31, 40 mm long; in diameters 40, 45, 50, 55, 60, 70, 80, 90, 100, 110, 120, 130, 140
Hand reamers: 28 and 40 mm long; in diameters 40, 45, 50, 55, 60, 70, 80, 90, 100, 110, 120, 130, 140
Implants: endodontic, 70, 80, 90, 100, 110, 120, 130, 140
Mandrels
Surgical needle holder

An array of endodontic stabilizer implants with their corresponding engine and hand reamers.

CAVEATS

The tooth or teeth that require treatment must have at least 25% of their alveolar support remaining. There cannot be an untreatable endodontic-periodontal complication. Consider mechanically splinting the tooth needing treatment (i.e., "A" splint, bonding, and ligation) and placing the endodontic stabilizer by means of an open-flap procedure. Complete the operation by performing a periodontoplasty and adding osseous grafting material (see Chapter 8). Do not attempt these procedures, however, unless sound capabilities in traditional endodontic and periodontal repair procedures have been acquired.

A minimum of 10 mm beyond the apex or apices is necessary unless the implant is being used to manage a root fracture. Treat multirooted teeth either with stabilizers for each of the canals or in combination with conventional canal obtundents for the canals not chosen for implant placement. If the tooth is nonvital, classic debridement, enlargement, and sterilization procedures are carried out until two successive negative cultures or dry, odor-free canals are achieved. If the tooth is vital, a one-visit procedure may be performed. Implant reamers are changed and discarded with frequency to avoid bone injury and instrument breakage. Each storage box is marked with the number of uses of the instruments stored within it. Use an instrument no more than five times before discarding it.

There is an array of endodontic stabilizer implants with their corresponding engine and hand reamers.

MATTE-FINISHED TAPERED IMPLANTS (HOWMEDICA, PARK)

For a vital tooth, using a rubber dam, the pulp chamber is opened and all overhanging dentin and enamel is removed with a No. 4 round bur (Figure 16-16). The pulp cornua is completely ablated as well. Direct straight-line access to the pulp canal is gained and the pulpal tissues are removed with a barbed broach. Using sodium hypochlorite as an irrigant, the apex is achieved in gradual stages until a No. 6 rat-tail file can be passed with ease (Figure 16-17).

The distance from the incisal edge of the tooth to the apex is recorded. Check the position of the file with a periapical x-ray film.

FIGURE 16-16. Isolate the tooth or teeth being treated, and if the teeth are vital, remove the pulps.

FIGURE 16-17. Each canal is instrumented to its apex with K-files and rat tails up to the No. 40 size.

Distortion is minimized and the length of the file on the radiograph is measured.

The following formula presents the amount of bone beyond the apex available for placement of an implant:

$$\frac{fl}{rf} = \frac{x}{rsd}$$

where *fl* is the actual file length, *rf* is the radiographic file length, *rsd* is the radiographic subapical distance, and x is the actual subapical distance.

When the actual incisal-to-apical length is added to *x* (the apex-intraosseous length), the total length of the endodontic stabilizer will be known.

Using an ultra–low-speed (10:1 reduced gear ratio) latch-type contra-angle, select the No. 40 diameter engine reamer of an appropriate length. (They are available in lengths of 28, 31, and 40 mm from the Union Broach Corporation or Park Dental Research Company.) The diameter of the engine reamer used to begin the procedure, No. 40, represents a diameter of 0.4 mm and is the size of the last hand reamer used. (Each instrument's number indicates its diameter; for example, a No. 100 is 1 mm at its widest diameter.)

A sterile rubber marker is placed on the reamer at the sum of the lengths of canal and bone. For purposes of illustration, a total length of 35 mm and a tooth length of 20 mm are planned; this means that the stabilizer will exceed into the subapical bone for a distance of 15 mm.

Use copious amounts of sterile saline or anesthetic that does not contain epinephrine as an irrigant and make sure that the reamer does not bind in the canal. Cut a 15-mm-deep subapical osteotomy using a gentle, pumping vertical motion. This creates a total length of 35 mm. Reverse the engine to remove the reamer, or if possible, back it out by hand. Turning the handpiece wheel counterclockwise helps.

Since a strong, rigid, and inflexible stabilizer is desirable, it is recommended that nothing smaller than a No. 90 implant be used. No. 110, 120, or even 140 in fact, are preferable. The results of placing implants of larger diameter warrant the extra time and effort. It is important, however, to ascertain whether the root diameter is capable of accommodating the larger-sized implants without fracture or a lateral perforation.

The procedure is performed in the following order: Nos. 45, 50, 55, 60, 70, 80, 90, and 100 reamers should be introduced, each to the same rubber-stoppered 35-mm length (Figure 16-18, *A*). Rotation must be slow, with no pressure placed on the contra-angle. If the reamer binds, stop the engine, detach the reamer by opening the latch, and back the reamer out by hand. Use the next smaller diameter, again with copious quantities of irrigant, and perform the enlargement slowly and with deliberation. A safe alternative is using hand reamers that are also available in a wide variety of lengths and diameters from the same manufacturers (Figure 16-18, *B*). This is far more arduous but much more conservative, since the handheld reamers rarely fracture. None of these intraosseous instruments may be used dry. Frequent pauses for irrigation with the anesthetic syringe offer the greatest levels of assurance of sparing thermal trauma to the bone.

When the proper length and diameter odontoosteotomy has been achieved (35 mm), seek the presence of bone perforations by using a No. 40 hand reamer as a probe. Ensure that neither the opposing nor any lateral cortical plate has been pierced. If the probe should pass out into soft tissues, take a radiograph to recheck the length from apex to cortex so that a shorter length can be selected. Dry and seal the canal and dress it with a dry formocresol dressing. The implant procedure may not be completed until a subsequent check demonstrates an acceptable environment for doing so.

When the canal and bone are ready to receive an implant, select a stabilizer of the proper diameter. Using a fine diamond disc, score it lightly at a point 15 mm from its apical end. Score it more deeply 35 mm from the apical end so that only a sliver of metal remains. The small amount left should offer just enough strength and rigidity to permit the manipulation and rotation of the implant, application of cement, and seating of the implant (Figure 16-19).

Shave 1 mm of metal from the apical end so that the implant does not rotate in the bone, but rather seats firmly in the apical area, thereby offering a sound bacteriostatic seal.

When the implant is seated, the 35-mm line must be level with the incisal edge. Sponge the implant with saline, place it in the bead sterilizer for 10 seconds, and store it in a sterile medicine-glass of saline. Extra-coarse absorbent points (J & J) should be used to dry the canal. They must be cut exactly 0.5 mm short of the apex (at 19.5 mm). If the points are even slightly overextended, a blood-free tip will never be forthcoming (Figure 16-20). When the canal is absolutely dry, remove the stabilizer from the saline, dry it in the bead sterilizer, and coat it with a layer of carboxylate cement (e.g., Durelon) from the first line (14 mm from the apex) to the second one (34 mm) (the intracanal portion) (Figure 16-21). Grasp the implant firmly with a needle holder or pliers, remove the final (and now dry) absorbent point from the canal, and seat the implant using gentle but firm rotation as well as thrust. Stop it at the 34-mm line (Figure 16-22).

After the extruded cement has hardened completely, twist the protruding end of the implant sharply. It will come away at the deeply scored incisal line. Smooth it level with the lingual surface of the tooth using a pear-shaped diamond drill. Conventional prosthodontic restorations may then be undertaken (Figure 16-23).

If a classic post-and-core type of restoration is required, the implant has to be scored deeply at 24 mm rather than 34 mm (leaving 10 mm, or half of the unfilled canal, available). The coronal 10 mm should not be coated with cement. With a simple twist, the extending

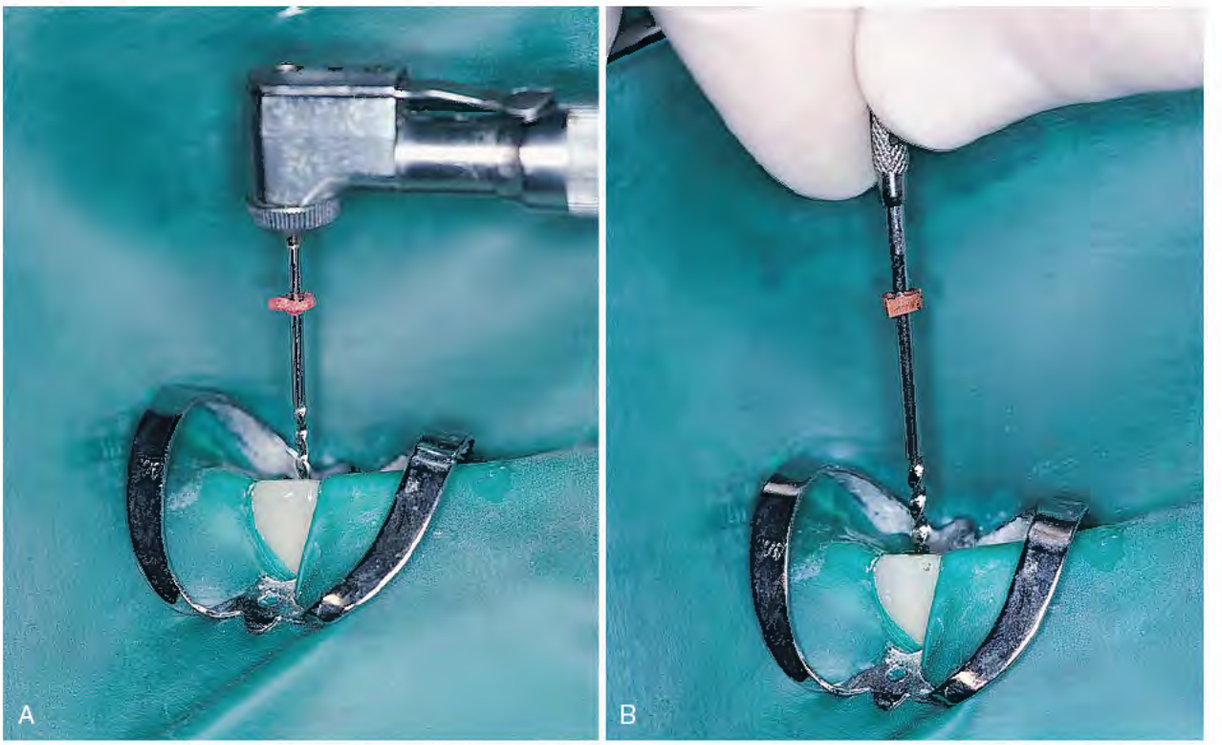


FIGURE 16-18. **A,** Prepare the odontoosteotomy using an ultra–low-speed saline-cooled handpiece with a No. 40 twist drill-reamer to the calibrated length. **B,** Enlarge the canal-bone preparation to at least a size 90 using either engine-driven or hand reamers.

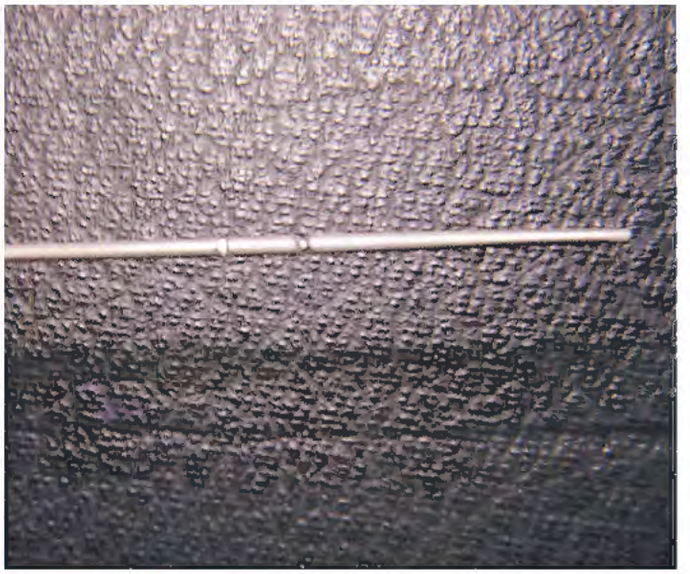


FIGURE 16-19. The approximately sized endodontic implant is tried in to verify its accommodation to the full length, and the implant is scored at the tooth's incisal edge and apical end after its removal and drying. A total of 1 mm is removed from the implant's apical tip.

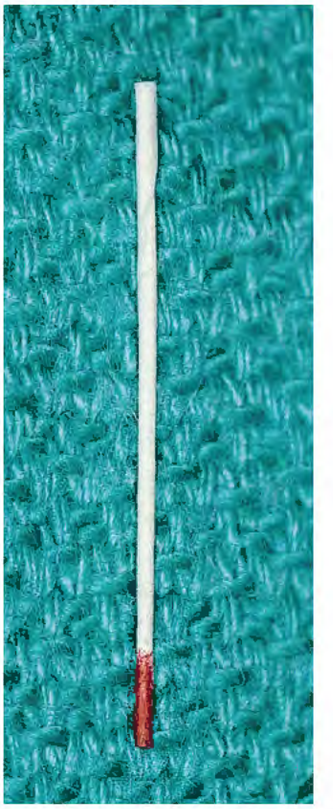


FIGURE 16-20. When the canal preparation is completed, there may be the slightest sign of blood on the tip of the inserted paper point. If so, refit a point that is slightly shorter. A totally dry point is mandated before implant cementation.

FIGURE 16-21. After the canal has been irrigated and dried again, coat the implant with cement between the scores for the entire length of the canal.

FIGURE 16-22. Each implant should be thrust to its full length, and the cement should be allowed to harden.

portion of the implant may be removed after the apical cement has hardened. Subsequent conventional post-and-core management then is made possible coronal to the implant.

If after cementation of a full length implant, the coronal portion of the tooth requires prosthetic augmentation, the implant should be permitted to protrude. Score this portion with a fine diamond to add retention to it, add two or three TMS minim pins, and complete a standard polymeric composite or glass ionomer buildup. This may be prepared for a crown in the classic manner. Place the crown margins on the natural tooth structure apical to the polymeric reconstruction.

FIGURE 16-23. After complete hardening of the cement, twist the protruding end of the implant sharply so that it comes away at the deeply scored incisal line.

STABILIZERS FOR NONCONFORMING TEETH

Occasionally, an endodontic implant is desirable for a tooth that is procumbent or in some other manner, does not have an axis that when extended beyond the apex, is contained within the bone. Under these circumstances, employing an alternative technique may enable the use of an endodontic stabilizer.

Complete the endodontic therapy in the classic manner, filling to the apex with gutta percha. After satisfactory obtundation, the series of stabilizer odontoosteotomies as described in Part I are performed in an eccentric angulation, keeping the instruments within the subapical bone. Most often, because the direct extension from the apex would lead to a labial perforation, make the entry through the labial surface. Enter in a direction that carries the drills obliquely into the supporting bone midway between the facial and palatal cortical plates (Figure 16-24, *A*).

Dry the prepared pathway within the tooth with absorbent points, coat the intradental portion of the implant with carboxylate cement, and seat it firmly. When the cement has set, snap off the implant at the countersunk score mark and cover it with opacifier and a composite polymer (Figure 16-24, *B*).

THREADED IMPLANTS

The preceding sections described the details of the classic tapered, matte-finished variety of endodontic stabilizer. There are also threaded varieties. The techniques used to place them differ slightly from the method formerly described. The first type of implant is threaded along its entire length and may be obtained from Park Dental Research Corporation (Figure 16-25). To use this type, prepare the host site exactly as described for the smooth implants, and fit the threaded implant using the routine technique. Apply the cement in the same manner as well, and insert the implant by rotating it into place. After the cement hardens, cut the implant at the desired coronal level.

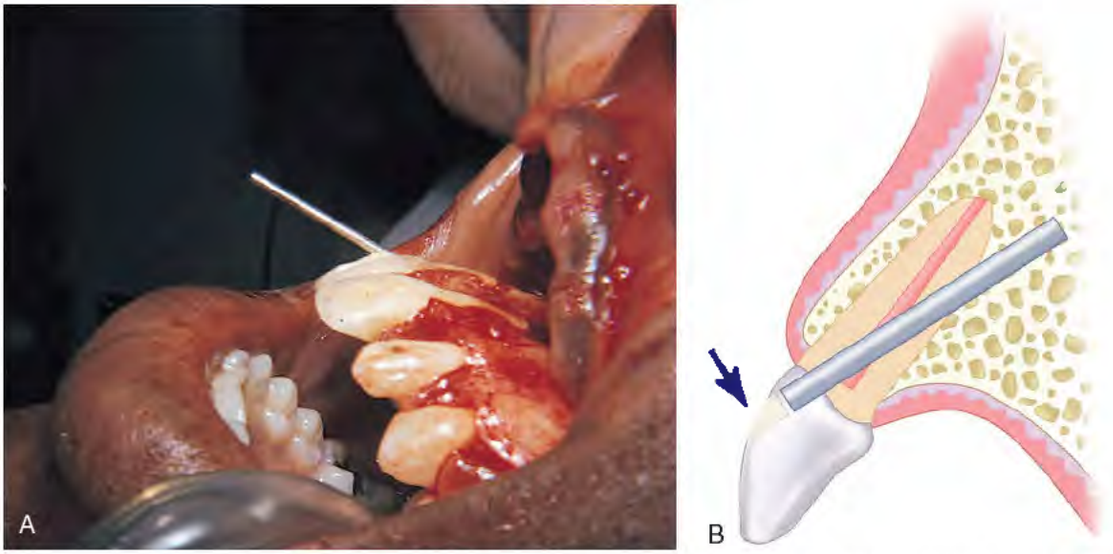


FIGURE 16-24. **A,** In cases of unfavorable axial inclinations of teeth that require stabilization, an oblique implant may be placed following an identical technique after conventional endodontic therapy has been completed. **B,** The diagram indicates, in a cross-sectional view, the relationship of the implant to the alveolar bone and its cortical plates and to the endodontically treated root. Before cementing the implant, score it deeply at a level below *(arrow)* the tooth surface. After twisting it off, fill the defect with composite resin.

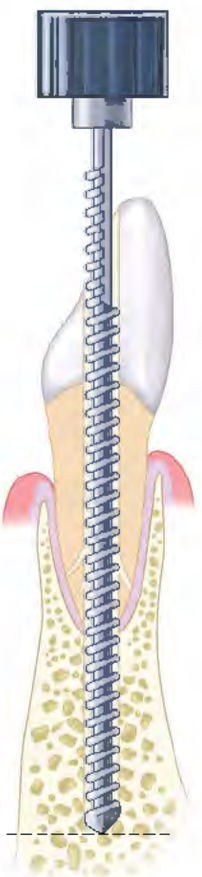


FIGURE 16-25. The threaded endodontic implant by Park Dental Research.

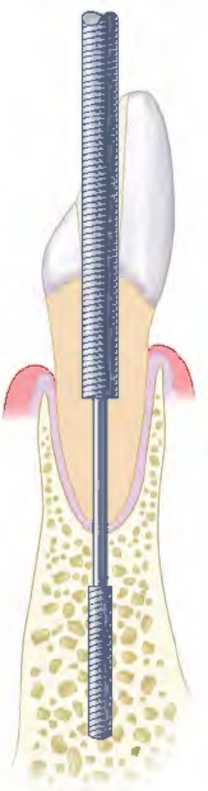


FIGURE 16-26. The TRI-LOCK endodontic implant by Park Dental Research.

The second type, called the TRI-LOCK endodontic implant, is also available from Park Dental Research (Figure 16-26). This implant is threaded in two areas: at the apical end, where the implant engages the supporting subapical bone, and at the coronal portion of the tooth, which gains retention within this area. The value of this second design, compared with the all-threaded one, is that a more reliable apical seal can be obtained, since the periapical portion of each implant is matte-finished rather than threaded. To use this design, measure and trim the implant with care so that the bone-threaded portion will be located beyond the apex. After preparing the host site, apply cement only to the intradental portion of the implant and insert it by rotation using finger pressure. (It comes with a large,

comfortable key that facilitates digital manipulation.) After the cement has hardened, trim the implant to its appropriate length at the coronal end and restore the tooth in the classic manner.

CERAMIC-COATED IMPLANTS

The Kyocera Company has introduced a single-sized No. 17, tapered, solid aluminum oxide (nonmetallic) endodontic implant, the Bioceram Anchor, that is 40 mm long with a diameter from 1.4 to 1.7 mm (Figure 16-27). The intradental portion is straight and entirely of the larger diameter. It can be purchased as part of an entire kit containing two diameters of extra-long contra-angle drills, two reamers (A and B), a trial insert (a good idea when using any coated implant system), and some No. 1 measuring rings that serve as disposable depth markers.

Since the system employs the use of only a single-sized endodontic implant, the placement regimen is quite uncomplicated and similar to that described earlier in this chapter. Use drills No. 13 and 17 to enlarge the canal, creating vertical walls. Create the tapered intraosseous component by using hand reamers A and B. On completion, a precise odontoosteotomy is created. Check its accuracy by placing the try-in. Only after its fit is satisfactory should the implant be cut, prepared, and cemented using glass ionomer or carboxylate cement. The alumina coating presents a promising bone interface and also supplies a good surface for cement adhesion and a reliable apical seal.

Kyocera also offers a No. 21 threaded pin, the Bioceram No. 2 (Figure 16-28), which is 2.5 mm in diameter and 35 mm long. It should be used for short-rooted teeth that may also require coronal reconstruction. The technique of canal preparation follows conventional methods, and this kit, called the *Bioceram Anchor Pin*, offers four contra-angle spiral drills: No. 13, 17, 19, and 22. The spiral drills, which are gently graduated in diameter, in conjunction with an apicoectomy procedure using a fully elevated flap allow the preparation of the entire tooth and periapical host site. Once this is done, the implant, which must be premeasured, can be affixed with carboxylate cement. For coronal buildups, place a small auxiliary pin (i.e., SMS minim) and allow the anchor pin to protrude for an acceptable length. Teeth treated in this manner may be restored using composites in Ion crowns or similar matrices. Endodontic implant stabilizers offer considerable additional strength, particularly when used in multiples (Figure 16-29).

After a 6-week postoperative period, "A" splints, ligatures, or other stabilizing devices may be removed. Before removing the fixation, address any significant periodontal deficiencies.

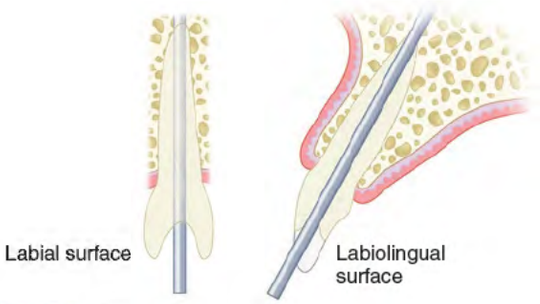


FIGURE 16-27. The Bioceram Alumina Anchor by Kyocera.

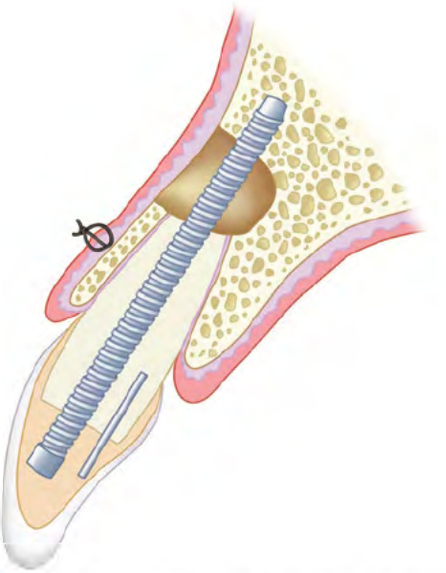


FIGURE 16-28. The Bioceram No. 2 threaded endodontic Anchor Pin Implant.

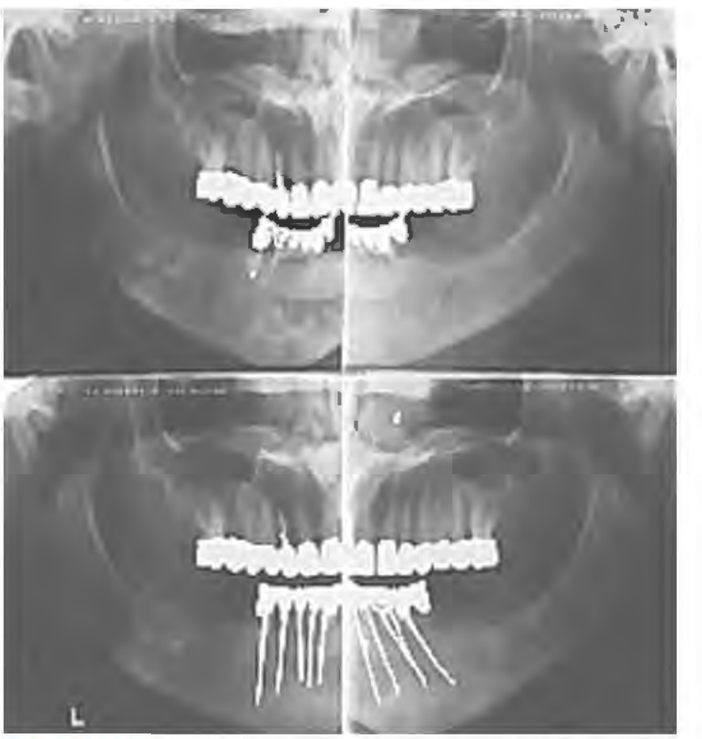


Figure 16-29. A critically important six-unit mandibular anterior fixed bridge that was virtually lost as a result of trauma was preserved for 17 years using endodontic implant stabilizers.

Zygomatic Implant Surgery and Prosthodontics

17 CHAPTER

ARMAMENTARIUM

Brånemark System Zygoma TiUnite Implants Regular Platform (RP)
Implants: 30, 35, 40, 45, 50, 52.5 mm (All Brånemark System Zygoma TiUnite implants are delivered with the implant mount premounted. Each package also includes a cover screw.)
Zygoma implants: RP machined
Implants: 30, 35, 40, 45, 50, 52.5 mm
Zygoma healing abutments (40-degree angle, 3-mm diameter; 40-degree angle, 5-mm diameter)
Multiunit abutments RP
Multiunit: 3, 15 mm
17-degree angle, multiunit: 2 and 3 mm
Zygoma drills
Round bur
Twist drill: 2.9 mm
Twist drill: 2.9 mm short
Pilot drill: 3.5 mm
Pilot drill: 3.5 mm short
Twist drill: 3.5 mm
Twist drill: 3.5 mm short
Zygoma instruments
Zygoma surgical kit
Z handle, Z drill guard,
Z drill guard short, Z depth indicator straight,
Z depth indicator angled.
Cover screwdriver: Brånemark System hexagon
Screwdriver: machine Unigrip 25 mm (to implant mount screw)
Screwdriver: manual Unigrip 28 mm (to implant mount screw)
Zygoma handpiece (to be used with OsseoSet 100) (semistraight ratio 20:1)
Connection to the handpiece
Motor: OsseoSet 100 handpiece
Drill: Zygoma 20:1
Surgical drill guide: NobelGuide (If the NobelGuide is used, the guided surgery kit for the Zygoma implants must be used.)
Forceps: Gerald (toothed)
Hemostats: long, curved (i.e., tonsillar)
Hemostats: mosquito
Impression material and adhesive: Impregum PVS
Needles: hypodermic 20 gauge, 1½-inch
Pliers: crimping
Retractors: beaver tails (Henahan), Army-Navy
Scissors: Mayo
Scalpel: long handle
Suture: 2-0 black silk
Suture: 4-0 dyed Vicryl
Tissue conditioner: Coe-Comfort, Viscogel

OSSEOCONDUCTIVE IMPLANT SURFACES

The TiUnite surface on Nobel Biocare implants has been shown to support the healing process and to maintain initial implant stability better than machined titanium implants. TiUnite is a highly osseoconductive surface.

Indications

The indications for Zygoma implants are as follows:

- When sufficient anterior bone remains for installation of standard implants and the posterior alveolar crest has resorbed to the extent that additional implants would require the support of onlay or inlay grafts.
- In areas where an anterior onlay graft is required for implant placement and the need to extend the graft posteriorly can be eliminated by placement of the Zygoma implant.
- For partially edentulous maxillae with unilateral or bilateral loss of premolars and molars, combined with severe bone resorption. In such cases, a Zygoma implant, in combination with at least two regular implants, offers adequate support for a fixed restoration.

Preoperative Prosthetic Considerations

Many factors contribute to the long-term success of zygomatic implant surgery. As many of these factors as possible must be carefully evaluated before the surgical procedure is started. An effective team approach must be established for proper treatment planning and long-term success. The preoperative prosthetic examination and evaluation should include the following:

- Facial profile and contours
- Parafunctional habits
- Horizontal and vertical jaw relationships
- Occlusal plane orientation
- Occlusal relationships
- Status of the opposing dentition

Position and Angulation of the Implants

The tooth positions for the planned restoration should be decided preoperatively. The ideal length and angulation of implants are best achieved by using the NobelGuide (see Chapter 4). This allows selection of the most appropriate position and angulation for each implant. The existing removable prosthesis often serves as a guide for these positions. In some cases, a diagnostic wax-up is necessary. The prosthetic team must ensure that the surgical team clearly understands the tooth positions required for the final prosthesis. A good means of doing this is to provide a surgical guide. A surgical guide can be fabricated quickly and simply by making a clear acrylic resin replica of the existing removable denture or the waxed-up try-in (see Chapter 4). Except for a supporting posterior connection, the palatal area of the replica is cut away, leaving only the buccal contours of the teeth.

BRÅNEMARK SYSTEM ZYGOMA IMPLANTS

The process for implanting the Brånemark Zygoma implant follows these steps.

1. The alveolar crest, including the palatal side, is exposed, and a 10 × 5-mm window is created on the lateral wall of the sinus, close to the infrazygomatic crest. Ideally, the sinus mucosa is kept intact during this process.
2. The sinus mucosa is carefully lifted away from the area where the implant will pass through the sinus, from the floor of the sinus to the roof, with care taken not to penetrate the mucosa (Fig. 17-1). Ideally, the implant is placed as posteriorly as possible, with the implant head as close to the alveolar crest as possible.

   The implant must simultaneously pass through the sinus close to the crest of the zygomatic bone and perforate the cortical bone of the zygomatic bone close to the incisura previously described. Anatomic variations may require adjustment of this ideal placement.
3. The exact point on the alveolar crest to start the drilling sequence is determined, as is the direction of the long axis of the implant based on the known anatomy of the sinus, the zygomatic bone, and its processes.
4. A retractor is placed at the previously described incisura to facilitate the correct three-dimensional orientation of the implant bone site, with special emphasis on preventing penetration of the orbital floor. The drills used to prepare the bone site for the Zygoma implant are quite long, therefore it is important to protect all oral soft tissues along the drill shaft during drilling. The drill guard must always be used, to prevent contact between the rotating drill shaft and soft tissue.

Operating Instruments

NOTE

The drill speed should not exceed 2000 rpm. Also, sufficient irrigation is important throughout the drilling sequence.

Recommendations for using surgical units other than Osseo-Set 100:

- Gearing of the contra-angle handpiece is adjustable to a ratio of 20:1.
- Maximum drill speed is 2000 rpm.
- Maximum speed for implant installation is 45 rpm.
- Maximum torque for implant installation is 50 Ncm.

1. The palatal mark for the implant entrance is made with the round burr, which penetrates and passes through to the sinus while the direction of the burr is checked through the sinus window. The burr must be directed toward the retractor, which previously was placed at the incisura (Fig. 17-2).
2. An entrance mark is made in the posterosuperior roof of the sinus and then continued with the twist drill (2.9 mm diameter), which is available in two lengths, until the drill penetrates the outer cortical layer of the zygomatic bone at the incisura.
3. It is imperative that the implant surgeon have full control of the area where the drill is penetrating the zygoma, to protect the soft tissue at the site and also to view the outer cortical layer at the level of the incisura.
4. The straight depth indicator is now used to determine the length of the Zygoma implant required (Fig. 17-3).

   If radiographs show that the zygomatic bone is thin, the implant surgeon must make sure the drill is directed toward the lateral

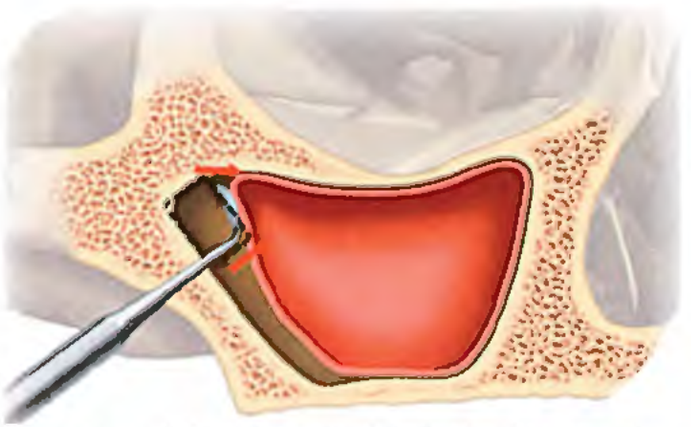


FIGURE 17-1. Caldwell-Luc approach to visualize the sinus cavity and elevate the membrane from the posterior aspect of the antrum. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

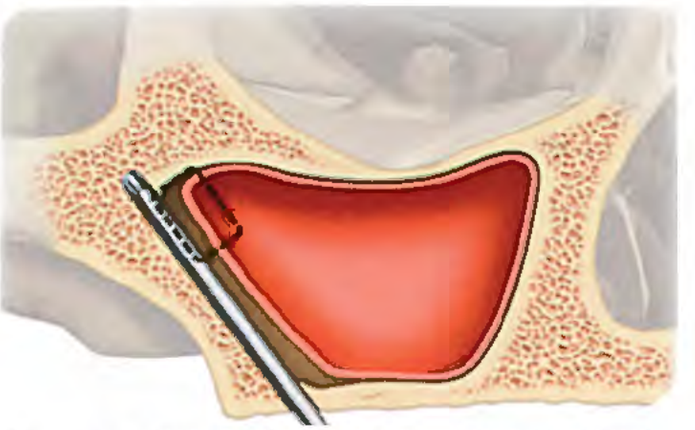


FIGURE 17-2. Direct visualization of the path of the drill through the lateral window is critical. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

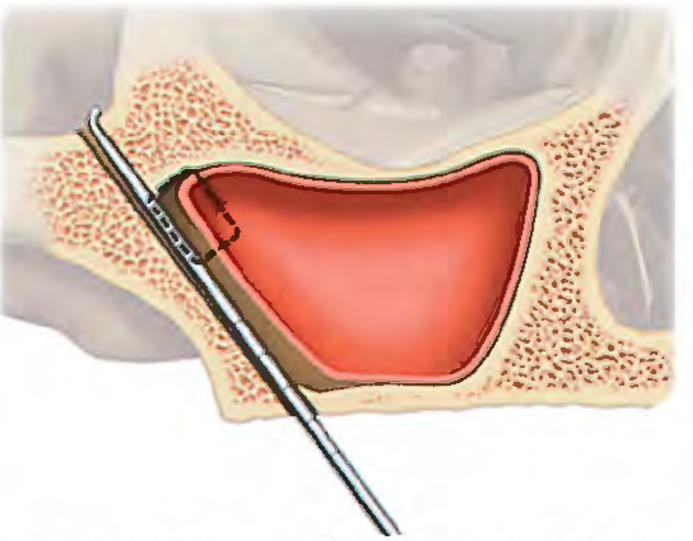


FIGURE 17-3. Depth gauge (indicator) for measuring the length of implant required. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

surface of the incisura to minimize or prevent medial perforation of the bone with the implant.

5. The bone site is widened successively with the following drills:
   - The pilot drill (3.5 mm), which is available in two lengths: The pilot end is used to find the entrance of the penetration of the sinus roof previously made by the 2.9-mm twist drill. (Drill guards are available in two lengths.)
   - The twist drill (3.5 mm), which also is available in two lengths: This is the last instrument used in the drilling sequence (Fig. 17-4).
6. The depth of the prepared bone site is verified with the angled depth indicator to ensure that the selected implant will fully seat without apical bone interference. If the sinus mucosa can not be kept intact, it is essential to prevent the mucosa from entering the implant bone site. Any mucosal remnants in the bone site may prevent osseointegration of the implant. Care must be taken to ensure correct angulation and to prevent drill wobble, which can widen the preparation site.

Implant Installation

The length and design of the Zygoma implant create three special concerns for the surgeon when installing the implant.

1. The surgeon must attach the connection to the handpiece to the Zygoma handpiece. The implant assembly is engaged and carried to the prepared implant site. Slow speed is used on the drilling unit when the implant's apex is engaged in the prepared bone site. The correct insertion angle of the implant is confirmed while continuing through the sinus until the implant's apex engages the zygomatic bone. The surgeon must make sure that the implant is guided along the correct path of insertion through the sinus. The connection to the handpiece is disengaged from the implant mount (Fig. 17-5, *A*), and the handle is connected with its adapter end to the implant mount (Fig. 17-5, *B*).
2. If the drilling unit, when set at 45 Ncm, stalls several turns before it reaches the implant's final seating position, the bone site has not been prepared to its full depth with the twist drills. The implant should be backed out and the bone site prepared again to match the chosen implant. Applying excessive torque can distort the implant head or fracture the implant mount or implant mount screw.
3. The implant should be rotated clockwise, using the handle, until the desired depth and head position are achieved. The angulated hexagonal top should be directed toward an ideal occlusal plane. This can easily be verified by checking the position of the implant mount screw which corresponds to the position of the abutment screw (Fig. 17-6).

Caution Bending forces should not be applied during this procedure, because they may distort the implant head or fracture or loosen the implant mount screw. If the hand wrench must be used excessively, the implant mount screw should be checked for loosening and retightened if necessary. When the correct implant head position has been verified, the insertion tool is secured with a suture through the hole in the tool.

4. A manual Unigrip screwdriver or a screwdriver installed on the contra-angle is used to remove the insertion tool. The screw is

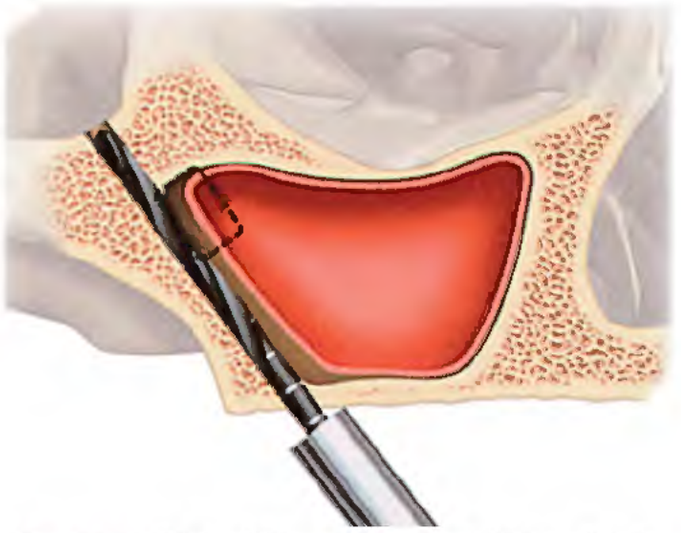


FIGURE 17-4. A twist drill is used as the final drill to the length of implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

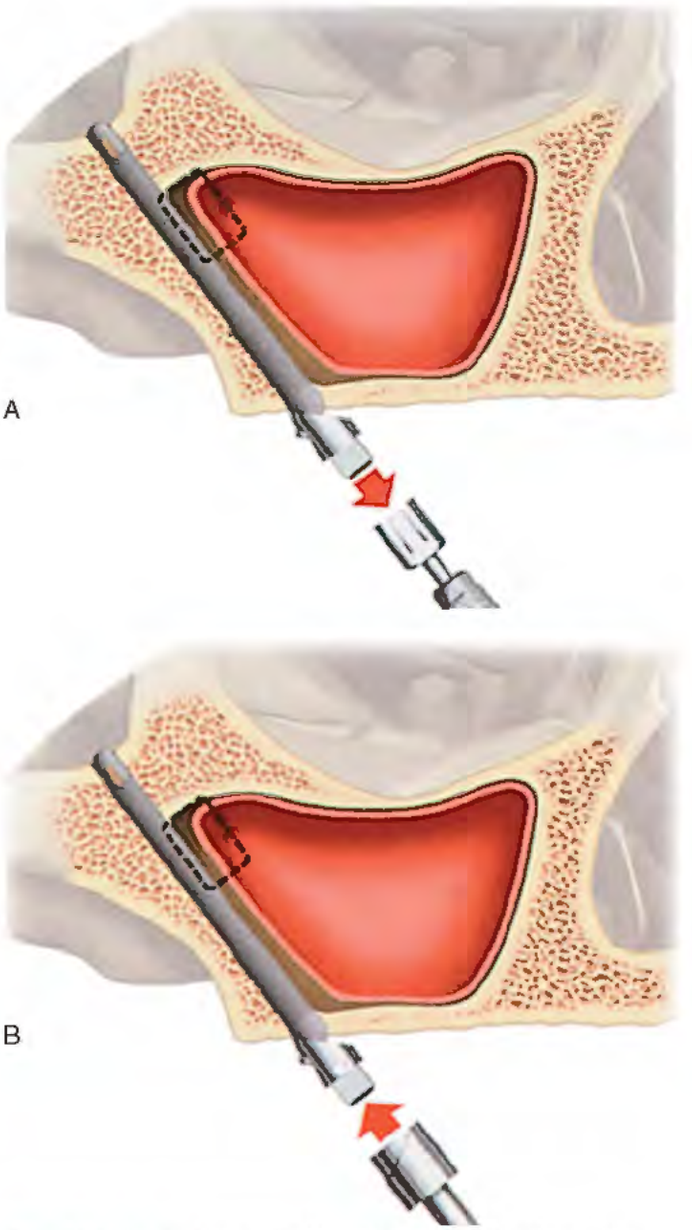


FIGURE 17-5. **A,** A motorized handpiece is used to insert the implant by disengaging the carrier mount. **B,** The carrier mount is then re-engaged into the handpiece. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

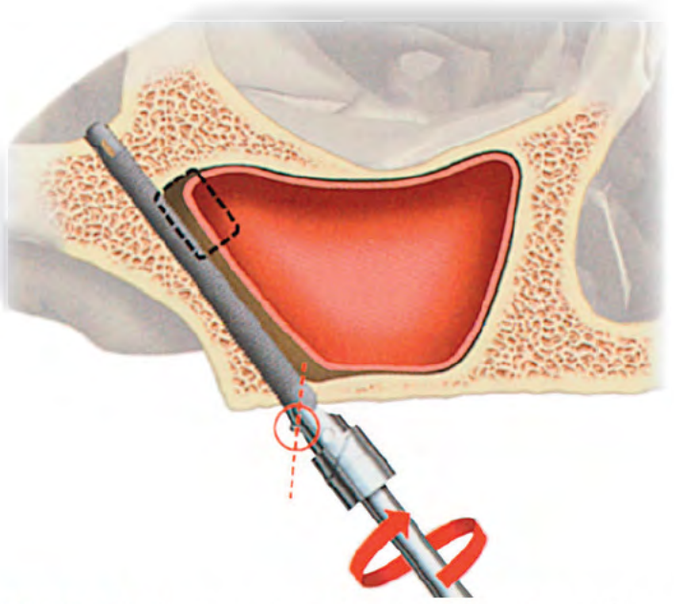


FIGURE 17-6. The implant is hand-tightened to the final position, keeping the timing in mind for the final position of the abutment. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

backed out one or two turns and, if necessary, the insertion tool is wiggled gently side to side to ensure that it is not binding on the implant head. The screw in the insertion tool is loosened completely and removed before the insertion tool is removed from the head of the implant.

Caution The locking screw always comes completely loose, which increases the risk of inhalation.

5. A cover screwdriver hexagon is used to connect the cover screw.

Caution The cover screw must be completely seated to avoid ingrowth of bone in the internal threads of the implant head. Ingrowth of this kind may prevent complete seating of the permanent abutment during the uncovering if a two-stage procedure is used.

Suturing

To minimize postoperative bleeding, ensure complete closure of the wound, and minimize the risk of dehiscence, the implant surgeon should:

- Start with submucosal sutures, using a resorbable suture material.
- Use nonresorbable vertical mattress sutures in the submucosa and mucosa.
- Place simple sutures between the mattress sutures. These sutures are not placed as deeply into the submucosa as the mattress sutures. They ensure water-tight closure of the wound.

Connection of Healing Abutment

Healing abutments are attached to the implant either as a one-stage protocol or at the uncovering phase to allow the formation of a surrounding soft tissue collar. The abutments are available in two lengths. The depth gauge should be used for soft tissue to measure the amount of tissue through which an opening must be maintained.

Connection of the healing abutment follows these steps.

1. The package containing the abutment is opened.
2. The contents are emptied into a sterile bowl.
3. The Unigrip screwdriver is pressed into the healing abutment, and the assembly is carried to the implant.
4. The abutment is screwed into place.
5. The mucosa is sutured between the abutments.

Implant Removal

The patient must be informed before surgery of the consequences of losing a Zygoma implant and the treatment involved. Failure of a Zygoma implant to osseointegrate or loss of an implant as a result of loss of osseointegration or fracture renders the implant useless for supporting a prosthetic restoration. This may lead to a delay in treatment, additional surgical procedures, and/or a change in the treatment plan.

To remove the implant, a Zygoma implant mount is secured to the implant with the implant mount screw. The adapter part of the handle is connected to the implant mount, and the implant is rotated counterclockwise until it is fully disengaged from the bone. Any connective tissue in the bone site must be removed carefully before a mucoperiosteal flap is positioned and sutured over the entrance. After a healing period of approximately 1 year, a new implant can be installed, if desired.

If a Zygoma implant has fractured, the coronal portion of the implant is removed, and the apical portion is left to heal in the bone. The implant and abutment connection are uncovered according to the standard implant protocol for a two-stage procedure.

Prosthetic Procedure

NOTE

Only the Brånemark System Zygoma Abutment Multiunit (RP) or Brånemark System Zygoma Abutment 17° Multiunit (RP) should be used with Brånemark System Zygoma TiUnite implants. Likewise, only the Zygoma Abutment Multiunit (RP) or Zygoma 17° Abutment Multiunit (RP) should be used with Zygoma implants.

Clinical Procedure

The prosthetic clinical procedure for the Zygoma implant follows the same sequence as a conventional Brånemark System Regular Platform case (also see Chapter 26).

1. *Impression:* A rigid impression material and impression coping multiunit open tray is recommended. An impression of the lower jaw is made, as well as a preliminary registration and jaw relation records.

NOTE

Before the impression is taken, it is important to use intraoral radiographs to verify that all abutments have been seated properly. The rotational stability of all abutment screws also should be verified.

2. *Adjustment and relining of the removable prosthesis:* Careful adjustment of the patient's existing denture is imperative during the course of the prosthetic treatment. This entails extensive relief of the palatal base. It is important to ensure that the healing caps do not interfere with the hard acrylic of the denture.
3. *Master cast fabrication:* The impression is delivered to the dental laboratory, and a master cast is made. An acrylic record base with a wax occlusal rim is fabricated on this cast.

4. *Registration of jaw relations:* The record base is attached to the abutments, and the occlusal rim is adjusted to the correct vertical height and occlusal plane orientation. Adequate lip support and facial contours are also evaluated, and appropriate adjustments are made to the occlusal rim. Tooth shape and shade are selected.
5. *Tooth setup in wax:* A preliminary tooth setup is made, according to conventional prosthetic principles.
6. *Try-in of the preliminary tooth setup:* The wax setup is tried in the patient. The surgeon should evaluate vertical dimension, occlusal relationships, cantilevers, cuspal inclination, tooth shade and shape, hygiene access, lip support, facial contours, and other factors.
7. *Framework fabrication:* A rigid framework with adequate volume and precision is made. Cast gold-alloy or precision-milled titanium frameworks (e.g., Procera Implant Bridge) are recommended. It is imperative that the framework fit passively on the master cast.
8. *Try-in of framework:* The passive fit of the framework is verified intraorally. Magnification loops can facilitate this procedure.
9. *Processing and delivery of final restoration:* The passive fit of the final restoration, once fabricated, is verified intraorally, and the retaining prosthetic screws are tightened to 15 Ncm. The occlusion is carefully checked and, if necessary, adjusted.

NOTE

Any primary occlusal contacts on distal cantilevers are eliminated. Screw access holes are temporarily sealed. Oral hygiene procedures are discussed with the patient, and the necessary instructions are given. Intraoral radiographs are recommended to verify component fit and to record baseline marginal bone levels.

10. *Postinsertion visit:* The patient should be seen 1 to 2 weeks after delivery for a checkup. The stability of the restoration is checked, and a general evaluation of function, phonetics, and esthetics is made. The stability of the bridge-retaining gold screws is also tested, and if necessary, the screws are retightened. The screw access holes can be permanently sealed. A soft, easily removed material is placed over the screw head, and a hard filling material, such as composite resin, is placed on top of that to seal the holes completely.
11. *Recall schedule:* A recall schedule is established, based on individual evaluation of each patient's needs and circumstances. Annual clinical checkups are recommended, with intraoral radiographic examinations after 1, 3, and 5 years.

Rigid Bar Splinting

If the Zygoma implant has no or very limited support from marginal bone, the individual fixtures should be splinted to each other. This should be done immediately after second-stage surgery (abutment connection).

Ideally, an impression is made at the time of second-stage surgery. A rubber dam can be used to cover the surgical incisions and sutures. The abutments and impression copings will penetrate the dam. A laboratory working cast is poured, and gold copings are attached to the abutment replicas.

A gold bar then is adjusted to fit and is soldered to the gold copings. The rigid bar is attached to the abutments intraorally and secured in place with gold screws. The patient's removable prosthesis is carefully adjusted and relined with a soft relining material, as previously described.

Caution

- The mechanical performance of implants, abutment screws, and prosthetic components, as well as long-term osseointegration, may be adversely affected by lack of passive fit of the restoration, inadequate prosthesis design, trauma to the oral region, and various other aspects of biomechanical overload.
- The Zygoma implant can withstand functional load only if rigidly connected to at least two (and preferably more) osseointegrated implants.

All-on-4 Implants

18 CHAPTER

ARMAMENTARIUM

All-on-four guide
Cold-cure acrylic and GC Pattern resin
Dental floss, orthodontic ligature wire, and wire cutter
Final or intermediate prosthesis
Impression and bite registration material
Impression trays
Necessary abutments and retaining screws
Necessary impression copings
Prosthetic kit
Surgical kit for the system used
Implants selected

The All-on-4 and All-on-4 with NobelGuide clinical solutions were developed by Dr. Paulo Maló at CM Clinica Maló in Lisbon, Portugal. The All-on-4 clinical solution was developed to maximize the use of available bone and allow immediate function. Using only four implants in edentulous jaws, this technique takes advantage of the benefits of tilting the posterior implants (which are longer than the vertically placed implants that otherwise could be accommodated in the available space) to provide secure, optimum prosthetic support for a prosthetic bridge, even with minimum bone volume.

TECHINIQUE FOR THE ALL-ON-4 CLINICAL SOLUTION

Implants That Can Be Used for All-on-4

Parallel Implants

- NobelSpeedy Groovy
- NobelSpeedy Replace
- Brånemark System Mk III Groovy
- NobelReplace Straight Groovy
- Brånemark System Mk III, TiUnite
- Brånemark System Mk IV, TiUnite
- Replace Select Straight

Tapered Implants

- NobelReplace Tapered Groovy
- Replace Select Tapered

Treatment Planning

The All-on-4 clinical solution has been developed to maximize the use of available bone and to allow for immediate function. When All-on-4 treatment is planned using a flap technique, both general and specific considerations must be taken into account.

General Considerations

1. The surgeon must be sure of the ability to achieve primary implant stability (35 to 45 Ncm insertion torque).
2. The patient must have no severe parafunctions.
3. The procedure is indicated for a totally edentulous maxilla with a minimum bone width of 5 mm and a minimum bone height of 10 mm from canine to canine.
4. The procedure is indicated for a totally edentulous mandible with a minimum bone width of 5 mm and a minimum bone height of 8 mm between the mental foramina.
5. To reduce the cantilever, the posterior implants can be tilted to a maximum of 45 degrees.
6. If the angulation is 30 degrees or more, the tilted implants must be splinted.
7. For tilted posterior implants, the distal screw access holes should be located at the occlusal face of the first molar, the second premolar, or the first premolar (depending on the location of the mental foramen).
8. The All-on-4 treatment does not require wider opening of the mouth than normal straight-positioned implants because of the angulation of the posterior implants.
9. If any remaining teeth require removal, the sockets should be cleaned and debrided thoroughly after extraction, and the implants should be placed between the extraction sockets into the interdental bone.

Specific Consideration: Implants

1. If possible, the posterior implants should be 4 or 4.3 mm in diameter.

NOTE

The 30-degree multiunit abutment is available only for regular platform (RP) implants. The 17-degree multiunit abutment is available both for RP and for narrow platform (NP) implants.

2. When posterior implants with an internal connection are placed (Fig. 18-1), one of the trichannel lobes on the implant must be pointing distally or slightly buccally.

Specific Considerations: Prosthetics

1. No extensions over one tooth on each side should be made for the immediate all-acrylic bridge, which should have a maximum of 12 teeth.
2. If the patient's removable prosthesis is in good condition, it can be used to fabricate the immediate all-acrylic bridge.
3. For proper esthetics and function, the final bridge should have 12 teeth.

FLAP SURGICAL APPROACH

Edentulous Mandible

The following step-by-step instructions outline the main procedures for All-on-4 treatment of a totally edentulous mandible. (The images show NobelSpeedy Groovy RP implants.)

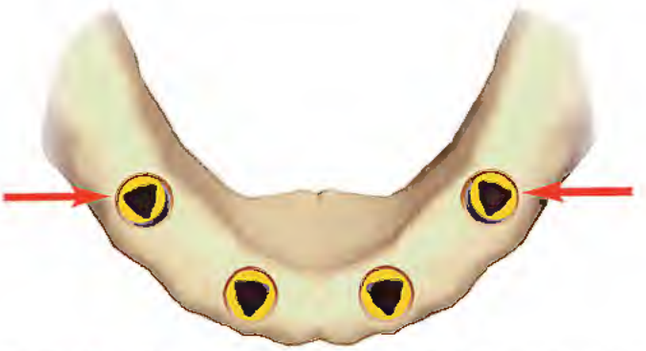


FIGURE 18-1. One lobe of the anterior implants is positioned midbuccal, and one lobe of the posterior implants is positioned at the distal line angle. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

1. Positioning of the All-on-4 Guide (Fig. 18-2)
   - An incision is made for flap elevation. A 2-mm twist drill is then used to make a 10-mm osteotomy in the midline.
   - The All-on-4 guide is placed in the osteotomy.
2. Posterior Site Preparation (Fig. 18-3)
   - A 2-mm twist drill tilted to a maximum of 45 degrees is used to drill to appropriate depth.

NOTE

It is important to identify the mental foramen and exiting inferior dental nerve. The final position of the implant should be at least 6 mm in front of the foramen to avoid the nerve loop.

- Correct angulation is checked with the All-on-4 guide.
- The site is enlarged according to the type of implant used and the density of the bone.
- An implant is installed (Fig. 18-4).
- A bone mill is used to correctly seat the abutment, if applicable.

NOTE

A bone mill is intended for use only with Brånemark System and NobelSpeedy Groovy implants.

- A 30-degree multiunit abutment is placed and tightened to 15 Ncm with the Unigrip screwdriver machine and manual torque wrench prosthetic. The same procedure is performed on the opposite posterior site.

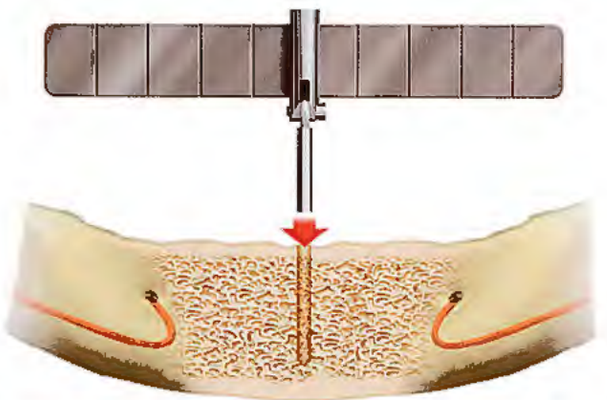


FIGURE 18-2. Proper identification of the midline is critical. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

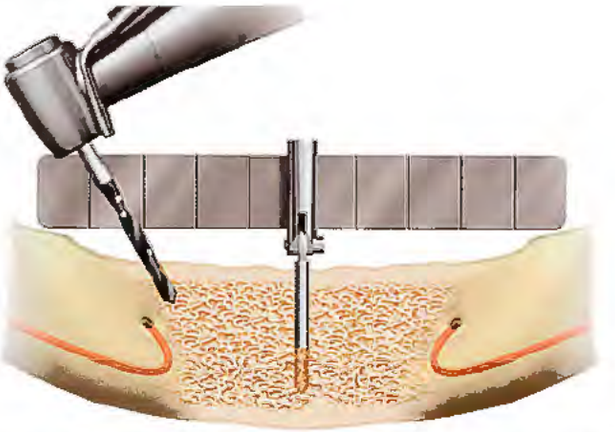


FIGURE 18-3. Visual identification of the mental foramen and the anterior nerve loop is very important. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

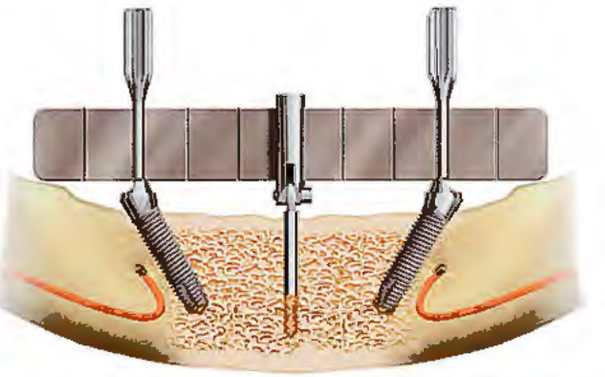


FIGURE 18-4. The use of angulation pins to verify 30-degree preparation is helpful for the placement of a 30-degree abutment in the posterior implants. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

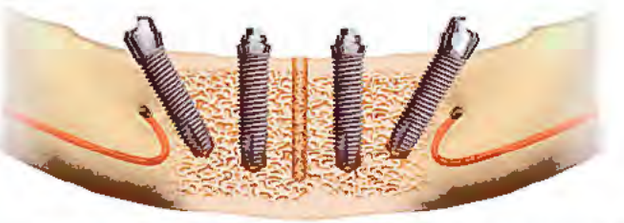


FIGURE 18-5. Alignment of the prosthetic screws in a single path is very important. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

3. Anterior Site Preparation (Fig. 18-5)
   - Two anterior sites are prepared as far apart as possible, allowing a safe distance from the apex of the posterior implants.
   - A bone mill is used to seat the abutments correctly, if applicable.

NOTE

A bone mill is intended for use only with Brånemark System and NobelSpeedy Groovy implants.

- Straight or 17-degree multiunit abutments are placed, allowing for proper emergence of the prosthetic screw.

- The 17-degree multiunit abutments are tightened to 15 Ncm using the Unigrip screwdriver machine and manual torque wrench prosthetic.
- Straight multiunit abutments are tightened to 35 Ncm using the screwdriver machine multiunit and manual torque wrench prosthetic.

4. Take an Impression (Fig. 18-6)
   - After suturing, the multiunit impression copings open tray is connected to the multiunit abutments.
   - An impression is taken using silicone soft putty material and a customized open tray.
5. Laboratory Procedure (Fig. 18-7)
   - A model and a restoration are made in the laboratory.
6. Connect the Bridge (Fig. 18-8)
   - Chlorhexidine gel is placed inside the copings, and the all-acrylic bridge is connected to the abutments.
   - The abutments are tightened to 15 Ncm using a Unigrip screwdriver machine and manual torque wrench prosthetic.
   - The occlusion is checked.
   - After a sufficient healing period, established prosthetic procedures are followed for the final restoration, preferably a Procera implant bridge with individualized Procera ceramic crowns.

Edentulous Maxilla

When an All-on-4 treatment also is performed in the maxilla, the following steps are used for the posterior sites, in addition to those for the posterior sites in the mandible.

1. Posterior Site Preparation (Fig. 18-9)
   - The anterior wall of the maxillary sinus is identified by drilling a small opening on the lateral wall of the maxilla where the anterior wall would be expected.
   - The wall is explored with a probe, and the window is extended if necessary.
   - The surgical marker is used to mark the position of the anterior wall (Fig. 18-10).
   - The site preparation is started as posteriorly as possible, allowing approximately 4 mm from the sinus wall (Fig. 18-11).

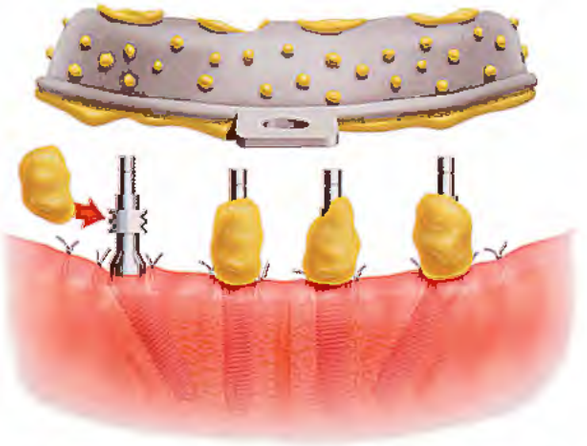


FIGURE 18-6. Using conventional crown and bridge impression materials, an open tray technique is used to take an impression. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-7. The fixed prosthesis is fabricated by the laboratory, and the fit is checked and verified on the model. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-8. The prosthesis is inserted and screwed into the implants. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

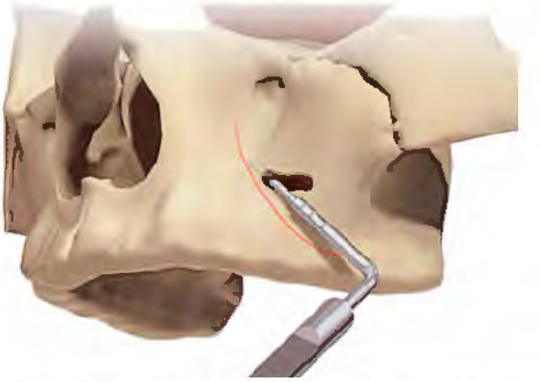


FIGURE 18-9. A small lateral window is created in the side of the anterior aspect of the maxillary antrum. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

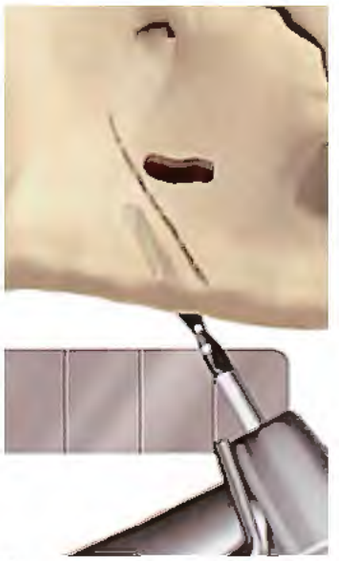


FIGURE 18-10. The outline of the anterior wall of the antrum is identified and marked to guide angulation of the osteotomy and to prevent penetration of the sinus. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

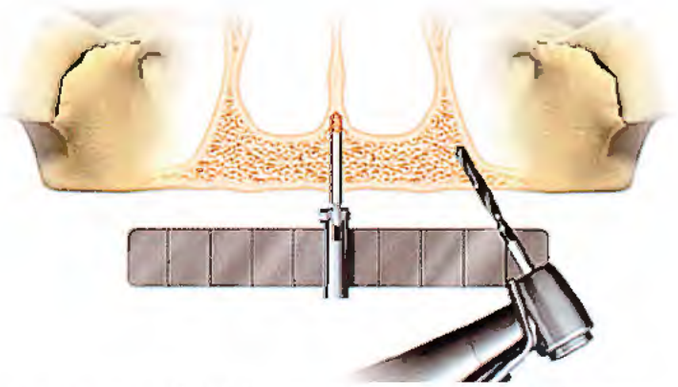


FIGURE 18-11. Guide and angulation pins are used to prepare the posterior sites. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

- The drill is inclined as far back as possible (not more than 45 degrees) to minimize the cantilever, and the implants are then inserted (Fig. 18-12).
- A soft tissue model is fabricated using the abutment replicas multiunit (Fig. 18-13).
- Guide pins or laboratory screws are used to place the temporary copings multiunit on the replica. The copings are adjusted if necessary.

FIGURE 18-12. The four implants are placed with the angulations in one path of insertion. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-13. On a soft tissue model, copings are placed and heights are adjusted as needed, and an acrylic fixed-detachable bridge is fabricated. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

- An all-acrylic bridge is fabricated from a high-density acrylic. The weak points of the prosthesis must be reinforced around the cylinders with more acrylic.

NOTE

If possible, a tooth setup should be tried in the patient's mouth before the bridge is finalized.

FLAPLESS/NOBELGUIDE APPROACH (Fig. 18-14)

Preoperative Checklist

- All-on-4 with NobelGuide
- Correct implants, guided components (Fig. 18-15), and instruments
- Operation specification
- Surgical template
- Surgical index
- Prosthetic components and instruments
- Jig construction for placing 30-degree multiunit (Fig. 18-16)

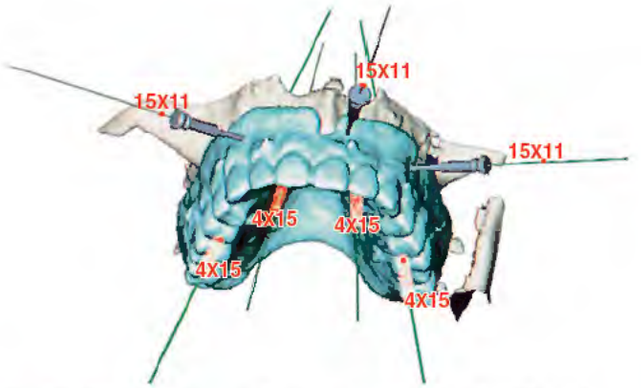


FIGURE 18-14. Procera software generated on the All-on-4 NobelGuide. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-15. Preoperative armamentarium. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

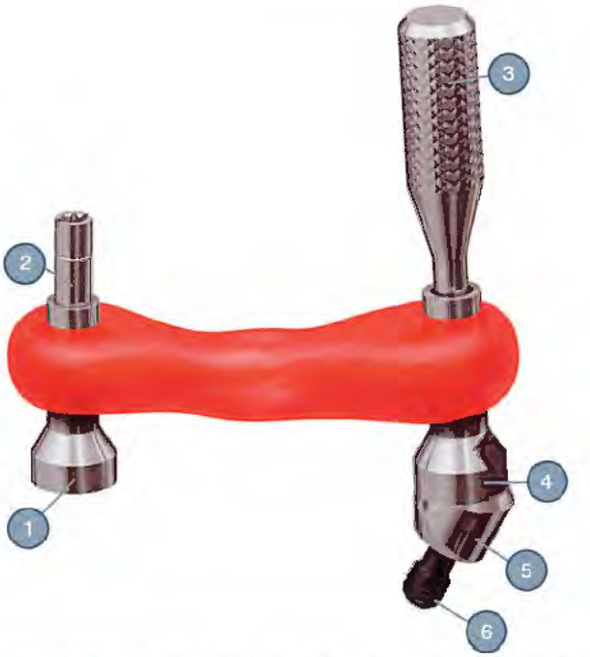


FIGURE 18-16. Laboratory-fabricated jig for positioning of the nonhex abutments. (Courtesy Nobel Biocare, Yorba Linda, Calif.) 1. Impression coping open, Tray multi-unit. 2. Guide pin. 3. Abutment holder. 4. Jig stabilizer. 5. 30° multi-unit abutment, nonengaging. 6. Abutment screw.

FIGURE 18-17. Implant placement using the NobelGuide. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

- Nonengaging abutments
  - Impression coping open tray multiunit
  - Guide pin
  - Abutment holder
  - Jig stabilizer
  - 30° multiunit nonengaging abutment
  - Abutment screw

Edentulous Maxilla

The following step-by-step instructions outline the main procedures for using the NobelGuide with the All-on-4 treatment for totally edentulous jaws. (The images show NobelSpeedy Groovy RP implants.)

1. Four implants are placed according to the computer-based plan (Fig. 18-17).
   - The surgical template is removed.
2. The multiunit abutments are connected.
   - A bone mill is used to seat the abutments correctly, if applicable.

NOTE

A bone mill is intended for use only with Brånemark System and NobelSpeedy Groovy implants.

   - The correct size and sterilized straight multiunit abutments are placed in the two anterior sites (Fig. 18-18).
   - The abutments are tightened to 35 Ncm using the screwdriver machine multiunit and manual torque wrench prosthetic.
3. The jig is placed to connect the 30-degree multiunit abutments (Fig. 18-19).
   - The disinfected jig is placed on the corresponding anterior abutment and posterior implant.
   - Correct seating of the jig is verified, and the guide pin is tightened to the anterior abutment.
4. The 30-degree multiunit abutment is connected (Fig. 18-20).
   - The 30-degree multiunit abutment is connected using a Unigrip screwdriver and tightened manually.
5. The Jig is disconnected (Fig. 18-21).
   - The jig is disconnected by unscrewing first the abutment holder and then the guide pin.
   - The entire procedure is repeated for the opposite side.

FIGURE 18-18. The abutments are secured to the anterior implants first, because this facilitates positioning of the jig for the posterior abutments. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-19. The anterior abutments are used as a positioning reference for the jig, which is needed to attach the 30-degree rotational abutments to the posterior implants. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-20. With finger pressure, the abutments are secured to the implants with the retention screws. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

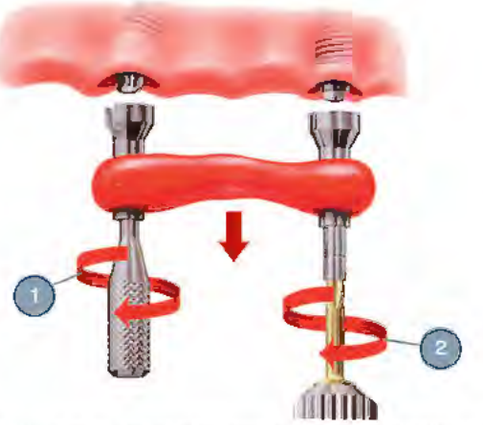


FIGURE 18-21. Once the abutments have been initially stabilized, the jig is removed. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

CAVEAT

The abutment holder connected to the 30-degree multiunit abutment is never unscrewed before the posterior angulated abutment is tightened completely.

6. Final tightening of the 30-degree multiunit abutments is performed (Fig. 18-22).
   - The 30-degree multiunit abutment is tightened to 15 Ncm using the Unigrip screwdriver machine and manual torque wrench prosthetic.

All-Acrylic Bridge (Fig. 18-23)

The all-acrylic bridge is delivered with the temporary copings multiunit in three implant positions. An extended hole is located in one of the posterior positions.

1. The temporary coping is connected.
   - The bridge is connected with three prosthetic screws and manually tightened with a Unigrip screwdriver.
   - A temporary coping multiunit is placed in the extended hole and manually tightened with a Unigrip screwdriver.
   - All the screws are tightened to 15 Ncm with a Unigrip screwdriver machine and manual torque wrench prosthetic.
   - Tooth color flow composite or acrylic is used to secure the temporary coping to the bridge, with care taken to keep the screw access hole free of composite.
2. The temporary coping multiunit is reinforced (Fig. 18-24).
   - The bridge is disconnected.
   - The gap between the temporary coping and the bridge is filled with self-curing acrylic.
   - The bridge is adjusted and polished.
3. The bridge is connected (Fig. 18-25).
   - Chlorhexidine gel is placed inside the copings, and the all-acrylic bridge is connected to the abutments.
   - The abutments are tightened to 15 Ncm with the Unigrip screwdriver machine and manual torque wrench prosthetic.
   - The occlusion is checked.
   - After a sufficient healing period, established prosthetic procedures are followed for the final restoration, preferably with a Procera implant bridge with individualized Procera ceramic crowns.

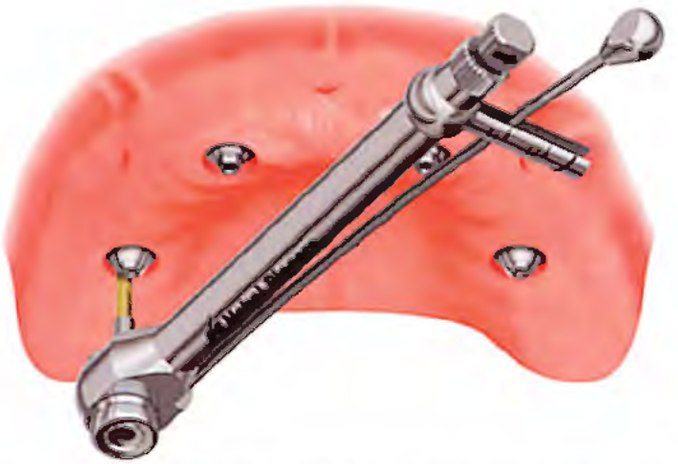


FIGURE 18-22. A torque wrench is used to tighten all the screws to 15 Ncm. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

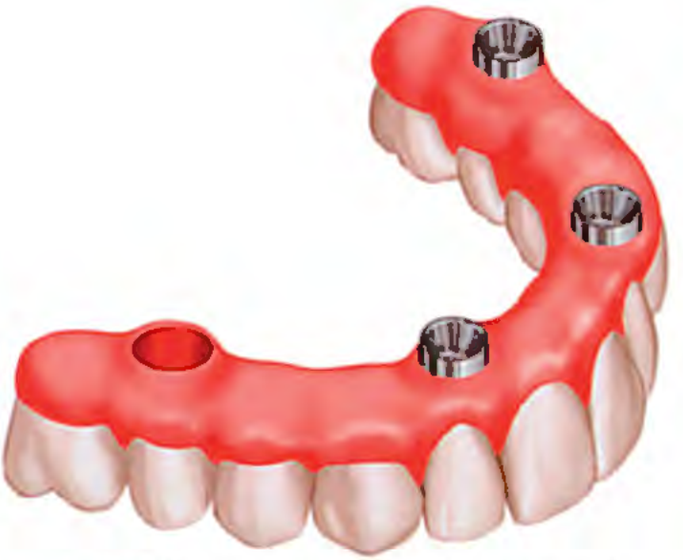


FIGURE 18-23. The prosthetic laboratory fabricates an acrylic fixed-detachable bridge on the model based on records transferred by the clinician. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

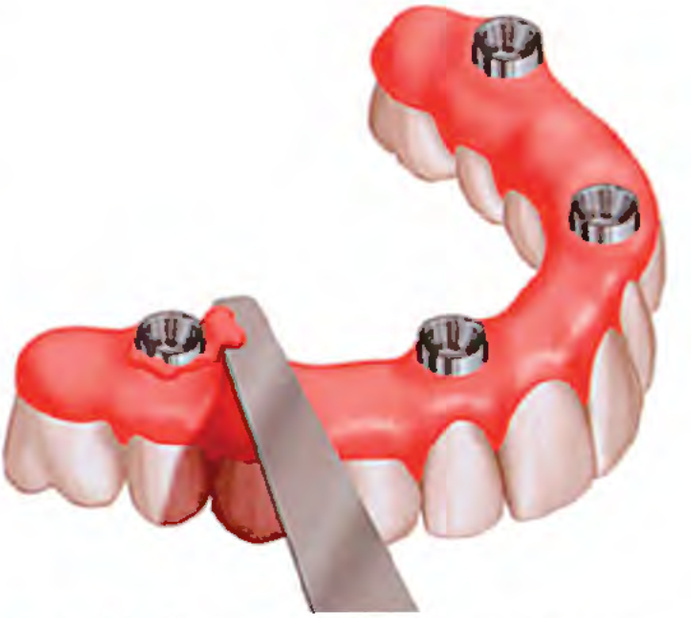


FIGURE 18-24. The prosthesis is returned to the clinician, who relines the acrylic base with conventional relining materials as needed so that the prosthesis seats properly on the soft tissue. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 18-25. The four abutment screws are finger-tightened, and then all screws are tightened with the torque wrench to 15 Ncm. The screw head is covered with a cotton pellet or gutta percha before a composite is used to close off occlusal access. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Crête Mince, Mini-Implant, Transitional, Temporary Anchorage Devices, and other Implant Surgical and Prosthodontic Procedures

19 CHAPTER

ARMAMENTARIUM

Bur: 700XXL
Dentatus/Imtec kit
Endodontic explorer
High-speed handpiece
Indelible pencil
Mini-implants
Orthodontic anchor implants
Orthodontic brackets (acid etch technique)
Orthodontic wire ligatures (.018 to .022 round and square), rubber bands, power chain, and springs of various gauges (to validate ligature diameters)
Pressure indicator paste (PIP)
Ratchet wrench: handheld, with attachment
Sendax kit from IMTEC
Scalpel:
Scalpel blade: Bard-Parker (BP) No. 11
Spade drills: generic, 1.2, 1.6, and 2 mm spade drills (for initial osteotomies)
Ultra-low-speed drill system with special mini bone taps

CAVEATS

As with all endosteal implant procedures, care must be taken not to impair vital structures.

Using infiltration anesthesia in the mandible helps guide drilling when the mandibular canal is approached, because the patient can report lip tingling.

The optimum prognosis is supported by slow drilling to keep intraosseous temperatures low, use of chilled saline irrigants, carefully planned implant placement, accurately directed drills, maintenance of the integrity of cortical plates, and use of a gentle, pressure-free, well-irrigated sharp instrument.

Instruments should be used with a vertical (not arclike) application, and they should be allowed to find and follow their own paths. The implants themselves are self-tapping.

The surgeon must plan carefully and must fabricate a fixed prosthesis with hollowed pontics designed to serve as their own surgical templates.

Small, cruciform incisions should be used, to prevent forced implantation of epithelial cells into the bone. Implanted epithelial cells may later proliferate, causing epithelial invagination and implant failure.

CRÊTE MINCE IMPLANTS

Crête Mince translates from the French as "thin ridge" (Fig. 19-1). Crête Mince implants were designed and introduced by Michel Chérchève and have been referred to as *mini-implants* or *M-C implants*. Because they are very thin, they lack strength and cannot be depended on to serve as free-end saddle abutments. However, their versatility and resilience when used in multiples, particularly in pier or interabutment regions, make them an extremely valuable adjunct to the armamentarium of the eclectic implantologist.

When Crête Mince implants are used, they are placed in medullary bone between cortical plates. The ridge thickness can be as slight as 2.5 mm. The implants are available in lengths as long as 20 mm, but they can be cut shorter. The surgeon should attempt to create bicortical osteotomies to gain maximum strength and longevity from these devices.

Surgical and Prosthodontic Techniques

Mini-implants are most successfully used in the anterior maxilla or mandible, where a long edentulous span can be found, such as from premolar to premolar. Fixed bridge prostheses are constructed on posterior implants or molars and, when available, premolars. When superior esthetics are required, a unit-built bridge design is used. This involves construction of individual cast gold pontics, which are stabilized by internal mini-implants after they are connected. Each is completed with an individually made, telescoped, porcelain jacket crown. With this technique, the multiple threaded pins are used to pin and abut the anterior and formerly unsupported portion of a long bridge to the underlying bone. The pins serve as reliable anterior pier abutments when used in this fashion. Observation, care, and troubleshooting are the same as the rules governing other root form implants (Fig. 19-2). In the anterior region, the laboratory should construct an appropriate number of pontics of the classic unit-built design, each well centered over the bony ridge. Each should be hollow from incisal edge to ridge lap and have a 2.5-mm diameter accommodation. This is sufficient to accept a mini-implant head. The laboratory should restore each pontic in the complex with a separate porcelain jacket made to telescope over it.

FIGURE 19-1. The Michel Chérchève Crête Mince (M-C or mini) thin-ridge implant is now produced in titanium by Bauer-Chérchève of Germany and by Michel Garard of Megève, France. Although these implants are self-tapping, a No. 4 starter bur should be used through the cortex, followed by a series of special twist drills supplied by the manufacturers. Implants of varying lengths are available.

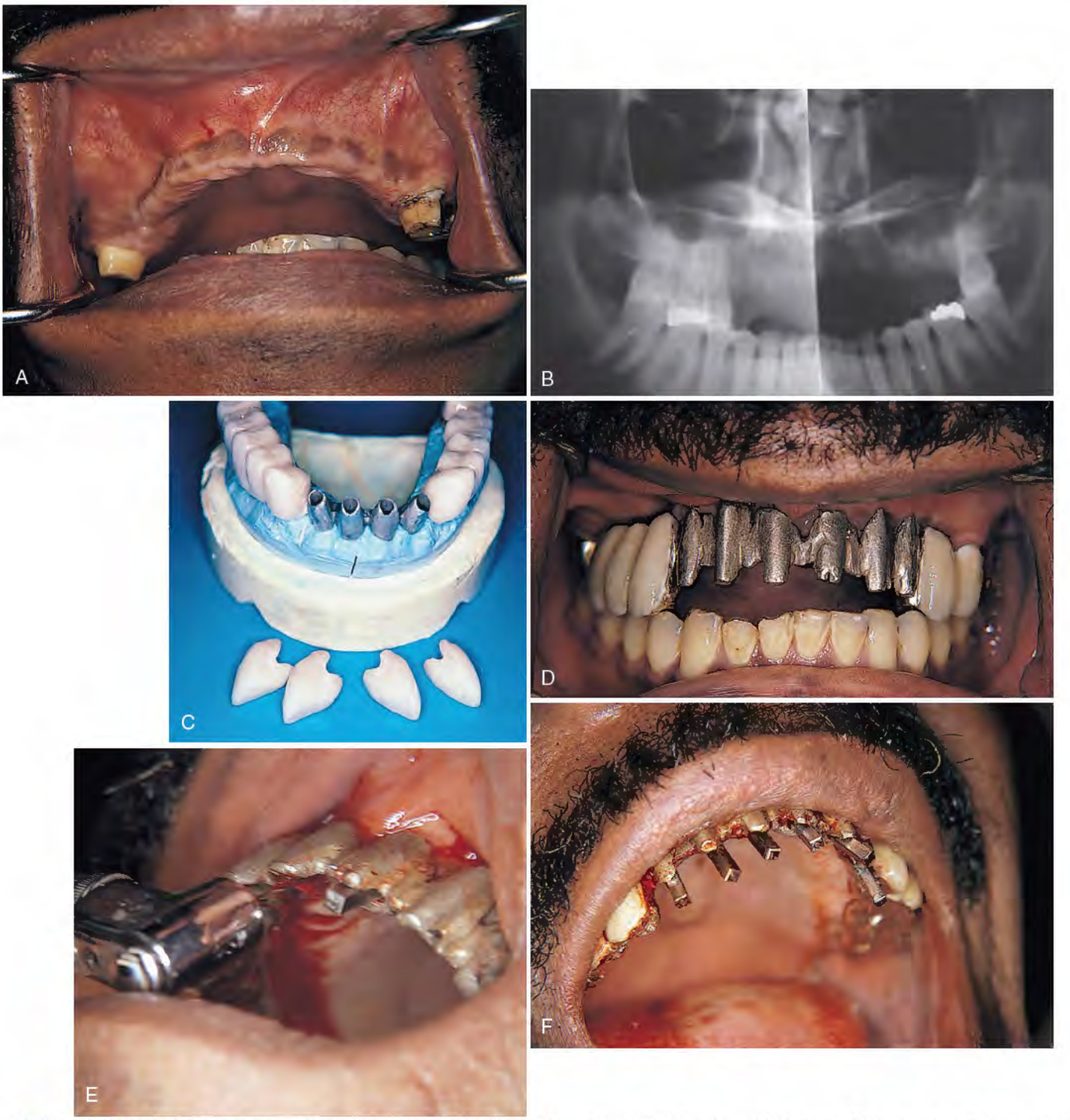
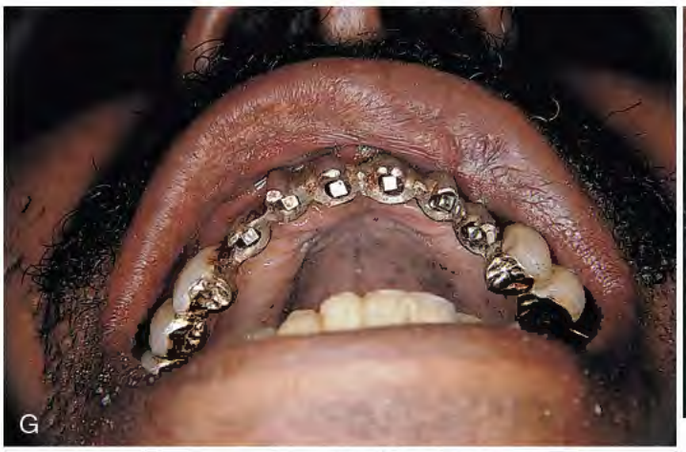
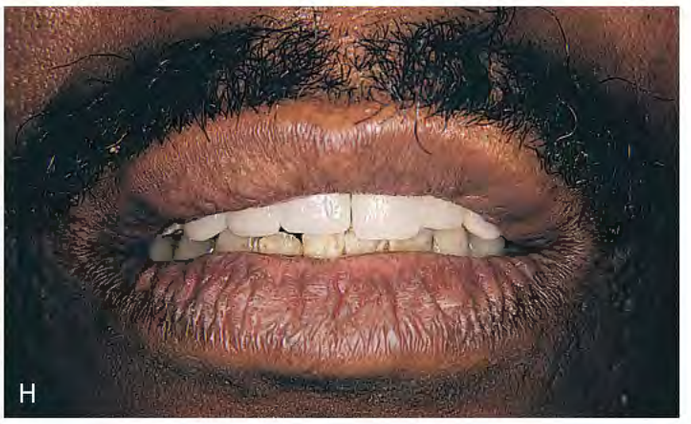


FIGURE 19-2. **A,** A significant traumatic incident caused this long edentulous span. The ridge width was affected materially, but more than 15 mm of height remained. **B,** The length of the edentulous spans discouraged any approach involving traditional fixed prostheses. **C,** A fixed maxillary prosthesis was fabricated with six separate anterior porcelain crowns. In this view, four of the six have been removed, revealing the hollow pontic design. **D,** On the day of surgery, a local anesthetic is administered and the fixed prosthesis is placed being used as a surgical guide, . **E,** Each pontic is used as a surgical template, and the twist drills, in graduated sizes and under saline coolant, are used to make the osteotomies. They must be made directly in the center of each pontic so that when the self-tapping mini-implants are introduced, their abutments are accommodated without trauma within the pontic walls. **F,** All implants have been placed concentrically.

Continued





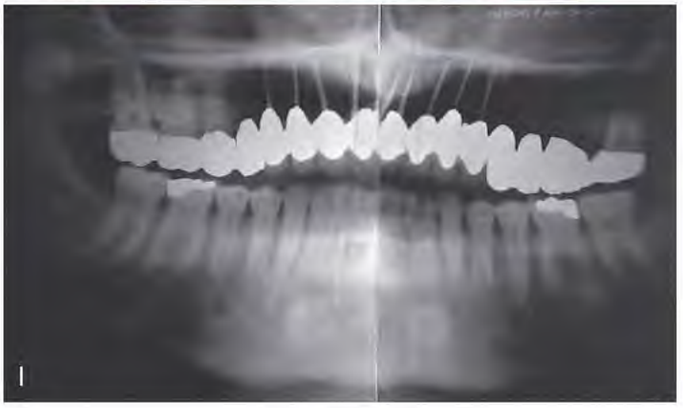


FIGURE 19-2, cont'd. G, Each implant is shortened so that it will fall within the confines of its assigned pontic and allow complete seating of the individual porcelain crowns. **H,** After abutment scoring, the bridge is cemented with composite resin to lock the pontics to the implants. The jackets are cemented separately to complete the reconstruction. **I,** A panoramic radiograph demonstrates the prosthesis in position, with the implants maintaining integrity anteriorly.

First, the completed bridge is placed in position. If all standard prosthetic criteria (crown margins, occlusion, and cosmetics) have been met satisfactorily, the bridge should be maintained in position. Each hollow pontic serves as the actual surgical template guiding the placement and direction of its implant.

After administration of a local anesthetic, each ridge lap is tattooed through the center of its pontic with an endodontic explorer tipped with an indelible pencil. The bridge is then removed, and cruciform incisions are made with a Bard-Parker (BP) No. 11 blade, using the tattoos to establish their centers. The bridge is replaced, and the osteotomies are made using the pontics as a template to guide the direction and depth of the drills (Fig. 19-3).

A round No. 1XXL bur in a high-speed handpiece is used to penetrate only through the cortex. Then, the ultra-low-speed system and copious external saline coolant are used. The 20-mm mini–twist drill is used next to create an osteotomy to the exact length of the implant and in the direction the implant should take. The drill is backed out slowly by reversing the motor. The osteotomy is irrigated, and the implant is placed in the opening (Fig. 19-4). The handheld ratchet wrench fits over the square head of the implant. Its handle is rotated so that it drives (taps) the mini-implant clockwise into place (Figs. 19-5 and 19-6). These implants bite the bone effectively, come to a readily noted stop when fully seated, and create firm seating for themselves. No suturing is required. Each square implant extension should be lying within its matching pontic's circumference.

The bridge is removed, and a diamond drill in a high-speed handpiece is used to score the heads of the implants, creating undercuts (Fig. 19-7). The bridge now is prepared and cemented using a composite or glass ionomer cement. A perforated rubber dam apron is placed around the implants to prevent cement from entering the peri-implant spaces (Fig. 19-8). The cement is removed from the open incisal edges of the pontics to restore them to their original contours (Fig. 19-9). A postoperative radiograph is taken to confirm the length and angulation of the implants, as well as the presence of ectopic cement (Fig. 19-10). The rubber dam apron is slit and removed, and after careful isolation of the abutment teeth and implants, the separate porcelain crowns are placed, using properly shaded zinc oxyphosphate cement.

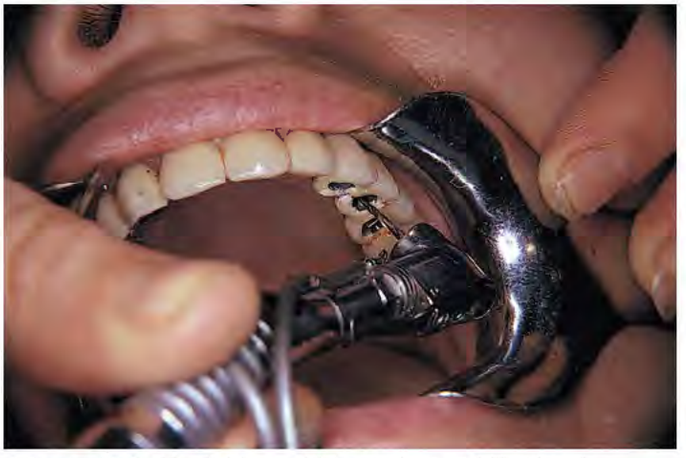


FIGURE 19-3. The bridge, which requires stabilization, is supplied by the technician with hollow pontics. The pontics serve as surgical templates for placement of the implants. At low-speed, well-irrigated, and contra-angle, a twist drill enters one of the pontics and, as guided by the pilot hole, pierces the bone to a preplanned depth. An intraoperative radiograph should be taken at this point to determine the appropriate angulation and depth.

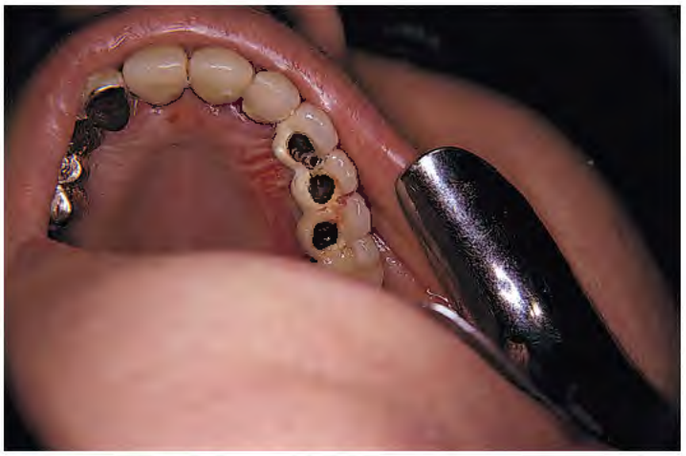


FIGURE 19-4. After each osteotomy has been made with increasingly larger twist drills, the implant is placed by hand. It should occupy the center of the pontic.

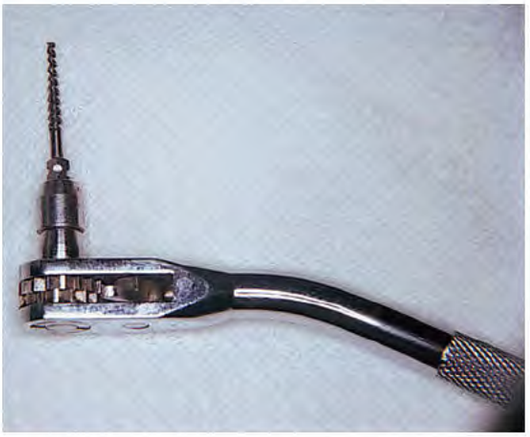


FIGURE 19-5. Mini-implants may be placed by wheel wrench or ratchet.

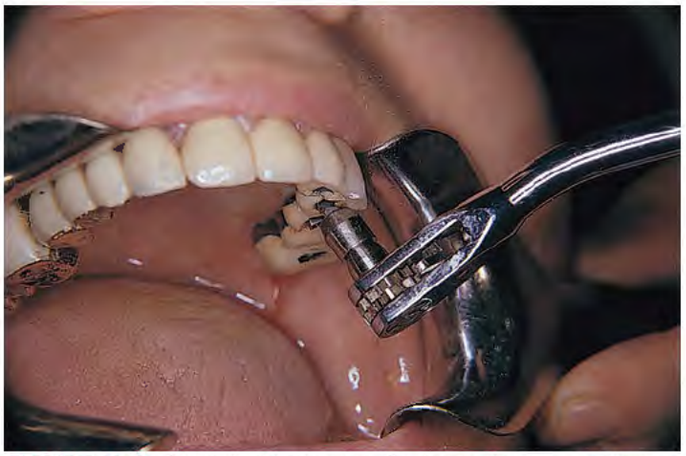


FIGURE 19-6. A handheld wheel or, for harder bone, a ratchet wrench is used to drive each implant to its full depth as allowed by the presence of the pontic.

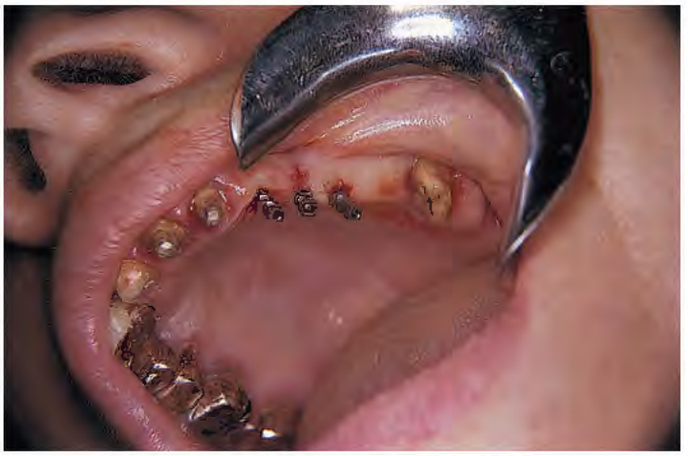


FIGURE 19-7. After all the implants have been seated, the bridge is removed, allowing final seating of each implant to its full-scored depth. Suturing is not required. Each implant abutment is scored for cement retention with a fine, water-cooled diamond.

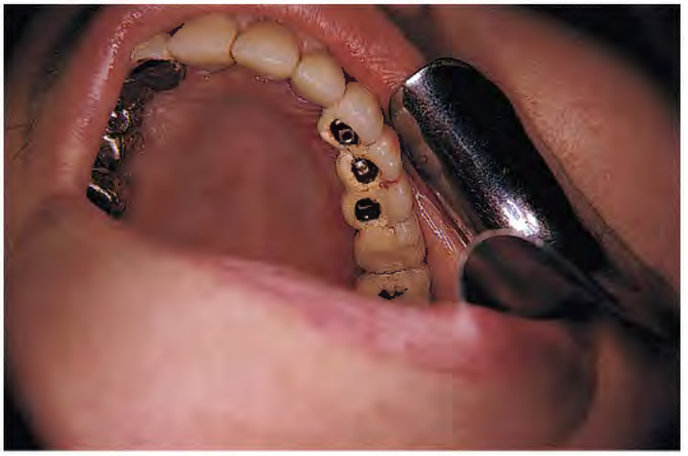


FIGURE 19-8. The bridge is replaced. When it is seated passively, it is cemented with a composite material to the natural abutments. A rubber dam apron is placed over the implants to discourage cement intrusion.

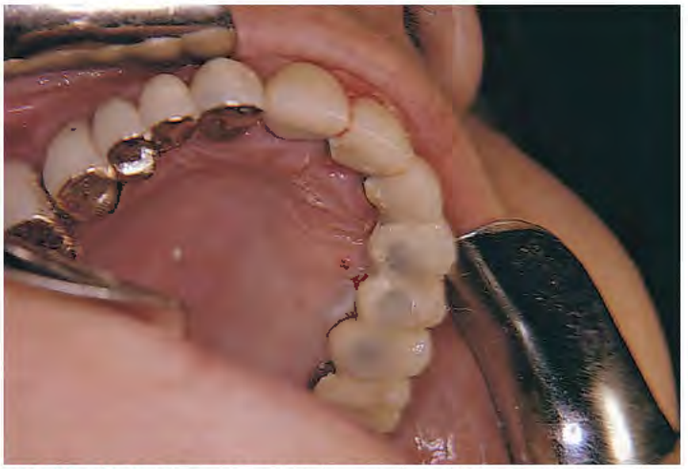


FIGURE 19-9. The restoration is completed by removing the dam and placing and polishing occlusal sealers around each implant.

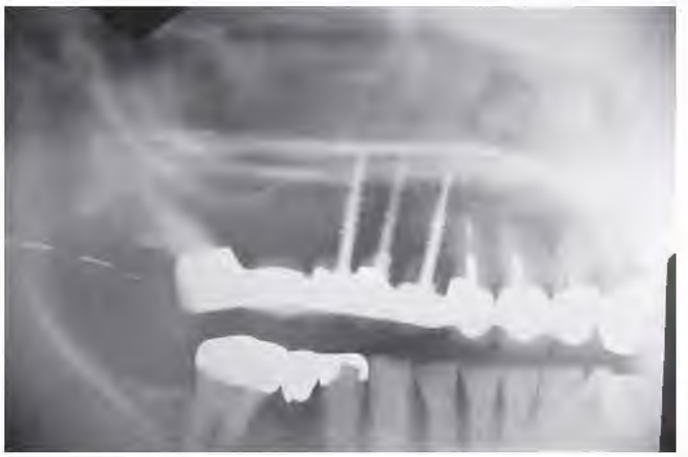


FIGURE 19-10. The postoperative radiograph shows the significance of these implants in supporting what otherwise would be an untenable fixed prosthesis.

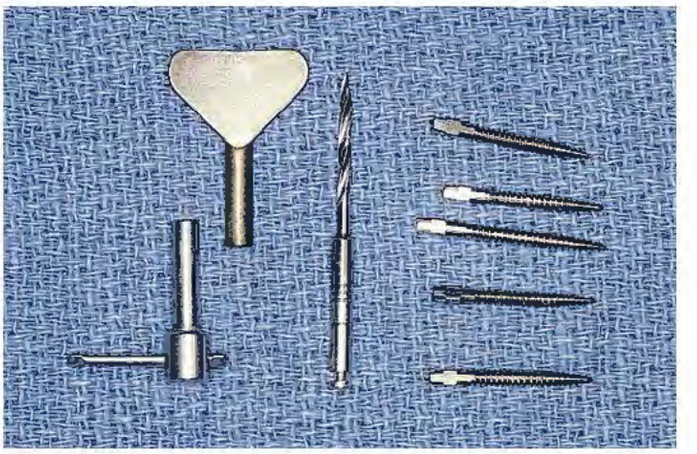


FIGURE 19-11. The Dentatus MTI custom consists of a single bone drill, threaded implants of various total lengths, and two key wrenches for manual insertion.

MINI-TRANSITIONAL IMPLANTS

In a manner similar to that used for Crête Mince implants and with a coordinated, simple set of drills, even smaller implants, called *mini-transitional implants (MTIs)*, may be used for auxiliary, long-term support in conjunction with conventional root form designs, or solely as interim devices to retain temporary prostheses. Two products currently in use are the Sendax (Imtec) and Dentatus designs; they are constructed of titanium alloy (Sendax) and commercially pure (CP) titanium (Dentatus) (Fig. 19-11).

The placement techniques are straightforward and generally do not require an incision; however, safe practice encourages the use of one. These implants follow the methods described for the Crête Mince implant, and they are accompanied by plastic transfer copings that allow fabrication of fixed acrylic or cast metal prostheses (Fig. 19-12).

MINI-SUBPERIOSTEAL BUTTON IMPLANTS WITH INTRAORAL BAR WELDING

Dr. Gustav Dahl and Dr. Ronald Cullen developed a small, collar button–shaped subperiosteal implant, which was altered somewhat by the Park Dental Research Corporation (Fig. 19-13). For this implant, the 3-mm diameter, fenestrated base is inserted into appropriately sized subperiosteal pockets by means of 3-mm long, full-thickness incisions, which are made at 3-cm intervals parallel to and at the crest of the edentulous mandibular or maxillary ridge. The periosteum is elevated facially and lingually, and the flat, slightly carved base of each implant is inserted beneath the flaps (Fig. 19-14, *A* to *C*). The procedure is completed with a single purse-string Polysorb suture tied firmly around the protruding abutment.

After 6 to 10 implants have been placed strategically, the Hruska intraoral spot welder is used to bond half-round titanium bar segments to the abutments (Fig. 19-14, *D*). No effort should be made to bend a single curved bar to a shape that can accommodate the implants passively, because minor torquing occurs even in the hands of the most skilled dental surgeon. Rather, the surgeon should cut and shape individual bar segments from implant to implant (Fig. 19-14, *E* and *F*). After the assembly is completed, an aggressively routed-out, full denture can be seated with assurance that it does not contact the implant bar complex. Retention is achieved with generous amounts of denture adhesive. Six weeks of observation, gentle irrigation, and denture adjustment follow. If the complex is firm, the denture then can be adapted to the bar with custom clips or the addition of a laboratory-processed soft lining (Fig. 19-14, *G*). In some cases, maxillary dentures can be altered by resection of the palatal acrylic, creating a more comfortable horseshoe design.

TEMPORARY ANCHORAGE DEVICES FOR ORTHODONTIC MOVEMENT OF TEETH

Temporary anchorage devices (TADs), or implants for orthodontic anchorage, are widely accepted. They are changing the way orthodontists treat some patients with malocclusions. TADs provide a fixed point from which to apply force to move teeth. Some of the dramatic movements, such as intrusion, can be achieved with these implants without the need for a segmental osteotomy and uprighting of supraerupted and tipped molars.

TADs are immediately loaded, titanium alloy miniscrew implants and osseointegrated palatal implants that range from 6 to 12 mm long and 1.2 to 2 mm in diameter, They are placed in bone to control tooth movement during orthodontic treatment, and they are removed when the treatment is complete. They are a relatively new addition to the dental armamentarium and can be used in some cases to replace traditional orthodontic extraoral appliances for retraction. TADs can contribute to predictable results, a shorter treatment time, and completion of active treatment on schedule. Placement of a TAD causes little or no discomfort, and hygienic care generally requires only routine brushing.

Because placement of TADs requires a surgical procedure, orthodontists often refer patients for this stage of the overall treatment plan to a practitioner who routinely performs implant placement surgery. TADs are versatile and can be used in different areas of the mouth during different parts of orthodontic treatment. Insertion is minimally invasive, and because bone has no nerve endings, simple infiltration anesthesia is sufficient for the placement surgery. Unlike traditional implant surgery, there is no need to reflect a flap.

The initial step is the creation of an osteotomy right through the gingiva or mucosa in the location where the TAD will be placed. The initial osteotomy should be narrower in diameter and no longer than the dimensions of the TAD to be inserted. The next and

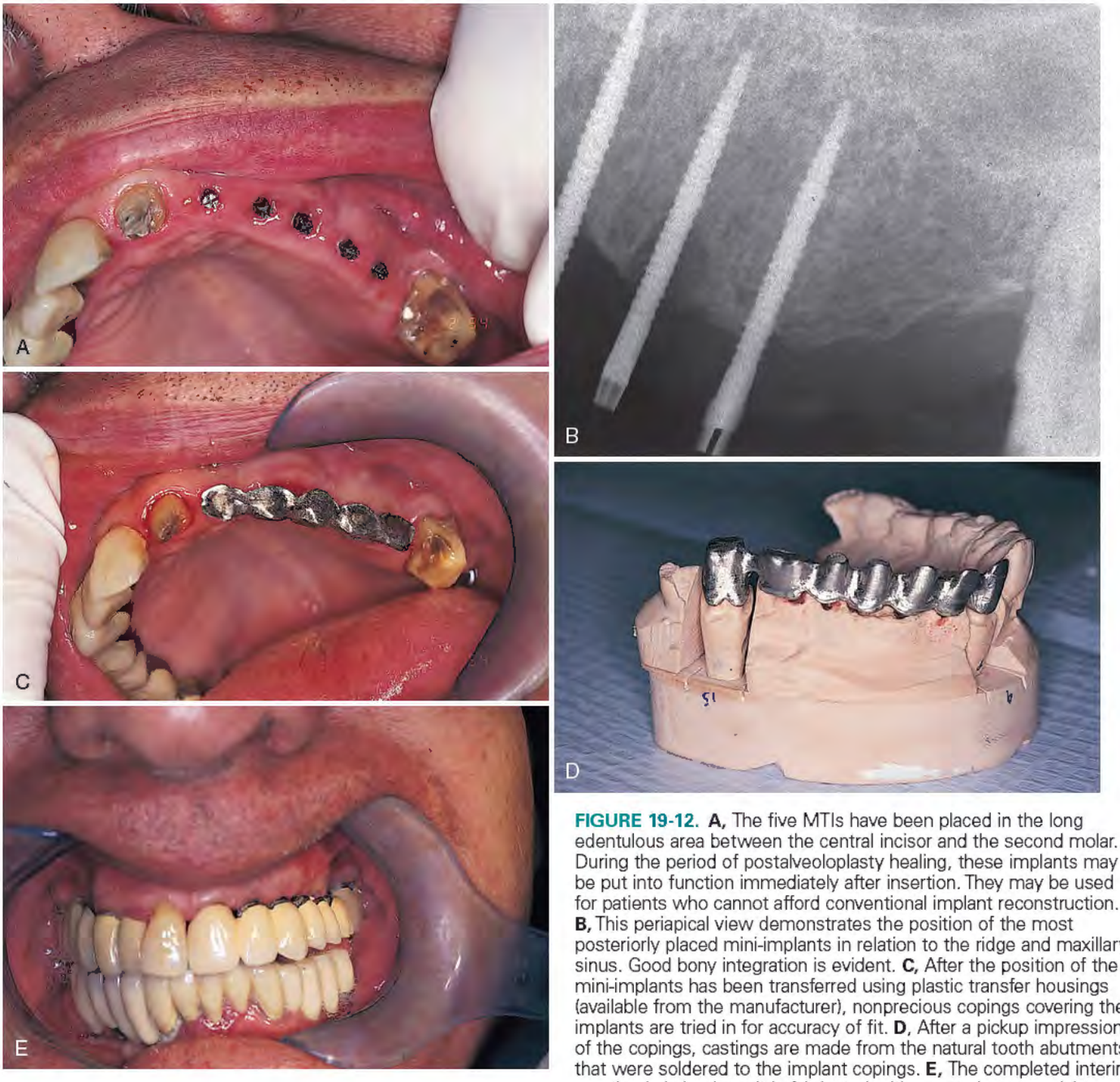


FIGURE 19-12. **A,** The five MTIs have been placed in the long edentulous area between the central incisor and the second molar. During the period of postalveoloplasty healing, these implants may be put into function immediately after insertion. They may be used for patients who cannot afford conventional implant reconstruction. **B,** This periapical view demonstrates the position of the most posteriorly placed mini-implants in relation to the ridge and maxillary sinus. Good bony integration is evident. **C,** After the position of the mini-implants has been transferred using plastic transfer housings (available from the manufacturer), nonprecious copings covering the implants are tried in for accuracy of fit. **D**, After a pickup impression of the copings, castings are made from the natural tooth abutments that were soldered to the implant copings. **E,** The completed interim prosthesis is in place; it is fabricated with an art glass porcelain composite veneer. The material is baked to the surfaces of the nonprecious alloy.

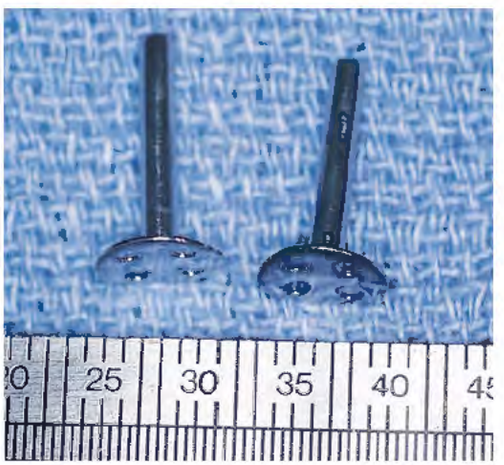


FIGURE 19-13. These Park Dental Research titanium mini-subperiosteal implants have long permucosal extensions (which can be cut to the length needed) and fenestrated curved bases. These implants, designed at Brookdale, were adapted from the devices introduced by Dr. Dahl and Dr. Cullen. Their curved bases can be bent to fit the underlying alveolar ridge.

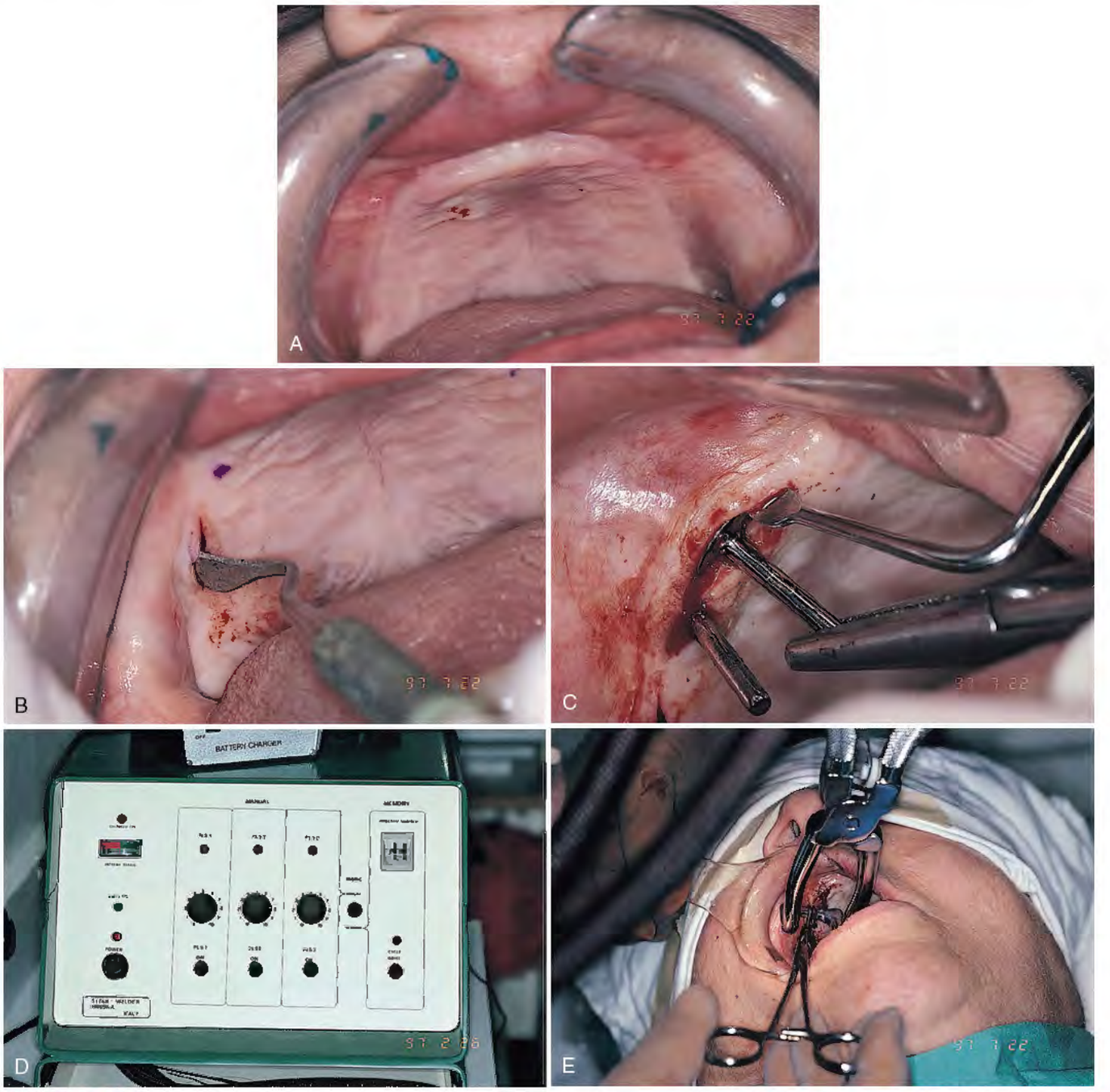


FIGURE 19-14. **A,** The preoperative appearance of the maxilla for which the mini-subperiosteal technique is to be used. The patient has an atrophic ridge that was unsuitable for retaining a conventional prosthesis. **B,** After the sites for implant placement have been delineated with a Thompson's marking stick (transferred from the tissue surface of the patient's prosthesis), 1-cm long, full-thickness incisions are made at the crest of the ridge. The mucoperiosteum is elevated buccally and lingually with a periodontal knife to accommodate the mini-subperiosteal bases. **C,** Each mini-subperiosteal implant is inserted by first placing it under the palatal flap and then raising the buccal flap under which the buccal portion of the base is situated. **D,** The Hruska titanium welder consists of a large console attached to an intraoral, handheld clamp and welder. Because of the unique nature of this apparatus, welding titanium to titanium does not generate heat. **E,** A single titanium bar is welded to two mini-subperiosteal implants. Subsequently, a bar is welded between the next two implants until all the segments are joined.

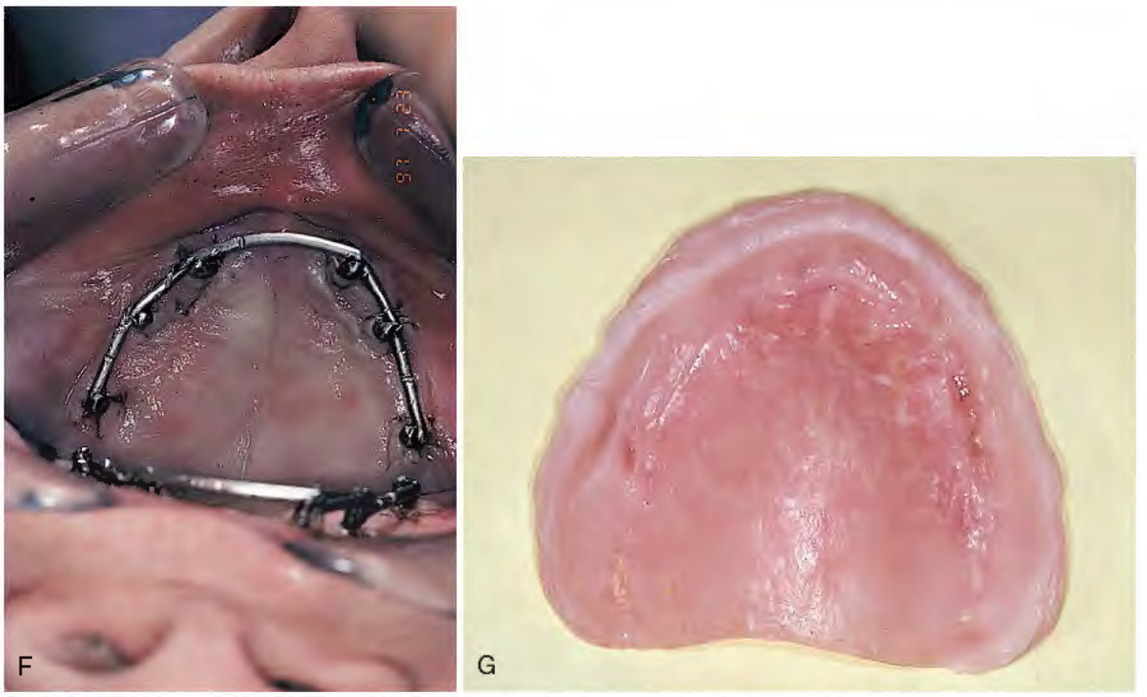


FIGURE 19-14, cont'd. **F,** The completed bar complex demonstrates all implants joined with individual titanium bar segments in a full arc. Use of a diamond bur allows sharp edges and extensions to be trimmed and smoothed. **G,** Postoperatively, the denture is relined over the implants to ensure that occlusal forces are not transferred to the implants. After a 6- to 8-week healing period, the denture is relined with a semipermanent soft lining material that allows an imprecise but reliable fit around the bar.

final step is to hand-screw the implant into position with the placement instrument provided. Extreme care must be taken not to damage any root surfaces of nearby teeth, because they are mostly placed in the bone between the roots of the teeth but occasionally are also placed in the bone in the roof of the mouth, maxillary tuberosity, and mandibular ramus.

Once the implant has been placed and the attachment is aligned according to the orthodontic treatment plan, the implant can be immediately loaded by attaching it to the adjacent bands and brackets using orthodontic wire or springs and rubber bands. Commonly used orthodontic instruments and techniques can be used for this purpose.

Implant Prosthodontics

Introduction to Chapters 20, 21, 22, 23, 24, 25, 26, and 27

There is nothing unique involved in the art and science of implant prosthodontics. The novice becomes confused at the entry level when he or she is introduced to the plethora of abutments and attachments made by each company multiplied by the variations and nomenclature that each contributes to the cumulative marketplace.

Added to this prosthetic Tower of Babel are methods of abutment attachment to external and internal hexagonal implant designs using threaded techniques, as well as several variants.

Essentially each company produces restorative systems that are similar to one another. Abutments, after all, must be attached to implants. They will have angulations and shapes required to fill anatomic and esthetic requirements. Patients will request fixed prostheses; dentists will select the option of removable overdentures. Decisions must be made on a basis of occlusal forces, numbers and dimensions of implants, patient compliance, economics, esthetics, and functional requirements.

The following seven chapters will guide restorative dentists and implantologists through each of the available options, problems and their solutions, and the principles of implant occlusion. Since implantology is prosthodontically navigated, the reader should refer to Chapter 5, since the location, design, and number of implants will be selected on a basis of the final prosthetics preferred by consensus after consultation between patient and practitioner.

Once this decision has been made, a classical and unswerving series of orderly procedures must be completed.

This section begins with descriptions of the fabrication of a clear acrylic device, which may go on to serve as a radiographic guide, surgical template, implant locator, and interim prosthesis.

Since implantologists are responsible for maintaining patient comfort, dignity, and self-respect, there must be assurance that, at no time during the entire therapeutic period, will he or she be permitted to function without a prosthesis.

Interim prosthesis are not difficult to prepare, and if designed correctly, can be altered at each phase to continue serving until the final restoration is delivered. Innovative dentistry requires thought, skill, experience, and the guidance offered in the following chapters.

Possibly the most complicated segment of this instructional manual is the section describing abutments. In order to deliver this information and the techniques that follow in a clear and comprehensible fashion, a generic system has been established from which information about individual company's products and techniques can be extrapolated. This includes single tooth restorations, mesostructure bars, overdentures, and fixed prostheses and fixed detachable prostheses, both hybrid and anatomic.

Occlusal principles unique to implant-borne prostheses are included.

Potential problems will be enumerated, and each will be addressed in a manner that will facilitate a solution.

ARMAMENTARIUM

Standard prosthodontic equipment and supplies
Transfer copings
Implant analogs
Hex drivers
Wrenches
Laboratory anatomic abutments
Plastic copings
A selection of attachments: O-rings, Zest, Zag, ERA, Harder, Dolder

CAVEATS

Listen to the patient with care. Make final decisions on a basis of good communication; mutual understanding of needs; and a clear, careful, and graphic description of the planned procedures and anticipated results.

There should be no doubt about the patient's expectations. If this is not clarified before the inception of care, the most satisfactory result will be disappointing.

Despite the fact that the doctor's philosophies play a significant role in treatment planning, temper the final prosthetic decision within reason by the expectations of the patient.

When plans are changed or problems arise, frank discussions and disclosures offer the best strategies to maintain high levels of ongoing cooperation.

Do not permit patient enthusiasm to cloud sound diagnostic and evaluative methods. Health status, quality and quantity of bone, operator skills, oral hygiene, and economics are the vital elements that create an admixture of satisfaction and success.

Preliminary Prosthodontics: Fabricating a Template

20 CHAPTER

After the patient has agreed with the treatment plan, the implantologist must perform a series of carefully planned steps.

FULLY EDENTULOUS JAW

Whatever the ultimate design of the prosthetic, if the jaw to be treated is fully edentulous, the patient should be supplied with a preliminary complete denture. Occlusal corrections to the opposing jaw also must be made. This may involve balancing the natural dentition, adding crowns or onlays, or completely habilitating the faulty opposing dentition. If this is not a practical solution, processed acrylic occlusal onlays should be used as an interim solution. The goal of the restoration should be an ideal occlusal relationship for the implant-supported jaw.

When a satisfactory occlusal height and plane have been established, procedures for the fabrication of an opposing full denture for the operative jaw can be started.

Impression making and record taking follow classic techniques. The denture should not be completed until the patient has expressed approval of her or his appearance.

When the denture is inserted, a corrected occlusal plane should appose it. This may involve increasing the vertical dimension and correcting centric occlusion. The trial period that follows is an essential interval of study that should ensure that the patient has become accustomed to and comfortable with the changes. If the patient complains of unrelenting facial or temporomandibular joint (TMJ) pain or aching, premature occlusal contact during chewing, or problems with deglutition that are not ameliorated by time, accommodations are made by increasing the interocclusal dimensions and shortening the teeth.

When a satisfactory result has been achieved, the denture serves as an indispensable guide. It has been designed to govern implant emergence profiles and abutment locations and lengths.

At this point, the treatment plan is finalized. Choices of a device and other elements are made on the basis of available bone and its quality; the patient's capabilities, aspirations, and finances; and the dental surgeon's skills and prejudices. The resulting prosthesis may be an overdenture totally supported by the tissue and retained by an O-ring or ball attachments. It may use two implants, three or more implants (with a fixed cemented or fixed-detachable mesostructure bar, which may be partly or fully implant supported), or five or more implants (buttressing an anatomic fixed bridge or a bar-borne hybrid fixed prosthesis) (Fig. 20-1). Whatever arrangement is chosen, the completed support mechanism (abutments, attachments, bars) must fit within the confines of the newly completed denture. If this cannot be done, the envisioned final appliance will be too large, which will create possibly insoluble esthetic and functional problems.

The denture, therefore, plays a significant role in the processes of planning, management, and fabrication of the complex restorative device. If the patient already wears a denture that satisfies the required tooth and flange positions, it can be replicated for use in creating the appliance. However, if the existing prosthesis is unacceptable, a new one that presents correct functional and esthetic characteristics must be made.

An acceptable denture is made by following the classic steps of prosthesis fabrication. Impressions are made using stock trays and modeling compound or alginate. A counterimpression of the opposing arch also should be made. The surgeon should make a record base on the cast of the edentulous arch, followed by a facebow recording, which is used to mount the maxillary cast. The record base is corrected to the proper vertical dimension and centric relationship, the denture teeth are selected and set, and the trial denture is fitted. Centric and vertical records are confirmed, and the patient must approve the esthetics. This trial denture does not require processing; however, in most cases it should be processed, because it has value as an interim prosthesis.

Replication of the Trial Denture

The trial denture is replicated for use as a surgical template in the following manner.

1. The lower half of a denture-duplicating flash is filled with alginate. The denture is pressed into it, tissue side down, and immersed to half its height. After the alginate has set, the excess flash is trimmed with a Bard-Parker (BP) No. 10 blade, and the denture is lubricated lightly.
2. The other half of the duplicator is filled with alginate, which is spread over the occlusal surface of the denture with a moistened finger. The duplicator is closed, and the alginate is allowed to set. The denture then is removed from the duplicator.

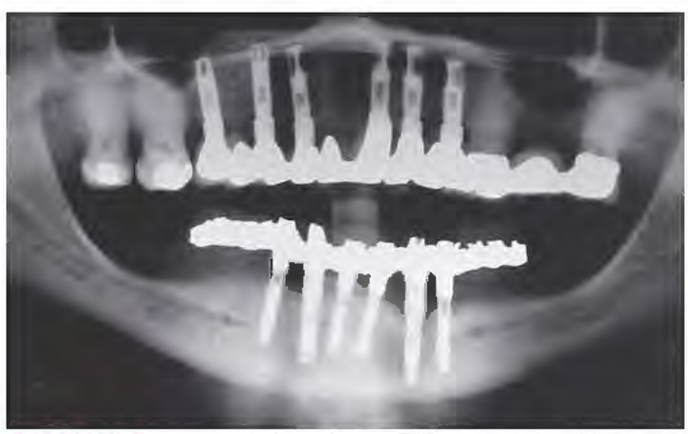


FIGURE 20-1. A panoramic radiograph showing a mixed tooth- and implant-supported, fixed, cementable, porcelain fused to metal prosthesis in the maxilla and an implant-supported, fixed-detachable hybrid mandibular prosthesis.

3. The impression of the denture is filled with cold-cure acrylic using the powder-liquid technique. After the impression has been filled, the duplicator is closed again and placed in a pressure pot for complete curing.
4. After 30 minutes at 300° F, the template is removed from the duplicator and the excess flash is trimmed with flame-shaped acrylic burs.
5. To allow the template to serve as a guide for implant positioning, the facial surfaces of the teeth are left intact. The incisal and occlusal surfaces are removed to allow access to the underlying potential host sites. The labial surfaces are the most important factor affecting implant position. A band of lingual or palatal acrylic is left intact to give the template rigidity so that it does not bend or fracture.
6. The access opening is cut at least 5 mm beyond the most distal implant positions expected, to permit flexibility and intraoperative changes in planned locations if needed. Implant locations should be idealized just lingual to the cingulum areas of the anterior teeth. This subsequently places the abutments, the bars, or both in the thickest part of the planned denture. If the implants are placed too far lingually, the abutments or bars are placed in the thinnest part of the denture, which might then be subject to a premature stress fracture.
7. The vertical height must be considered during implant positioning for overdentures. Factors that must be taken into account are the heights of the abutments or other attachments, the height of the bar, the height of a superimposed metal casting (if used), the height of the male or female attachments to be placed in the denture acrylic, and the thickness of the denture acrylic. These numbers are added, and the result is the total height available for final construction. This number actually represents the vertical distance from the tops of the implants to the incisal edges of the teeth in the surgical template; a minimum of 15 mm should be available. If this not the case, a variety of shorter abutments can be used to satisfy the overage (see Chapter 22).
8. The denture also acts as a computed tomography (CT) radiographic guide (Fig. 20-2). To serve this function, it must be replicated in clear acrylic (Fig. 20-3, *A* to *C*). This can easily be done by a staff member, using a Lang duplicating flash filled with alginate (Fig. 20-3, *D* to *F*). The final clear acrylic reproduction has many uses. To enforce the dimensional stability, it should be seated on its model, placed in a pressure pot filled with hot water at a minimum of 150^0 F, and further cured for 30 minutes (Figs. 20-4 to 20-6).

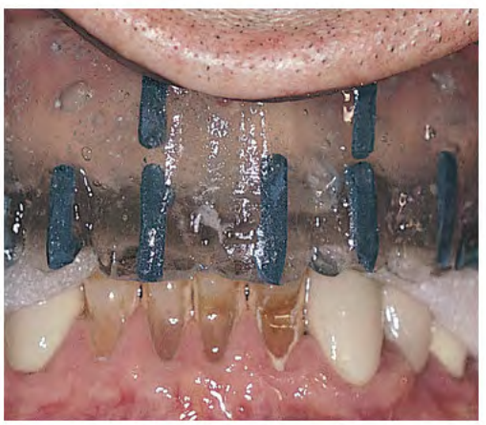


FIGURE 20-2. A radiographic template is tried in the mouth to check fit and comfort. By disoccluding the template in the anterior, 3 mm of cold-cure acrylic can be added to allow the jaw to be in a resting position. Petroleum jelly is placed on the opposing dentition to ensure that the cold-cure acrylic adheres only to the template. The radiographic markers in this template are composed of amalgam and acrylic in a 1:3 ratio.

The clear acrylic denture fulfills its first critical function in presurgical CT scanning. Chapter 4 describes in detail the techniques for embedding a radiopaque medium into premeasured grooves; this process is essential for verifying the locations and dimensions of host sites intraoperatively (see Fig. 20-2). Adding a 3-mm occlusal run to the appliance stabilizes the jaw and provides comfort in the resting position.

After the appliance had been used for CT scanning, it can be used as a surgical template. However, an additional alteration is required. The occlusal incisal edge and lingual acrylic of all potential implant host sites must be cut away (Fig. 20-7). This allows surgical access to the bone while the template occupies its anatomic position. The radiopaque markers allow the surgeon to transfer image findings and dimensions directly to the bony host sites (see Chapter 4).

Suturing completes the first stage of implant surgery. The original denture now continues its essential role as a stent and wound protector while providing the patient with cosmetic and functional benefits. It requires alteration and relining to satisfy this purpose.

In the second stage of surgery, the clear replica is used to localize the buried implants, especially if it was marked with amalgam-filled bur locator holes in the first stage.

After the healing collars or abutments have been attached, the original denture again can be adapted to serve. After the soft lining has been stripped out, it is altered to fit over the permucosal protrusions or transepithelial abutments (TEAs), where it can function through completion of the reconstruction. As an alternative, it can be trimmed back to its dentoalveolar components by grinding away the palate and flanges and then used with cement or even abutment fixation screws as a transitional prosthesis. The significance and versatility of this appliance and its clones cannot be overemphasized.

Surgical templates are necessary to position implants accurately and predictably. Two different designs of surgical templates are recommended for partially edentulous areas. The first style replicates the provisional denture restoration and is made on the corrected replicated cast. The second style uses an Omnivac template but relies on adjacent teeth and soft tissues for support and positioning. If more than two implants are planned, the surgical template that replicates the provisional prosthesis, rather than the Omnivac template, should be used (Fig. 20-8).

A surgical guide for placement of implants can be fabricated either on a cast or using a computer-aided design/computer-aided manufacturing (CAD/CAM) system. The guide is made from the diagnostic wax-ups (model-based method) or from computerized planning of implant placement (computer-based method).

The first steps are the physical and radiologic examinations of the patient (see chapters 3 and 4). The implantologist then decides which planning method to use (model based or computer based). The fabrication company (e.g., SciCat [Sirona], Procera [Nobel Biocare], Navigator system [Biomet-3i]) provides the necessary components to create a customized surgical template. Based on the design of the surgical template, they also supply the implants and the surgical and laboratory instruments required to facilitate the operation.

Before surgery, the surgeon can have a temporary or final prosthesis fabricated that can be attached in the same session as the implant installation.

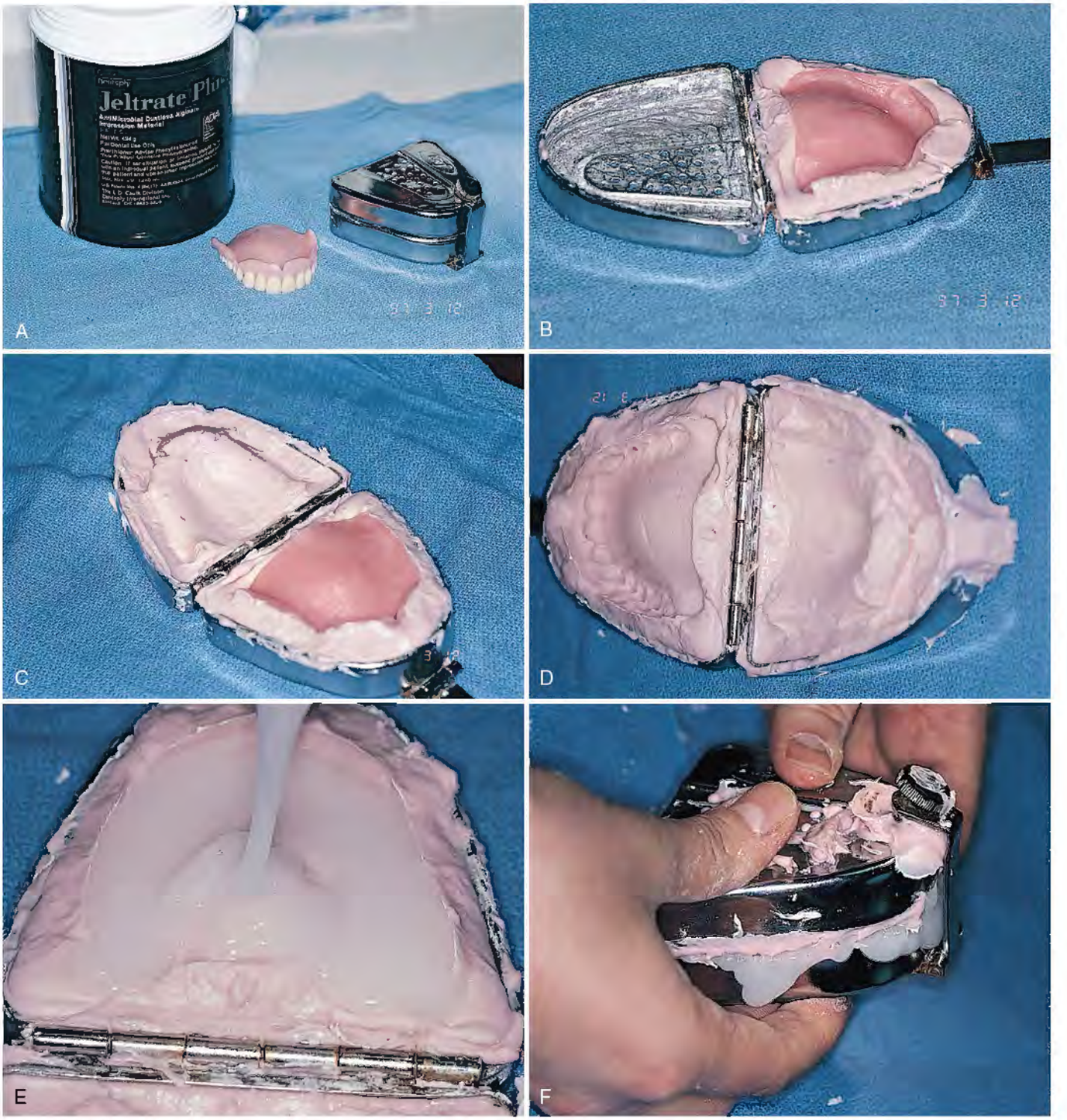


FIGURE 20-3. **A,** The Lang denture duplicator. The patient's dentures (or an acceptable wax try-in) are required to fabricate a duplicate denture. **B,** First, the denture is seated in alginate in one half of the denture duplicator. The alginate is allowed to set. Then, alginate is placed in the other half of the duplicator, which is fully closed. **C,** After the alginate has set, the two halves are separated (because alginate does not stick to set alginate, the two halves can be separated easily). An accurate reproduction of the internal surface of the denture is revealed. **D,** The denture is removed from the set alginate. The reproduced tissue and external surfaces are clearly identified. **E,** Clear, cold-cure acrylic is overfilled into the concave reproduction of the external side of the denture. **F,** The duplicator is fully closed and locked into position. Escaping excess acrylic ensures that no voids are present in the template.

MODEL-BASED PLANNING

Indications: Totally and partially edentulous jaws, as well as single unit cases.

Main benefits: Allows easy, predictable, quick, and minimally invasive delivery of dental implants and prostheses according to planning performed in advance. NobelGuide (Nobel Biocare) and SiroGuide (SiCat) components and instruments are available for treatment planning in both computer-based and model-based methods.

Definitions

NobelGuide, SiroGuide: Cases in which a surgical template, based on model- or computer-based planning, is used to guide the surgeon during the procedure.

FIGURE 20-4. The pressure pot is filled with hot water, and the Lang duplicator is placed in it at 30 psi for 30 minutes to allow the acrylic to set completely.

Model-based planning: Surgical planning on a stone model using established techniques. No CT scan data are required, and the surgical template is made at the laboratory.

Computer-based planning: CT scan data are basis for surgical planning in a three-dimensional computer method. The surgical template is made by Nobel Biocare.

Teeth-in-an-hour: The screw-retained, permanent prosthesis is attached in the same surgery session.

ARMAMENTARIUM

Guided System Kits
- Brånemark System Guided Surgery Kit (Nobel Biocare)
- Navigator Guided Surgery Kit (Biomet-3i)
- NobelDirect Guided Surgery Kit (Nobel Biocare)
- NobelReplace Tapered Guided Surgery Kit (Nobel Biocare)
- NobelReplace Straight Guided Surgery Kit (Nobel Biocare)

Drill inserts for guided surgery: sequentially increasing in diameter; available from dental suppliers (e.g., Salvin Dental, SiCat)

Guided drill stop kit (for combination with parallel wall implants)

Galaxis software (Sirona)

Procera software (Nobel Biocare)
- Clinical Design Pro (software)
- Clinical Design Premium (software)

The conventional approach to implant surgery follows these steps:

1. Treatment planning
2. Surgical procedure
3. Relining of the temporary prosthesis
4. Removal of sutures
5. Abutment connection
6. Temporary prosthetic solution
7. Soft tissue control
8. Impression making
9. Try-in of prosthesis
10. Final prosthetic solution

The computer-guided approach shortens the interval between surgery and the final prosthesis:

1. Treatment planning
2. Surgical procedure

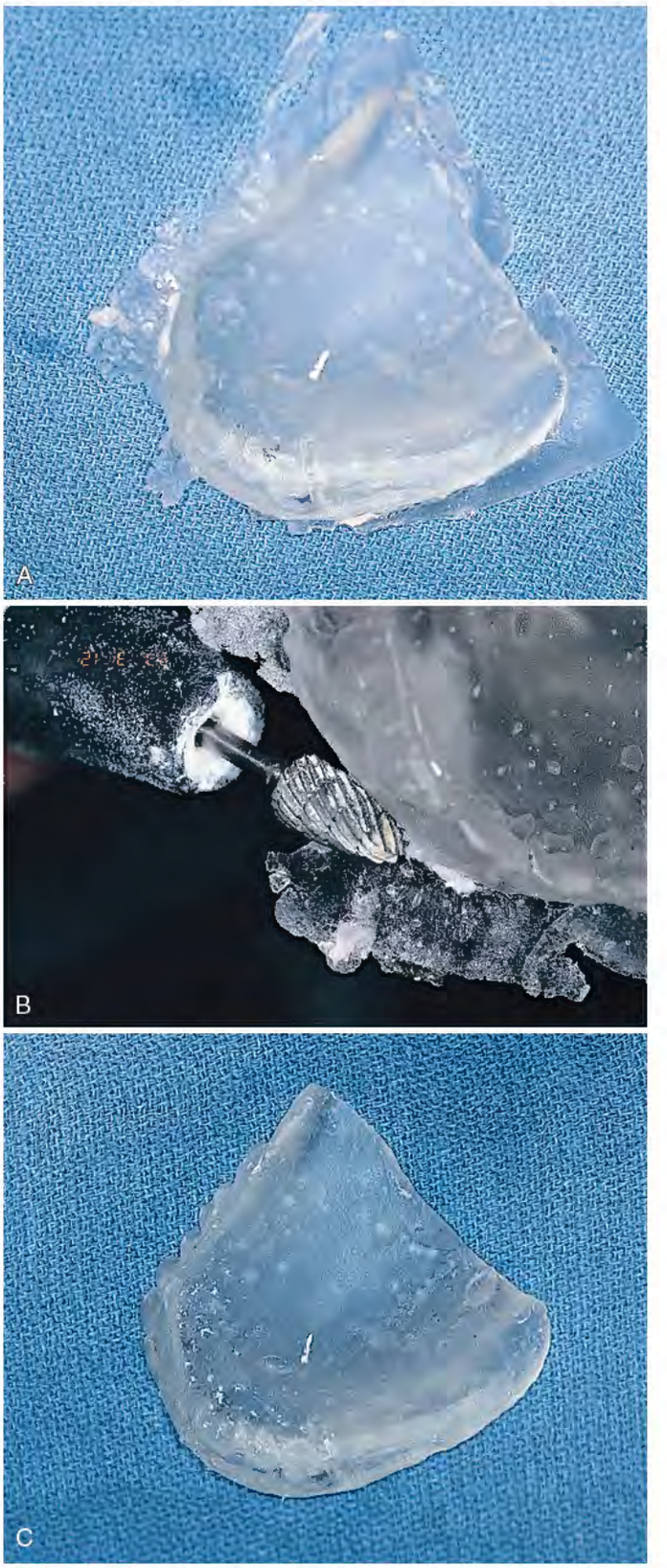


FIGURE 20-5. **A,** The clear acrylic duplicate denture after removal from the duplicator. Excess flash is always present. **B,** Excess flash and rough spots are trimmed with an acrylic bur. **C,** The finished template should be free of sharp edges and have smooth flanges.

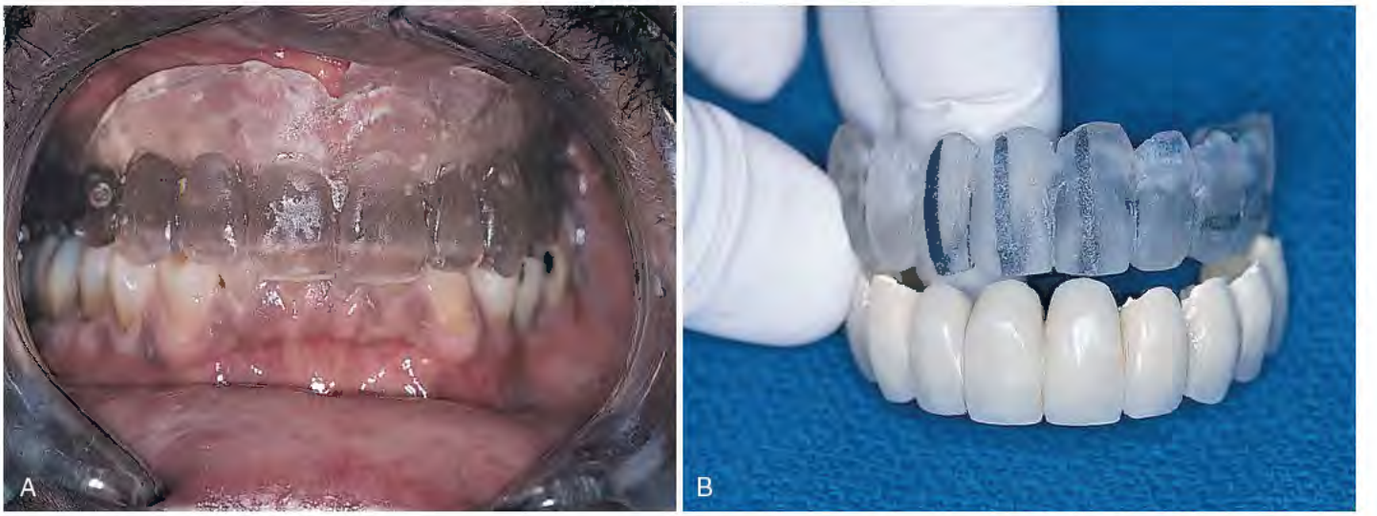


FIGURE 20-6. **A,** The template is tried in the mouth to ensure comfort and proper occlusion. Final adjustments often are required at this step. **B,** A temporary fixed prosthesis may be duplicated in a Lang duplicator to form a surgical template and CT scan template.

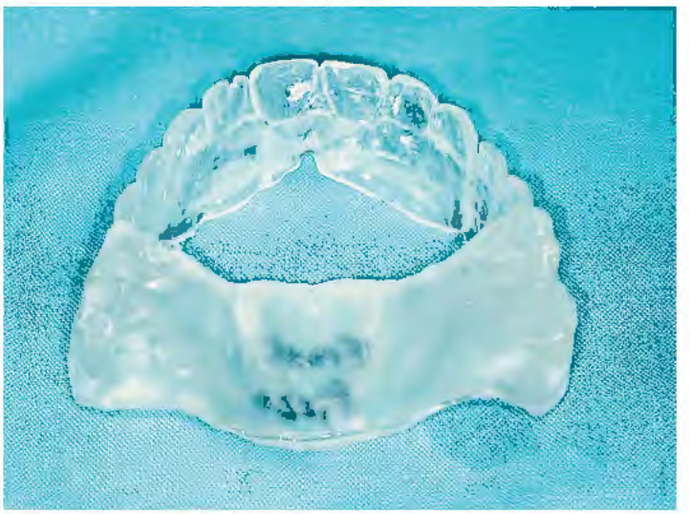


FIGURE 20-7. The template is relieved to allow access for surgical placement of implants.

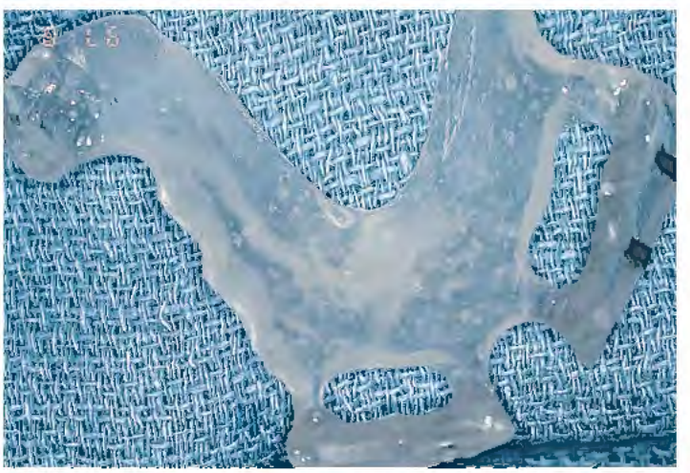


FIGURE 20-8. An example of a template for a partially edentulous patient. In this case, the template was fabricated from an acceptable acrylic partial denture in a manner described for complete templates. As an alternative to this procedure, a template can be fabricated based on a suitable wax-up (see Chapter 4).

3. Temporary prosthetic solution
4. Final prosthetic solution

The results are significantly reduced chair time and increased profitability

The surgical treatment in the computer-guided approach is based on minimally invasive, guided keyhole surgery. For the patient, this means considerably less pain and swelling than with conventional treatment. This approach also reduces the number of appointments and chair time for the patient. In addition, the patient can return to work and/or social life immediately after treatment, because this method is based on the concept of immediate function. For many practitioners and patients, this means a significant cost savings.

The combination of immediate function and a temporary or final prosthesis that is ready at surgery (e.g., Teeth-in-an-Hour [Nobel Biocare], Diem [Biomet-3i]) radically shortens treatment. By planning the treatment and transforming the data into a surgical template, the surgeon achieves a higher level of safety and predictability. Three-dimensional surgical planning programs have exceptional predictability and produce optimum implant placement. Planning allows for preproduction of either the final or a temporary prosthesis at implant level, or a combination of choice of abutments. Each system provides a total solution that supports the surgeon from the planning stage to completed oral rehabilitation. The software (i.e., Procera or Galaxis) makes the process simple and convenient. Also, because the implantologist knows what instruments and components are needed beforehand, inventory requirements are minimal, and the process is orderly.

Computer-Based Treatment Planning and Surgery

An impression should be made of both jaws, as well as a bite registration index. A stiff material should be used for the index.

For fully edentulous jaws, the bite registration should be made using the existing optimized prosthesis or, if needed, a newly produced prosthesis (i.e., the radiographic guide).

If the patient has only a few teeth in the opposing jaw and does not wear a partial prosthesis, the surgeon must make sure to fill the area where the teeth are missing with occlusion index material to make contact with the alveolar ridge. This ensures a horizontal,

well-balanced bite registration. The radiographic guide is used to simulate the teeth, soft tissue surface, and edentulous space during the CT scan.

Optimal Representation of Position of Restored Teeth

- An optimum anatomic fit must be ensured for the palate and the gingiva.

The existing denture (if applicable), if it covers the buccal, lingual, and occlusal aspects and extends over the buccal and lingual soft tissues to the vestibular extension, presents an ideal setup of teeth in terms of occlusion, position, occlusal height, and lip support.

In partial and single cases, inspection windows should be made in a nonopaque material (i.e., acrylic with 25% barium sulfate).

Extend the distal borders of the duplicate denture to the retromolar area and gutta percha can also be inserted as markers.

Correct designing of the radiographic guide is a prerequisite for successful treatment, because the guide determines the final outcome of the rehabilitation.

NOTE

To fabricate a radiographic guide, the surgeon must use acrylic or a material with a similar density. If the jaw is fully edentulous, the existing optimized prosthesis or, if necessary, a new prosthesis should be used. For single and partial cases, the laboratory should be instructed to fabricate an acrylic radiographic guide.

If the prosthetic treatment plan is to place a temporary or final screw-retained or cemented prosthesis at the time of implant placement surgery, the steps of the process are as follows:

1. The planning is done with Procera or Galaxis software.
2. The stone model and surgical index are fabricated to include the teeth to be replaced. The stand-in teeth (made of acrylic and 25% barium sulfate) are the appropriate size and shape and in the correct occlusal scheme as the missing teeth. They are mounted on the stone model.
3. On the stone model, a vacuum form is made of the entire jaw, with the acrylic teeth firmly attached to the vacuum form. This serves as the radiographic template.
4. The radiographic template is attached to the scan template.
5. The patient is registered in the software.
6. The patient is scanned with the radiographic scan template.
7. The surgical template is ordered in the software used (i.e., Procera or Galaxis).
8. Placement of the implant replica into the implant sites is planned and mapped in the scan using Procera, Galaxis, or an equivalent software program.
9. The implant planning is copied onto a CD-ROM, and the surgical guide is ordered in the Procera or Galaxis software.
10. The CD-ROM, stone model, and radiographic scan template are sent to SiCat if the Procera program was used and to Sirona if the Galaxis program was used for CAD/CAM fabrication of the surgical guide.
11. At this point, the implantologist can choose to perform the surgery as a one-stage procedure with immediate implant-supported provisionalization or final prosthetics, or treatment can be provided as a two-stage procedure. If the decision is made to use the one-stage approach, the laboratory will create a working model based on the prosthetic plan with implant analogs in place. It also will fabricate the substructure of the interim or final prosthesis in either titanium or zirconia, using the CAD/CAM program, and then finish the final design in acrylic, composite resin, or porcelain.

MODEL-BASED PLANNING AND PROCEDURE WITHOUT A THREE-DIMENSIONAL SCAN

1. Impressions of both jaws are made, along with a bite registration (Fig. 20-9, *A*).
2. The stone model is fabricated (Fig. 20-9, *B*).
3. The positions of the implants are marked on the stone model with a string of wax that reaches from the buccal to the lingual side over the soft tissue (Fig. 20-9, *C*).

Fabrication of the Mapping Guide

1. A vacuum form template is pressed over the stone model to make the mapping guide (Fig. 20-10, *A*).
2. A series of holes is made in the line marked by the string of wax; these should include three buccal holes, three lingual/palatinal holes, and one hole on top of the crest (Fig. 20-10, *B*).
3. The mapping guide is placed in the patient's mouth (Fig. 20-10, *C*).

Caution Before proceeding to step 4, the surgeon should administer either a topical anesthetic or an infiltrative, short-lasting local anesthetic.

4. A probe is used to perforate the soft tissue through the mapping guide (Fig. 20-10, *D*).
5. The mapping guide is removed, and a probe with a plastic endodontic disc (rubber stop) is used to measure the thickness of the soft tissue (Fig. 20-10, *E* and *F*).
6. The positions of the holes are marked on the stone model (Fig. 20-11, *A*).
7. Lines are drawn to connect the holes.
8. For the next step, either of two methods can be used:
   - The stone model is sectioned in the line previously marked with the string of wax where the implant should be placed (Fig. 20-11, *B*).
   - The stone model is sectioned according to the ordinary crown and bridge work (Fig. 20-11, *C*).
9. Next, the thickness of the mucosa is measured. The lines previously drawn on the model give the correct position for each depth measurement. The thickness measurements are marked on the side of the sectioned stone model (Fig. 20-11, *D* and *E*).
10. The stone model sections are ground down according to the bone profile, exposing the topography of the underlying bone (Fig. 20-11, *F*).
11. A hole for the implant replicas is ground or drilled into the planned implant site (Fig. 20-12, *A*).
12. The implant replicas are glued into the stone model in relation to the bone and planned implant position.
13. The exact orientation and angulation of the implant can further be checked with guide pins (Fig. 20-12, *B* and *C*).
14. The mapping guide is used as a mold for the soft tissue replica (Fig. 20-13, *A* and *B*).
15. The implant replica is uncovered with a soft tissue punch (Fig. 20-13, *C*).
16. Two key components for producing a surgical template are the guide cylinder and its pin. These components ensure the geometric relationship between the guide sleeve (to be embedded in the template) and the implant (Fig. 20-14, *A*).

FIGURE 20-9. **A-C,** Model-based planning without a three-dimensional scan. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

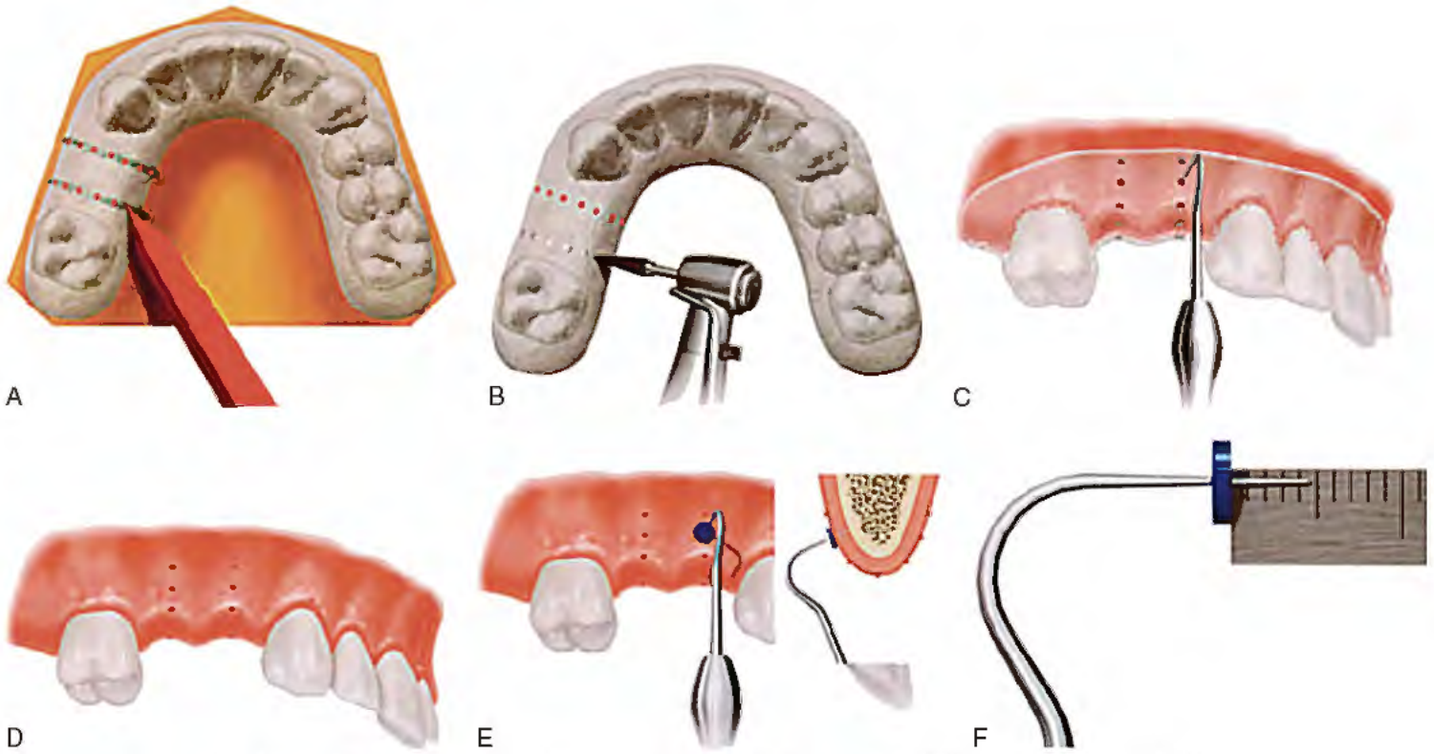


FIGURE 20-10. **A-F,** Fabrication of the mapping guide. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

17. The guide sleeve is placed between the guide cylinder and the pin, and a screwdriver is then used to screw it to the implant replica (Fig. 20-14, *B*).
18. Undercuts are blocked, and all surfaces that will not be embedded in the surgical template are lubricated (Fig. 20-14, *C*).
19. The entire jaw and the guide sleeve are embedded in acrylic. Care must be taken to use enough material to produce a strong, stiff surgical template.
20. The acrylic is allowed to set. Then, the guide cylinder and its pin are unscrewed, and the surgical template is removed (Fig. 20-14, *D*).
21. The surgical template is ground into the desired shape.
22. Care must be taken that the tops of the guide sleeves are exposed without damaging the sleeves.
23. The inspection windows are ground through the top of the surgical template to allow inspection of the underlying dentition and to confirm proper seating of the surgical template (Fig. 20-14, *E*). The inspection windows should be monitored throughout the surgery to verify correct seating.

Abutments

A wide range of abutments can be used in a guided surgery prosthetic procedure, such as:

- Immediate temporary abutment (for single cases)
- Zirconia abutment (for partial edentulous cases)
- Peek abutment
- Multiunit abutment

The steps of the process are as follows:

1. A temporary bridge is fabricated in the laboratory prior to surgery (Fig. 20-15, *A*).
2. The surgery is performed according to the protocol specified by NobelGuide or Diem using the laboratory-made surgical template (Fig. 20-15, *B*).
3. The surgeon then carries out the prosthetic procedures to connect the abutments and temporarily cement the bridge (Fig. 20-15, *C*).
4. Established prosthetic procedures are followed to make the final restoration after a sufficient period of healing (Fig. 20-15, *D*).

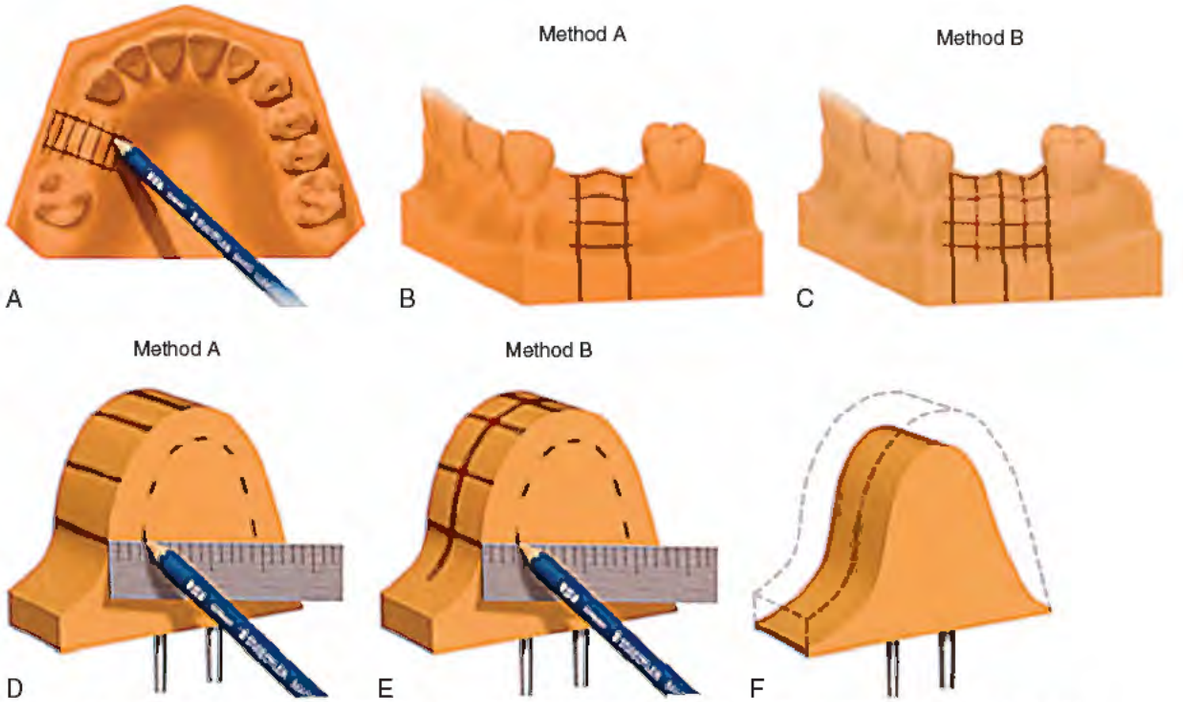


FIGURE 20-11. **A-F,** Fabrication of the mapping guide. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

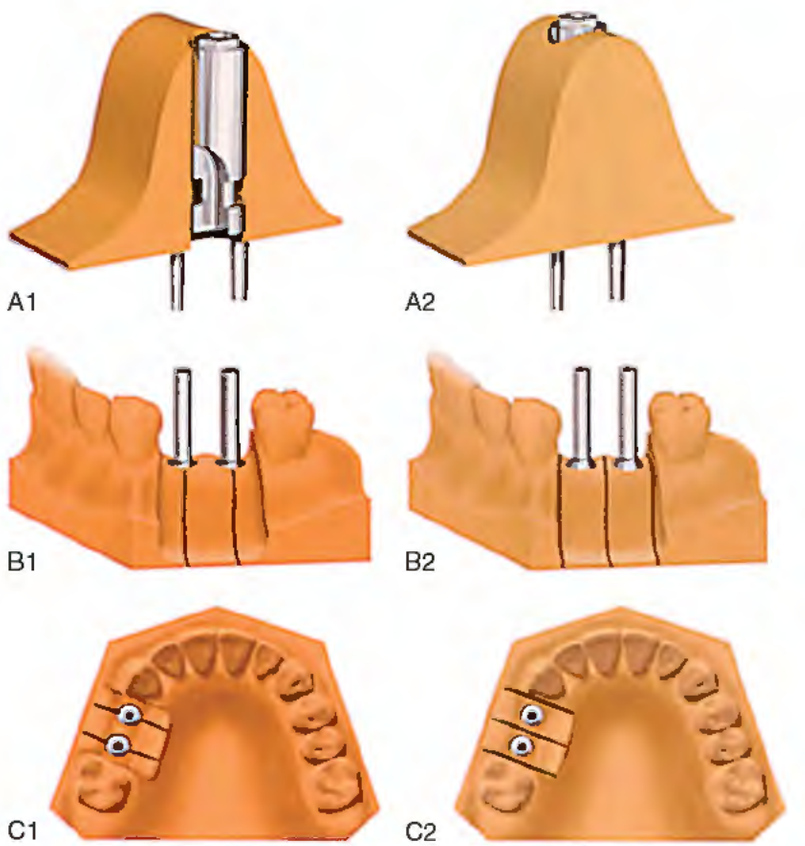


FIGURE 20-12. **A-C,** Placement of the implant replica. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

FIGURE 20-13. Soft tissue replica. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

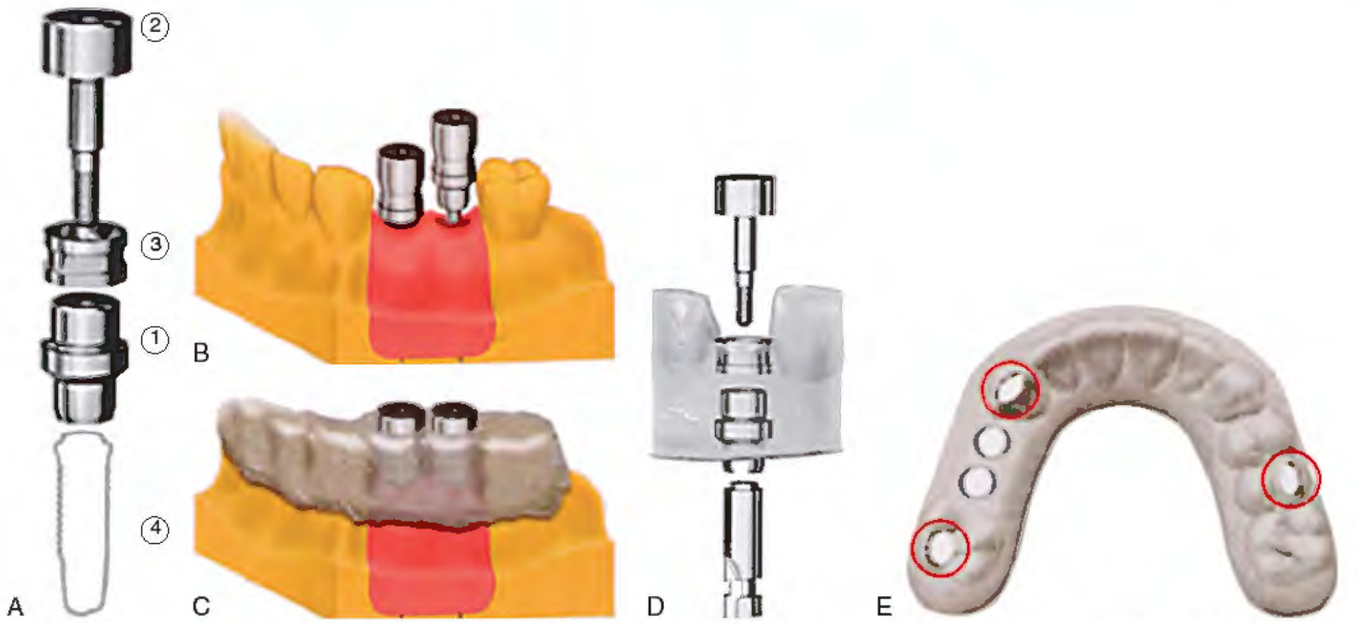


FIGURE 20-14. Fabrication of the surgical template. 1. Guided cylinder. 2. Pin. 3. Guided sleeve. 4. Implant. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

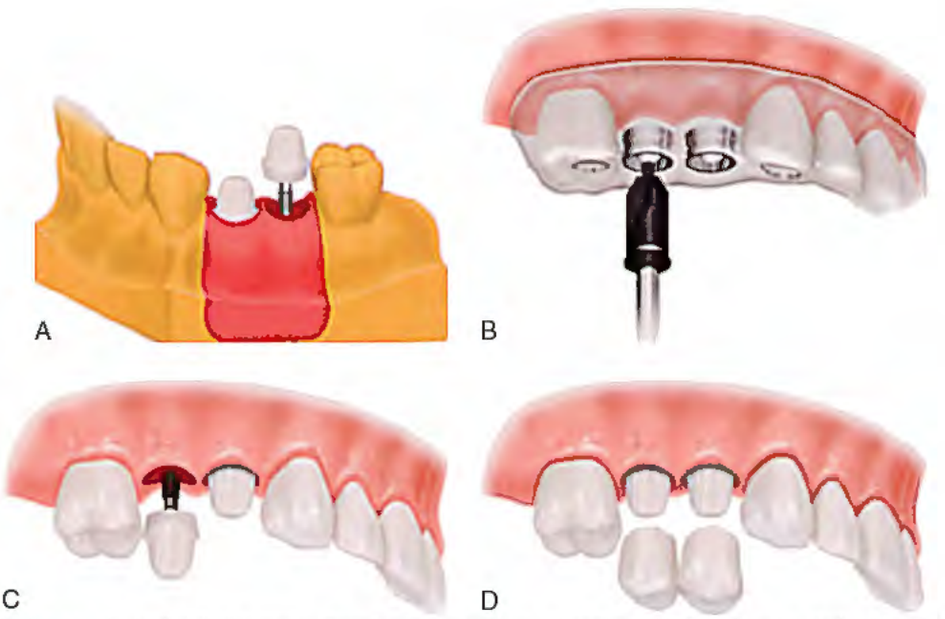


FIGURE 20-15. **A-D,** Guided surgery prosthetic procedure. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

NobelGuide-Specific Computer-Based Planning and Procedure

NobelGuide computer-based planning is intended for single, partial, and fully edentulous jaws when the patient meets several criteria:

- The patient must meet the general health requirements for undergoing oral surgery (see Chapter 3).
- The patient must be fully healed after any dental grafting procedures and must have a sufficient amount of jawbone (see chapters 7 and 8).
- The patient must be able to open the mouth sufficiently to accommodate the surgical instruments.

Patient Registration in Procera Software

The Procera software guides the dental surgeon through the computer-based NobelGuide process. It also is used to access the Procera Software Planning Program.

First, the surgeon uses Procera to register the patient and to obtain a treatment identification number. Next, the radiographic guide is prepared as described previously.

General Design Requirements for the Radiographic Guide (Fig. 20-16)

The radiographic guide must achieve the following goals:

1. It must optimally represent the position of the restored teeth.
2. It must provide the optimum fit to the anatomy, including:
   - Palate (if applicable)
   - Gingiva
   - Existing denture (if applicable), covering buccal, lingual, and occlusal aspects
3. It must extend over the buccal and lingual soft tissue to the vestibular extension.
4. It must reflect the ideal setup of the teeth in terms of occlusion, position, occlusal height, and lip support.
5. It must include inspection windows (partial and single cases).
6. It must be made of a nonradiopaque material (e.g., acrylic).
7. It must extend back to the retromolar area.
8. Gutta percha markers should be inserted.

Radiographic Guide and Surgical Template

The geometry of the radiographic guide is transferred to the surgical template (Fig. 20-17, *A*).

Fully Edentulous Cases

1. The existing optimized prosthesis, a specially produced prosthesis, or the radiographic guide is used where the teeth are more optimally placed for factors such as occlusion, position, occlusal height, and lip support (Fig. 20-17, *B*).
2. A sufficient part of the gingiva is covered to accommodate for guided anchor pin placement.
3. The surgeon must make sure that the anchor pins have a large enough base of thick material to provide for optimum stiffness of the anchor pin sleeves (Fig. 20-17, *C*). This can be further verified in the planning program.

Single and Partial Case

1. Stone models of the patient's jaws are fabricated based on the impressions.
2. The stone model is set up in the articulator using the bite registration index.
3. A diagnostic wax-up of the patient's tooth (or teeth) is made to be restored on the stone model.

FIGURE 20-16. The radiographic guide is prepared with general design requirements in mind. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

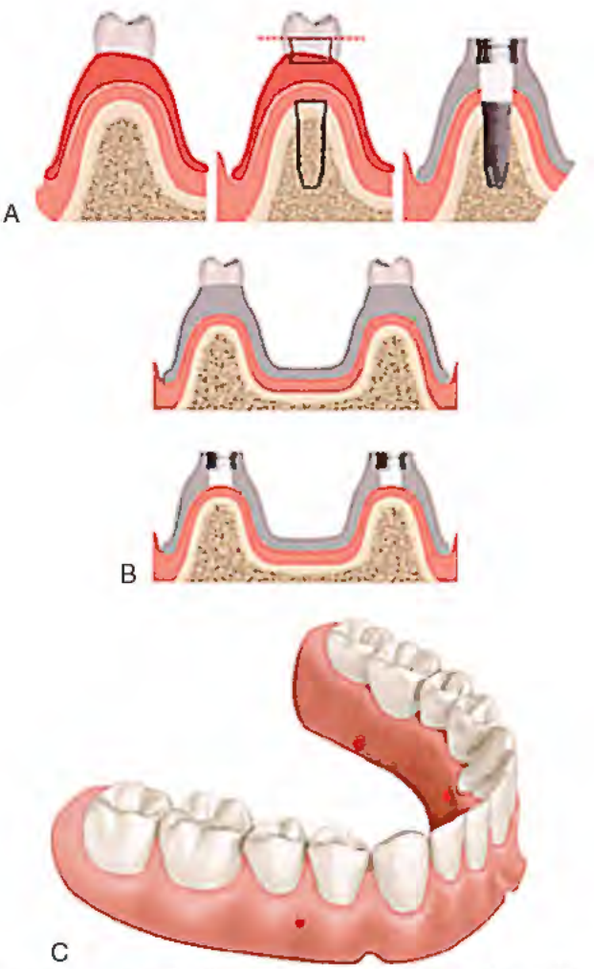


FIGURE 20-17. A-C, Radiographic guide and surgical template for fully edentulous cases. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

4. The existing teeth are covered down to the vestibular extension with a resin material 2.5 to 3 mm thick. The palate also is covered, if applicable.
5. Care must be taken to block all undercuts.
6. The surgeon must make sure that the guided anchor pin has a large enough base of thick material to provide for optimum stiffness of the anchor pin sleeve (Fig. 20-18, *A*). This also can be verified in the planning program. The buccal, lingual, and occlusal sides must be covered for optimum retention of the surgical template.

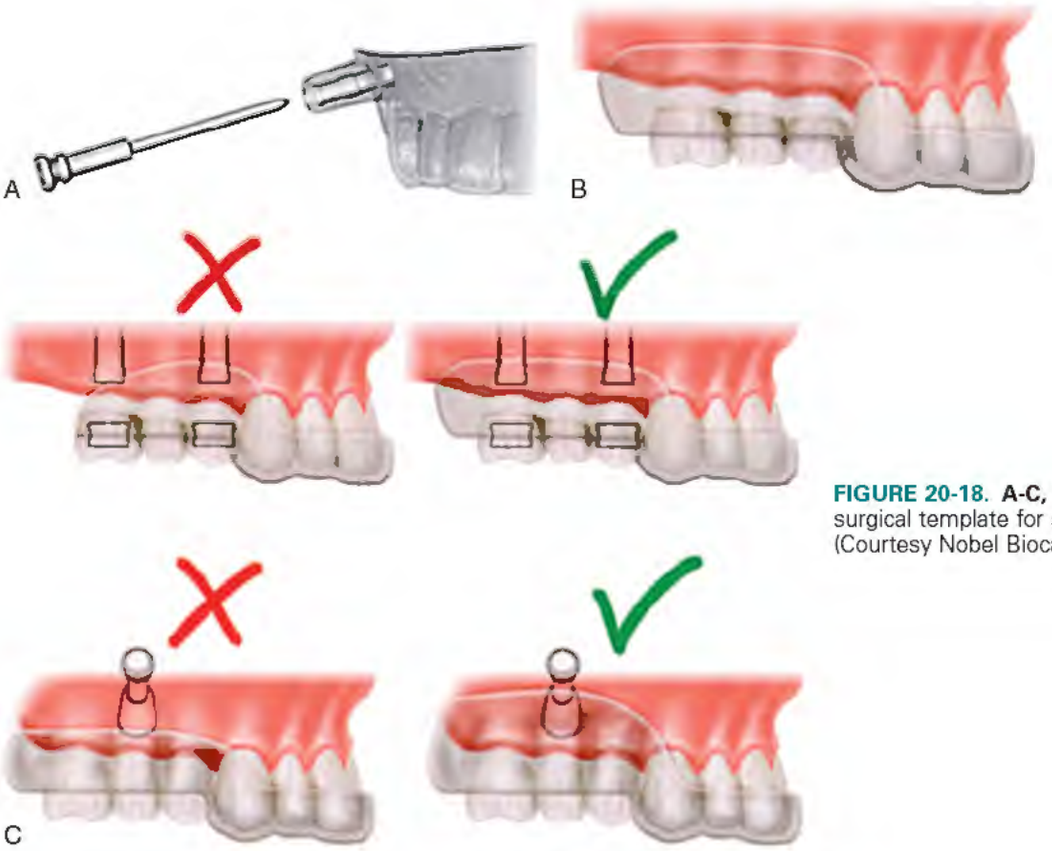


FIGURE 20-18. A-C, Radiographic guide and surgical template for single and partial cases. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

7. The occlusal plane is left untouched in areas to be restored. Only the buccal and lingual aspects are covered with plastic (Fig. 20-18, *B*); this ensures that the correct occlusal plane is transferred to the planning program (Fig. 20-18, *C*).

Preparing and Making the Radiographic Guide (All Indications)

1. The resin cover is attached to the lingual and buccal sides of the diagnostic wax-up, but the material is not added on the occlusal aspect.
2. The surgeon must make sure that the optimum, homogenous bond exists between the wax-up and the acrylic.
3. The radiographic guide must extend all the way back to rest on the retromolar area. *Option*: The set-up of the teeth can also be made of acrylic as long as the geometry is optimal.
4. The radiographic guide should be made of homogenous and uniform acrylic; this can be beneficial during the CT scan.

Reference Points (All Indications)

To facilitate the double CT scanning technique and the subsequent matching of the two CT scans in the Procera software, six reference points must be inserted into the radiographic guide.

1. Six small holes (1.5 mm in diameter) are made in the radiographic guide. The holes should be no more than 1 mm deep.
2. Two of the reference points are placed linguopalatally to the canines, two distobuccally to the premolars, and two in the molar region (Fig. 20-19, *A*). The reference points are placed at different levels in relation to the occlusal plane.
3. The holes are filled with gutta percha.
4. In single and partial cases, when metal fillings are present in the existing denture, the reference points are placed on levels other than those of the fillings (e.g., below the teeth).

Inspection Windows (Partial and Single Cases)

The inspection windows made on single and partial radiographic guides are transferred to the surgical template, where they allow inspection of the underlying dentition and confirmation of proper seating of the surgical template during surgery (Fig. 20-19, *B*).

1. The inspection windows are made in the radiographic guide through the occlusal surface over the existing dentition.
2. Three or four windows are distributed evenly over the entire arch; one or two windows are located adjacent to the area to be restored.
3. The inspection windows preferably are placed over a cusp or a corner of a tooth so that the underlying dentition protrudes through the window (Fig. 20-19, *C*).

Radiographic Index

For fully edentulous cases, the bite registration index is the radiographic index (Fig. 20-20, *A*).

Radiographic Index for Partial and Single Cases

1. The radiographic guide is put in the articulator, and a stiff material is used make an occlusal index between the radiographic guide and the opposing dentition.

NOTE

In partial cases, if the patient has only a few teeth in the opposing jaw and does not wear a partial prosthesis, the surgeon must make sure to fill up the area where the teeth are missing with occlusion index material to make contact with the alveolar ridge. This ensures a horizontal, well-balanced bite registration.

2. The radiographic guide and the radiographic index to be used during the CT scan are delivered (Fig. 20-20, *B*).

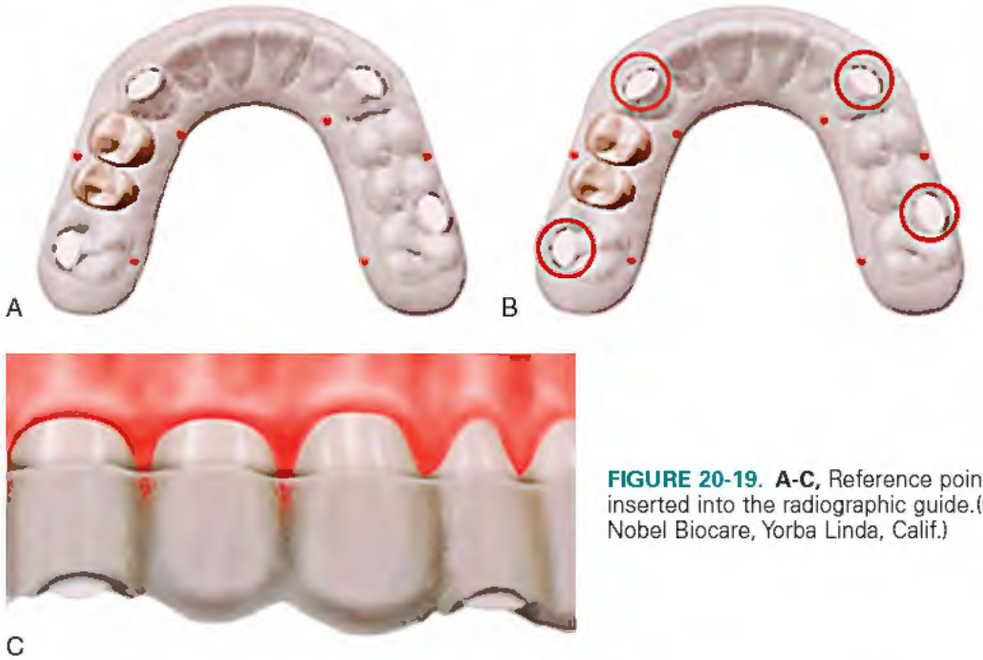


FIGURE 20-19. A-C, Reference points must be inserted into the radiographic guide.(Courtesy Nobel Biocare, Yorba Linda, Calif.)

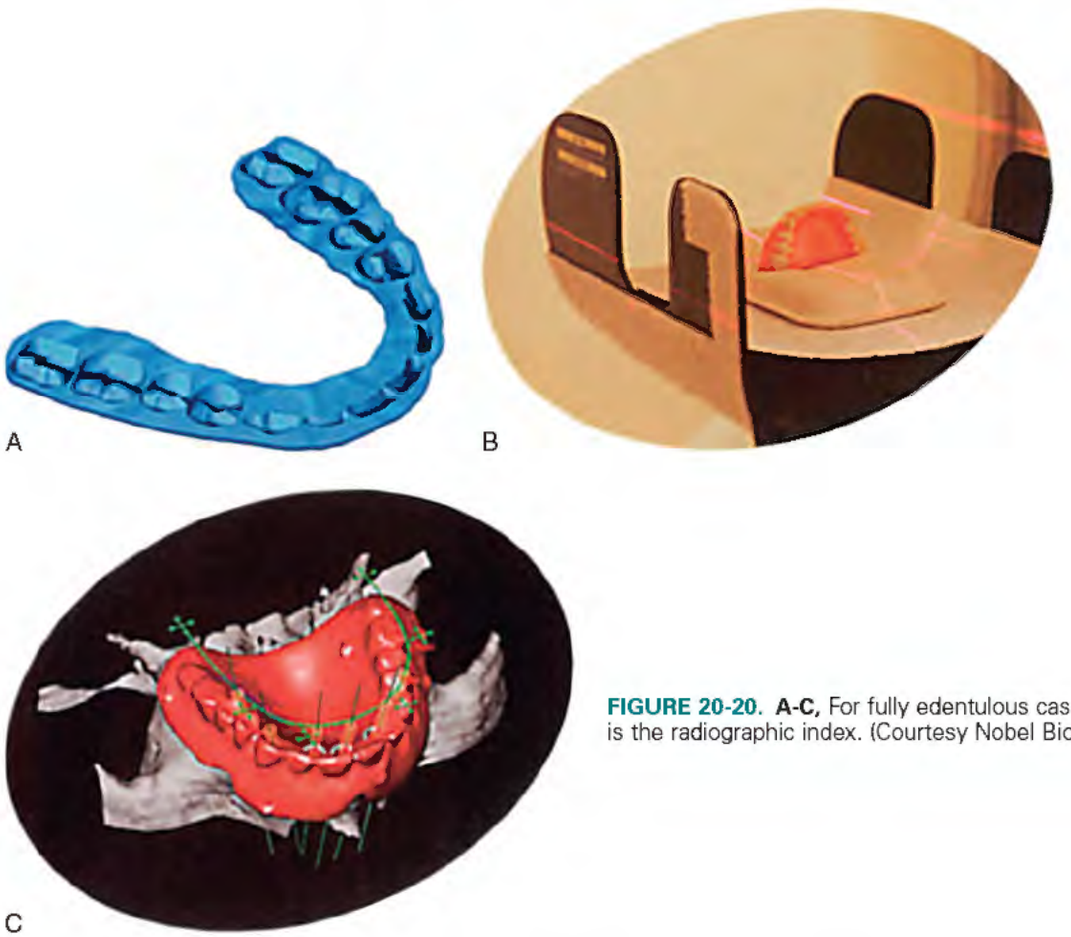


FIGURE 20-20. A-C, For fully edentulous cases, the bite registration index is the radiographic index. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

3. A CT scan is made with the patient wearing the radiographic guide and radiographic index.

Radiographic guide on its own Planning Program Surgical application, and order Convert the CT DICOM files into a file format compatible with Procera Software Planning Program–Surgical.

4. The patient's treatment is planned in the Procera software planning program–surgical application, and all necessary components are ordered, including the customized surgical template and duplicate denture (if needed for laboratory work) (Fig. 20-20, *C*).

Planning in Procera Software

The Procera software guides the surgeon through the computer-based NobelGuide process. It also is used to access the Procera Software Planning Program–Surgical. Procera software is available

in two versions for NobelGuide applications: Clinical Design Premium and Clinical Design Pro.

Clinical Design Premium (Fig. 20-21, *A*)

Clinical Design Premium includes the file conversion application for converting CT scans to a three-dimensional planning model. The surgeon receives the CD with the CT data from the radiologist and therefore can convert the files directly, saving time and conversion costs. In short, the process is as follows:

1. The patient information is registered and edited, and a treatment identification (ID) number is assigned.
2. The Procera CT scan file converter application is started.
3. The Procera Planning Program–Surgical is opened.
4. The planning data are imported into Procera CadDesign.
5. The surgical template is created.
6. The surgical template is verified.
7. Products (e.g., drills, instruments) are verified, and operation specification documents are printed.
8. The surgical template and surgical and laboratory products are ordered.

Clinical Design Pro (Fig. 20-21, *B*)

With the Clinical Design Pro application, the surgeon pays a fee and uploads the CT scan files to Nobel Biocare's Web site (the NobelGuide Extranet Area). The files are converted to a three-dimensional planning file and sent back to the surgeon. The process, in general, is as follows:

1. The patient information is registered and edited, and a treatment ID number is assigned.
2. The CT scan data are sent to Nobel Biocare, and the company returns three-dimensional planning files.
3. The Procera Software Planning Program–Surgical is opened.
4. The planning files are imported into Procera CadDesign.
5. The surgical template is created.
6. The surgical template is verified.
7. Products (e.g., drills, instruments) are verified, and the operation specification documents are printed.
8. The surgical template and surgical and laboratory products are ordered.

IMPORTANT!

The clinician is responsible for storing all planning and CT scan files in the same way as other radiographic material.

The Procera system is best installed on a dedicated, stand-alone computer according to the latest hardware recommendations.

The Procera Software Planning Program–Clinical Design is a three-dimensional, image-based program for planning the position and orientation of dental implants. It is used to determine the optimum sites for implant placement, taking into account anatomic constraints and also prosthetic and esthetic considerations.

The program is based on the concept of representing a three-dimensional medical image volume as a three-dimensional scene. This approach bridges the gap between conventional (stacks of) two-dimensional radiographic images and the actual view of a patient in the operating theater. In a three-dimensional scene, the surgeon gains a good understanding of the patient's anatomy in relation to implant components and to the prosthetic situation.

Each planning process is unique and is based entirely upon the specific considerations and prerequisites for the individual patient. The implant sites must be planned with a minimum distance from center to center, depending on which platform or platforms are used. The yellow zone around implants indicates a distance of 1.5 mm. Some factors that must be considered include whether all the patient's teeth are missing, several are missing, or one tooth is missing.

All teeth missing: Three anchor pins (1.5 mm diameter) are planned in the jawbone between the implants in an axial plane to enable proper stabilization of the surgical template during surgery (Fig. 20-22).

Several teeth missing: A minimum of one anchor pin is recommended.

One tooth missing: The surgical template is retained on the existing denture only.

When the plan has been finished, the surgeon must verify and approve it. The surgeon then orders the surgical template using the Procera software.

When the practitioner receives the surgical template, he or she must verify that the treatment ID number is correct. The surgeon then instructs the laboratory to fabricate (1) the stone model, (2) the surgical index, and (3) the temporary and final prostheses.

The surgeon must make sure that the mechanical strength of the surgical template is sufficient; the recommended thickness is 2.5 to 3 mm. If necessary, it can be reinforced by adding plates or a light-cured tray material (e.g., Triad). If material is added, care must be taken to leave the top of the guide sleeves untouched so that the reference level is maintained.

FIGURE 20-21. Procera software is available in two versions for Nobel Biocare applications: Clinical Design Premium **(A)** and Clinical Design Pro **(B)**. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

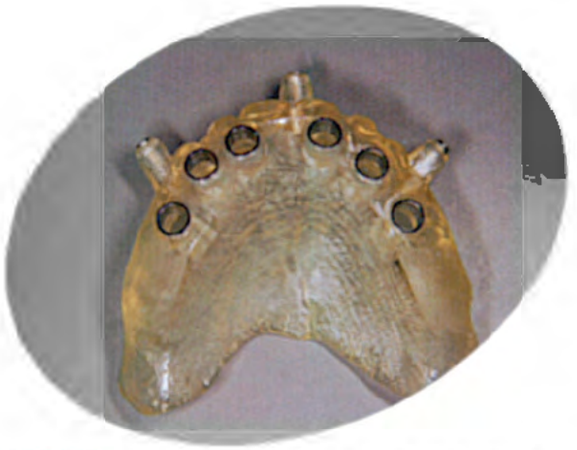


FIGURE 20-22. The surgical template. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

The surgeon then ensures that the surgical template can be correctly positioned on the teeth; the inspection windows are used to check the position. Adjustments are made, if required. The surgical index is then made.

Fabrication of Stone Model and Surgical Index

The surgical index is used during surgery to position the surgical template on the jaw before it is anchored with anchor pins.

The surgical template is developed in a CAD program and has all the necessary information for making the stone model, on which a permanent or a temporary prosthesis can be fabricated. The surgical template is made of a material that is sensitive to moisture and ultraviolet (UV) light. It should be stored with a moisture absorbant in the UV-protective plastic bag in which it is delivered. The following rules should be observed:

1. The surgical template should always be stored in a dark, dry place.
2. The surgical template should never be exposed to direct sunlight.
3. The moisture absorbant should never be removed from the plastic bag containing the surgical template.
4. The surgical template should be disinfected with a high-level disinfectant (e.g., CidexOPA Solution) for 12 minutes at room temperature. It is then rinsed thoroughly with sterile water and dried quickly, but without the use of heat.

Caution The surgical template may deform if exposed to liquids (even water) for longer than 30 minutes.

Workflow (Fully Edentulous Case)

1. The surgeon must verify that the correct treatment ID number is engraved on the lingual aspect of the surgical template and that the template's overall geometry is similar to that of the radiographic guide.
2. A key component for producing a surgical template is the guide cylinder with pin. These two components ensure the geometric relationship between the guide sleeve and the implant (Fig. 20-23, *A*).
3. The implant replicas are mounted in each of the holes in the surgical template using the guide cylinder with pin. The replicas and the type of guide cylinder used are specified in the documents accompanying the case (see Fig. 20-23, *A*).
4. Anchor pins are inserted into the anchor pin sleeves (see Fig. 20-23, *A*, and Fig. 20-23, *B*).
5. The bottom of the guide cylinder with pin and the top surface of the surgical template are lubricated with petroleum jelly for easier dismounting of the soft tissue replica.
6. The soft tissue replica is added. A very small tube is used to ensure that the surgeon can reach down to the guide cylinder with pin (Fig. 20-23, *C*).
7. The soft tissue replica or boxing wax is used on the buccal side of the vestibular extension to prevent the surgical template from locking after the plaster has set.
8. Die stone model plaster is poured in (Fig. 20-24, *A*).
9. A plaster box is used to facilitate the manufacture of the stone model.
10. After the plaster has set, the anchor pins are removed.
11. Next, a Unigrip screwdriver is used to remove the guide cylinder with pin is removed. The surgical template also is removed.
12. A cutter is used to remove the high edges around the holes (Fig. 20-24, *B*).
13. The duplicate denture (ordered through the Procera Software Planning Program–Surgical) or the patient's optimized prosthesis is attached to the stone model, which is mounted in an articulator along with the model of the opposing jaw. The radiographic occlusal index is used to verify the correct occlusion (Fig. 20-24, *C*).
14. The radiographic guide is replaced with the surgical template and secured with anchor pins (Fig. 20-24, *D*).
15. Index material (e.g., A-silicone) is added on top of the surgical template.

NOTE

If the patient has only front teeth in the opposing jaw and does not wear a partial prosthesis, the bite in the area where the teeth are missing must be built up to make contact with the alveolar ridge. This ensures a horizontal, well-balanced bite registration.

16. A string of index material is added on the opposite jaw, and the jaws are closed. Care must be taken to add enough material to get a good index.
17. The surgical template is returned to its UV-protective plastic bag.
18. The surgeon now has a finished surgical template and a surgical index for use during surgery.

Workflow (Single and Partially Edentulous Cases) (Fig. 20-26)

1. The surgeon must verify that the correct treatment ID number is engraved on the lingual aspect of the surgical template.
2. Proper seating of the surgical template on the original stone model is verified by using the inspection windows.
3. The approximate locations of the implants are marked on the model.
4. The section to be restored on the stone model is cut away to make room for the implant replicas (Fig. 20-25, *A*).
5. A key component for producing a surgical template is the guide cylinder with pin. These two components ensure the geometric relationship between the guide sleeve and the implant.
6. The implant replicas are mounted in each of the holes in the surgical template using the guide cylinder with pin (Fig. 20-25, *B* and *C*). The replicas and the type of guide cylinder used are specified in the documents accompanying the case.
7. The surgeon must verify that the mounted implant replicas fit in the cutaway section of the stone model.
8. The anchor pins are mounted in the surgical template, if applicable.

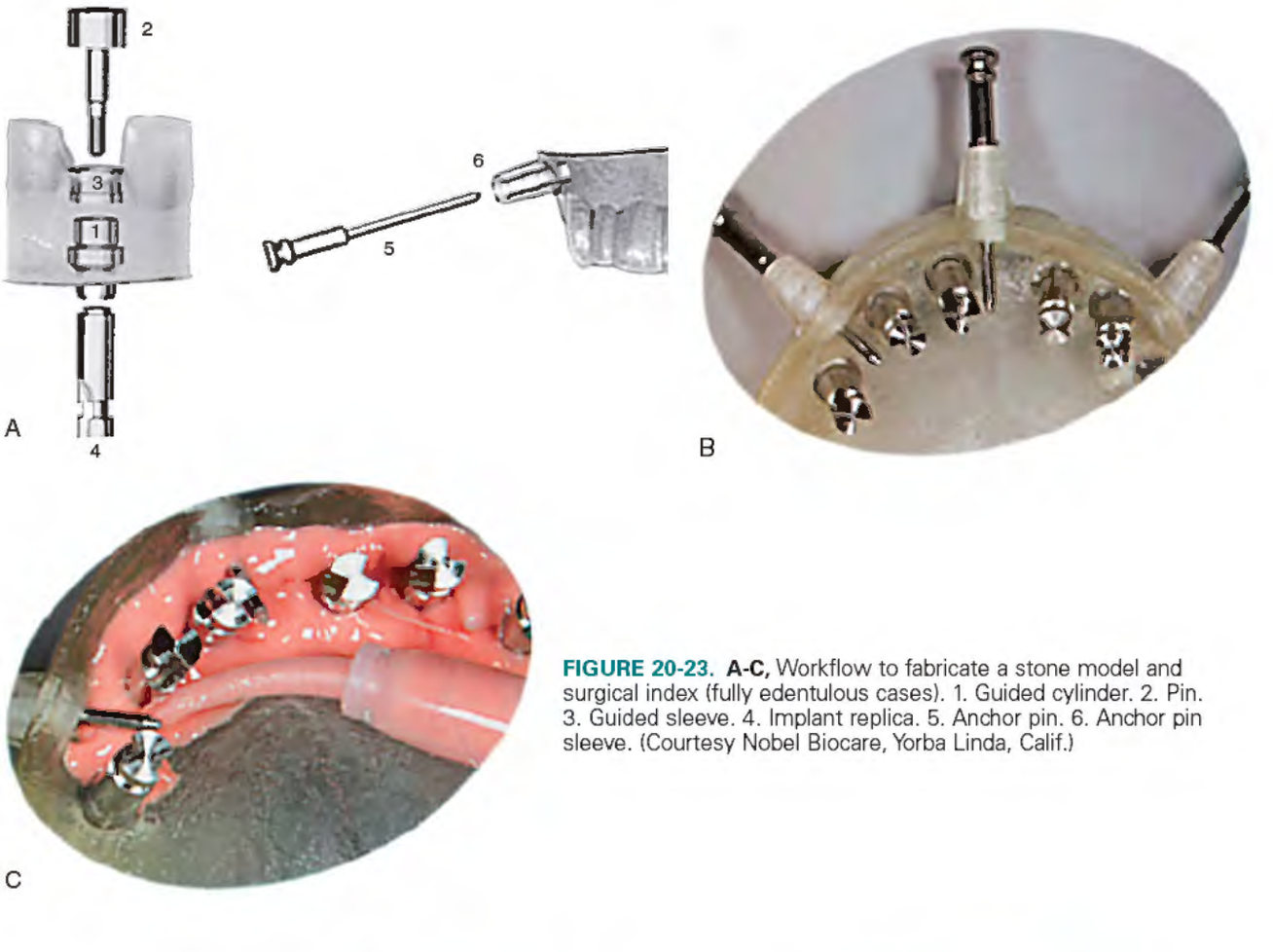


FIGURE 20-23. **A-C,** Workflow to fabricate a stone model and surgical index (fully edentulous cases). 1. Guided cylinder. 2. Pin. 3. Guided sleeve. 4. Implant replica. 5. Anchor pin. 6. Anchor pin sleeve. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

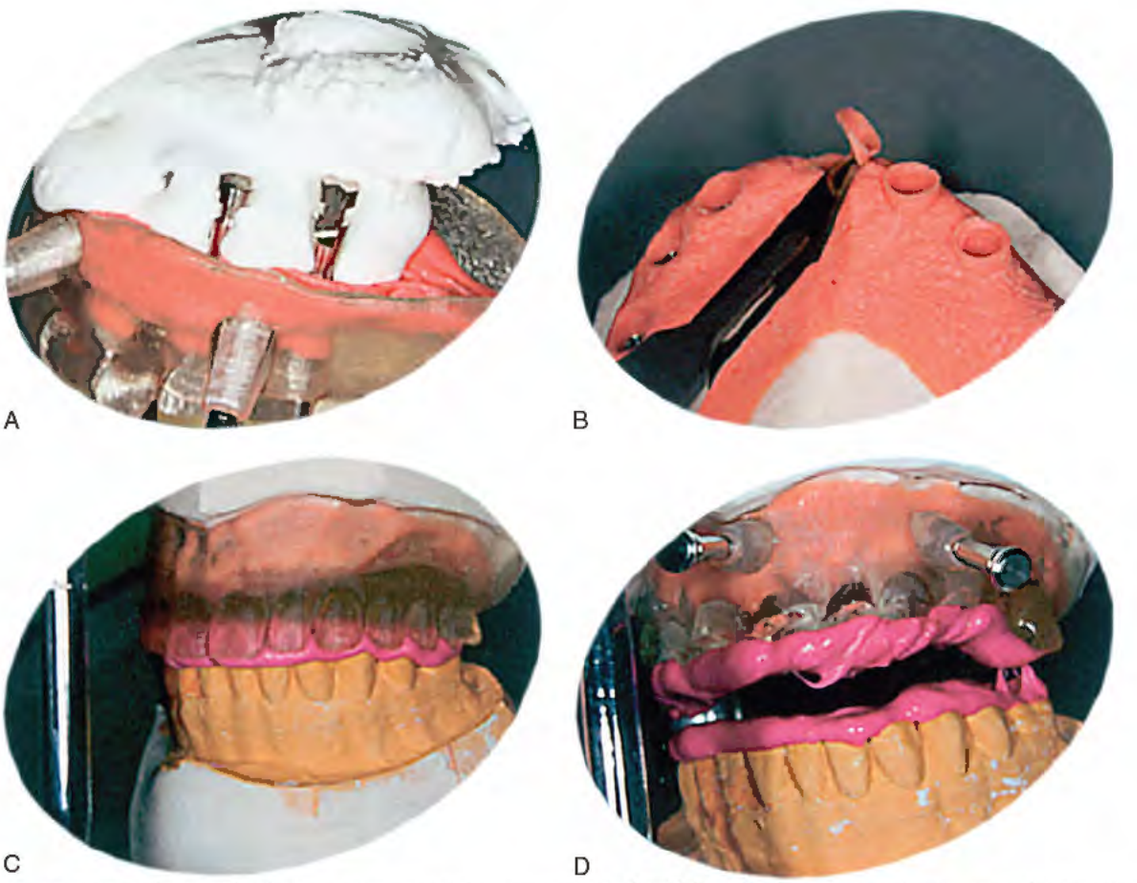


FIGURE 20-24. **A-D,** Workflow to fabricate a stone model and surgical index (fully edentulous cases). (Courtesy Nobel Biocare, Yorba Linda, Calif.)

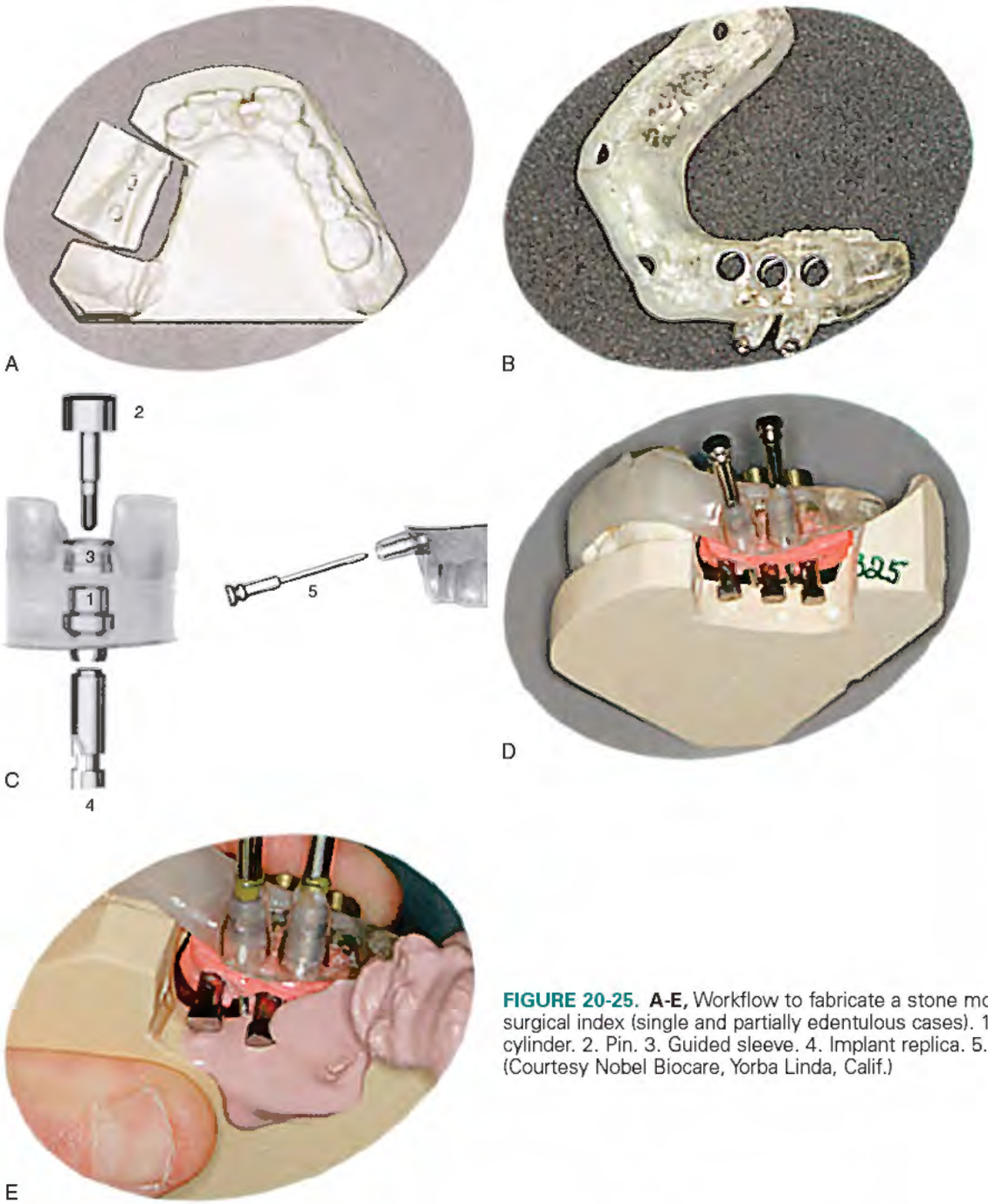


FIGURE 20-25. A-E, Workflow to fabricate a stone model and surgical index (single and partially edentulous cases). 1. Guided cylinder. 2. Pin. 3. Guided sleeve. 4. Implant replica. 5. Anchor pin. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

NOTE

When an engaging abutment (i.e., a rotational lock abutment) is used, care must be taken to rotate the implant replicas so that the side of the hex is parallel to the curvature of the jaw (Brånemark system) or so that a lobe of the internal connection is oriented buccally (NobelReplace).

9. The bottom of the guide cylinder with pin and the surface of the surgical template are lubricated with petroleum jelly for easier dismounting of the soft tissue replica.
10. The soft tissue replica is added in the area of the restoration. A very small tube is used so as to ensure that the surgeon can reach down to the guide cylinder with pin.
11. The surgical template is positioned on the stone model. Some sticky wax is added to secure the surgical template in the proper position (Fig. 20-25, *D*).
12. Proper seating of the surgical template is verified through the inspection windows.
13. The area to be restored is filled with die stone (Fig. 20-25, *E*).
14. Proper seating of the surgical template is verified through the inspection windows throughout the setting process for the die stone.
15. Once the plaster has set, the guide cylinder with pin and the anchor pins are unscrewed, and they and the surgical template are removed (Fig. 20-26, *A*).
16. Any high edges around the template cylinder holes are removed.
17. The radiographic guide is attached to the stone model and mounted in an articulator with a stone model of the opposing jaw and the radiographic index (Fig. 20-26, *B*).
18. The radiographic guide is replaced with the surgical template, and the correct position is verified through the inspection windows.

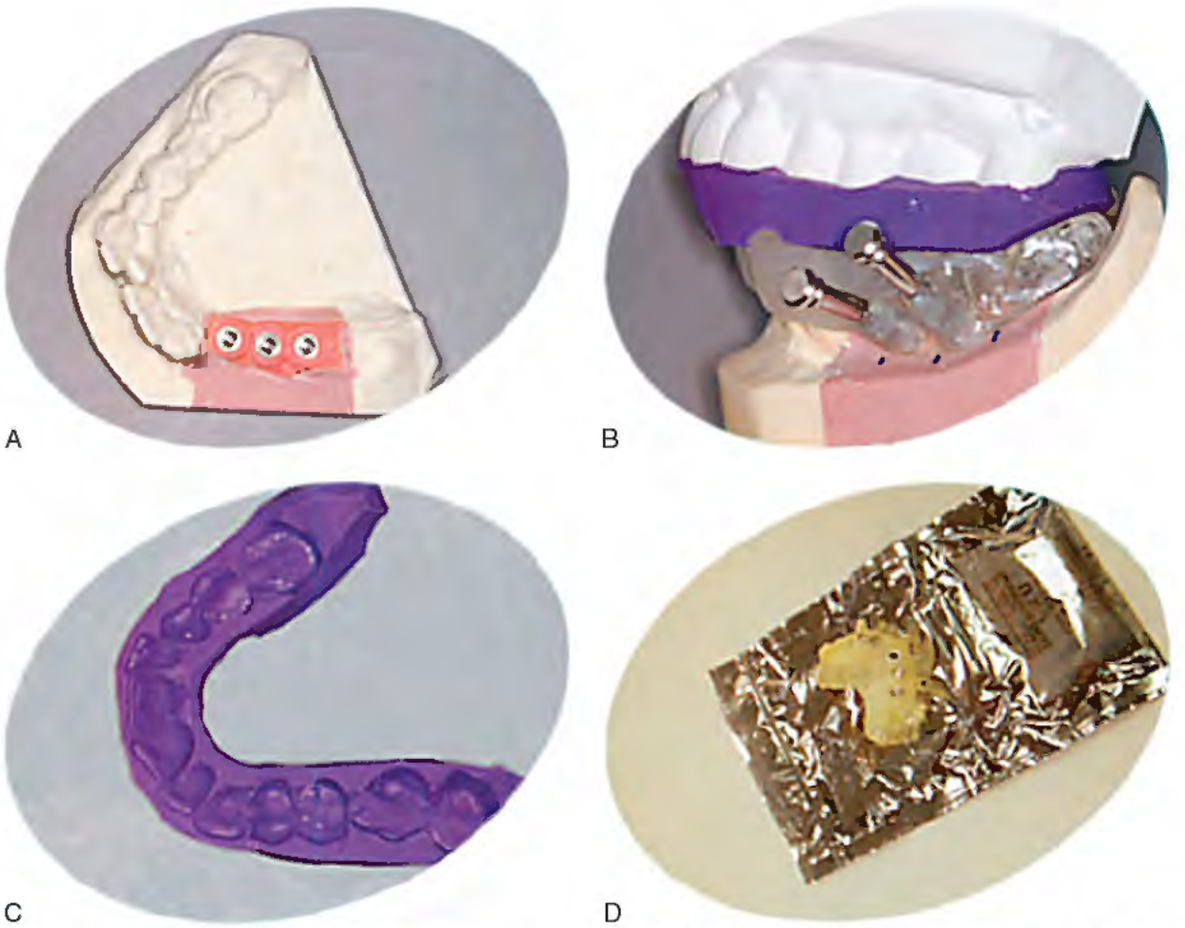


FIGURE 20-26. A-D, Workflow to fabricate a stone model and surgical index (single and partially edentulous cases). (Courtesy Nobel Biocare, Yorba Linda, Calif.)

19. If applicable, the surgical template is secured with anchor pins.
20. Index material (e.g., A-silicone) is added between the surgical template and the opposite jaw, and the jaws are closed. The surgeon must make sure to use enough material to get a good index (Fig. 20-26, *C*).

NOTE

If the patient has only front teeth in the opposing jaw and does not wear a partial prosthesis, the bite in the area where the teeth are missing must be built up to make contact with the alveolar ridge. This ensures a horizontal, well-balanced bite registration.

21. The surgical template is returned to its UV-protective plastic bag in which it was delivered (Fig. 20-26, *D*).
22. The appropriate prosthetic solution to meet the patient's requirements and the clinical situation is chosen.
23. When a guided surgery prosthetic procedure is performed, a wide range of Nobel Biocare abutments can be used:
    - Immediate temporary abutment (single cases)
    - Guided abutment (partial and fully edentulous cases)
    - Procera abutment
    - Snappy abutment
    - Esthetic abutment
    - Multiunit abutment

In both model-based and computer-based procedures, after the production of the stone model, most prosthetic procedures are the same as in conventional treatment.

Teeth-in-an-Hour Solutions

NobelGuide has developed screw-retained devices based on adjustable guided abutments.

1. A set-up of teeth is made in the articulator (Fig. 20-27, *A*). If possible, the set-up of the radiographic guide is used as a template.
2. A silicone key is made so that the teeth can be replaced in the same position on top of the model.
3. The guided laboratory abutment and guided titanium temporary copings are mounted together and connected to the implant replica using the guide pin and the Unigrip screwdriver (Fig. 20-27, *B*).
4. A resin replica is made of the bridge frame into which the guided titanium temporary copings are embedded (Fig. 20-27, *C*).
5. A new silicone key is made that follows the frame. Some silicone is put under the frame to create the space for the surrounding acrylic.
6. The resin frame and stone model are sent to Nobel Biocare's production facilities, according to normal procedures for the Procera implant bridge.
7. After the implant is returned, normal finishing procedures are followed (Fig. 20-27, *D*).

NOTE

The guided titanium temporary copings can also be used for temporary restorations.

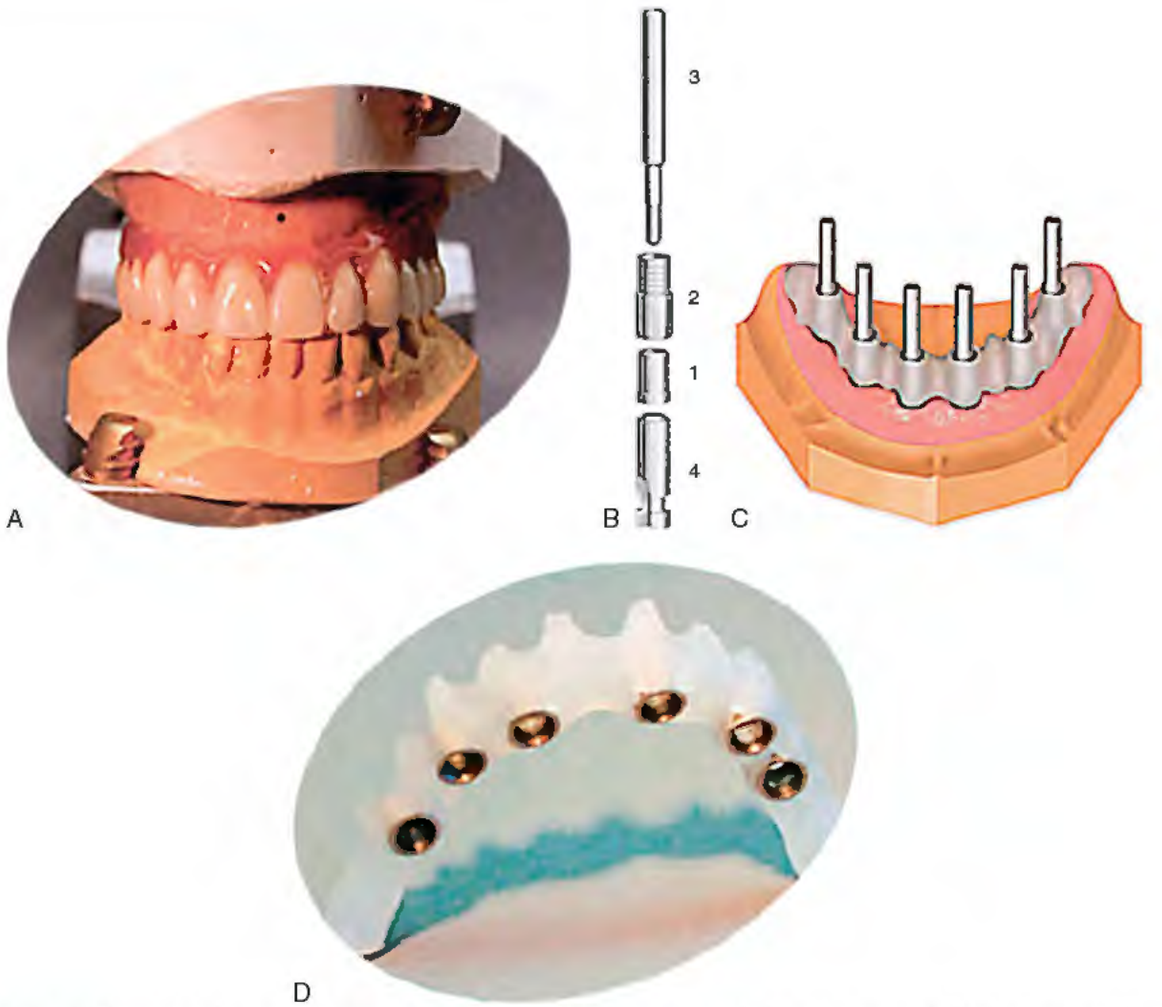


FIGURE 20-27. A-D, Sequence for screw retained devices based on adjustable guided abutments. 1. Guided laboratory abutment. 2. Guided Ti temporary coping. 3. Guide pin. 4. Implant replica. (Courtesy Nobel Biocare, Yorba Linda, Calif.)

Double Scan Technique

In computer-based NobelGuide cases, CT scan data are used as a basis for surgical planning and for the production of a surgical template that guides the surgery during installation of dental implants. Therefore, it is vital that the CT scan data are a true representation of the patient's dental anatomy.

The purpose of a double scan is to obtain clear, precise data of the patient's alveolar bone and of the radiographic guide. These can then be shown clearly in the Procera Software Planning Program–Surgical application.

The double scan technique is the key to realizing this goal. The two CT scans performed are:

1. A patient scan with radiographic guide and index
2. A radiographic guide scan without index

Because the Hounsfield units generated for the radiographic guide resemble so closely those of soft tissue, the double scan is used to solve the problem of extracting the guide from a single CT scan. The gutta percha markers on the radiographic guide are crucial as reference points to allow accurate fusion of the two scans.

IMPORTANT

In fully edentulous cases, the patient's existing optimized prosthesis or, if needed, a newly produced prosthesis should be used as the radiographic guide.

Radiographic Guide and Index

Apart from the referral with the treatment ID number, the patient should bring two important items from the referring dentist to the CT scan:

- *The radiographic guide:* An optimum radiographic guide is required for a successful treatment.
- *A radiographic index:* This index ensures the optimum bite of the patient and is used to make sure the radiographic guide is in the optimum position during the CT scan.

IMPORTANT

If the patient does not bring the radiographic guide and/or the radiographic index, the CT scan cannot be done. The patient must return to the referring dentist to get them and schedule an appointment for scanning at some later time. Also, if the radiographic guide has no markers, the CT scan cannot be performed, and the radiologist should contact the referring dentist.

Computed Tomography Scan Protocol

First Scan

The first CT scan in the procedure is a scan of the patient wearing the prepared radiographic guide and the radiographic index. The following routine is recommended.

1. The patient is positioned in the CT scan with the radiographic guide in the proper edentulous place in the mouth.

NOTE

In single and partially edentulous cases, holes, or inspection windows, should be drilled in the radiographic guide to allow verification of the correct position over the remaining teeth.

2. The patient should be asked to lean the head forward with the chin close to the chest, yet still remain comfortable.
3. The patient must be positioned with the occlusal plane and the horizontal laser indicator parallel and coinciding (if the CT scan has a vertical laser indicator, this should be positioned between the central incisors). No gantry tilt is allowed.

NOTE

In single and partially edentulous cases, if the patient has metal restorations on the remaining teeth, they may create artifacts on the CT scans. Attempts should be made to position the patient so that most of the field of interest of the axial slices through the radiographic guide does not pass through the metal restorations.

4. The patient should be advised to remain very still and not swallow during the whole scanning process.
5. The correct distance between the axial slices must be chosen (the recommended maximum distance is 0.5 mm).
6. When the scout image is shown on the computer screen, the patient's position should be corrected so that the hard palate is in a horizontal position. The field of interest for axial slices, parallel to the horizontally positioned hard palate, then can be assigned.
   In single and partially edentulous cases:
   - The previous point about the scout image applies to the upper jaw. For the lower jaw, either the occlusal plane, if enough teeth remain, or the alveolar crest, alternatively the middle part of the basis mandibulae around the premolar region, is horizontally positioned, giving almost horizontal axial slices in the field of interest. No gantry tilt is allowed.
   - The radiographic index is inserted in the correct position between the radiographic guide and the opposing teeth. It is very important that the patient bite firmly on the index and radiographic guide during the scanning, so that the guide is aligned with the soft tissue and any air pockets are eliminated.

NOTE

The patient should not bite so hard that the radiographic guide deforms in any way.

7. The patient's position is checked to make sure it remains stable, and scanning then starts.

Second Scan

After the first CT scan, the patient is allowed to leave the scanner and remove the radiographic guide from the mouth so that the guide alone, without the index, can be scanned.

The radiographic guide should be scanned in a position similar to that used for the patient scan. The guide is attached to a suitable object of radiolucent material and positioned in the CT scanner as closely to possible to the way it was located in the patient's mouth during the first scan.

NOTE

The positioning of the radiographic guide is important only for a good orientation. An accurate final match is performed during preprocessing of the data with the Procera Software Planning Program–Surgical, based on the gutta percha markers.

The material used to properly position the radiographic guide should be as radiolucent as possible. The material must be significantly darker after scanning than the radiographic guide. Paper boxes or other head-sized objects made of polyethylene and polyurethane foam materials are suitable. Adhesive tape (e.g., Leukoflex, Leukosilk, Nexcare paper tape, Durapore tape) is used to attach the radiographic guide to the material. The same CT settings are used for the second scan as were used for the first, including the same distance for the axial slices.

When the double scan is complete and the radiographic guide and radiographic index have been returned to the patient, the CT data are transferred to the dentist in the uncompressed DICOM 3 format for preprocessing.

Generic CT Protocol

Single Slice CT Scanner

Scan Settings

Spiral CT
No gantry tilt
Tube voltage: 120 kV
Effective tube current: 100 mAs
Collimation: 1 mm
Table speed: 1 mm/rotation
Gantry rotation speed: 1 rotation/sec
Reconstruction interval: 0.5 mm
Reconstruction kernel: sharp bone filter (preferred)

Multislice CT Scanner

Scan Settings

Spiral CT
No gantry tilt
Tube voltage: 120 kV
Effective tube current: 90 mAs
Collimation equals (number of detectors °—): smallest detector width
Feed/rotation: set equal to collimation °— 0.7
Gantry rotation speed; about 0.75 sec/rotation
Reconstruction interval: half detector width (typically, 0.3 or 0.5 mm)
Reconstruction kernel: sharp bone filter (preferred)

Cone Beam CT Scanner

Cone beam CT scanners are dedicated to imaging of the skull. The manufacturer's instructions must be followed to scan a jaw for oral implant planning.
The side of a cubic voxel should be within the range of 0.3 to 0.5 mm.
During reconstruction, no tilting of the axial slices is allowed.
The following Nobel Biocare implant systems are included in the NobelGuide treatment concept:
Brånemark System Mk III Groovy
Brånemark System Mk III Shorty
NOBELSPEEDY Groovy
NOBELSPEEDY Shorty
NOBELSPEEDY Replace

NOBELREPLACE Straight Groovy
NOBELREPLACE Tapered Groovy
NOBELDIRECT Groovy Implant

OMNIVAC SURGICAL TEMPLATE

Omnivac surgical template, which is simpler to prepare, is used when adjacent teeth are not being restored. The Omnivac template relies on these fixed structures for support and positioning. This type of surgical template is fabricated by adding wax or denture teeth to the planned operative sites on a stone cast. The template is trimmed below the height of contour of the adjacent teeth; it fits snugly, yet can e removed without difficulty.

At the planned implant sites, occlusal holes are cut in the Omnivac material. The buccal facings are the most important guides in implant positioning, therefore they should be preserved.

These simple devices are readily sterilized, and they can be retained for use in the second stage of surgery for identification of implant sites. (See Chapter 22 for abutment selection after implant exposure.)

Provisional Prostheses

21 CHAPTER

In the cascade of therapeutic events surrounding implant placement, the patient requires a provisional or interim prosthesis at two stages: during the integration period after first-stage surgery and after placement of the healing collars and abutments.

Several significant factors must be considered with regard to a provisional prosthesis. Acceptable and believable esthetics are required at every stage in oral reconstruction. In addition, sound prosthetic principles must be observed. Well-balanced occlusion and correct centric occlusion and vertical dimension are necessary, as is built-in protection for implant areas during the healing period. If natural teeth are to be part of the final restoration, they should be used for a temporary fixed prosthesis, which spares the gingival tissues overlying the implants. If a fixed prosthesis cannot be made, a tissue-borne, removable prosthesis must be constructed that is broad based enough to distribute forces evenly. Sound measures incorporate soft relining material (e.g., Coe-Soft, Viscogel, PermaSoft), which is frequently changed; careful examination of the tissues overlying the operative sites to detect early signs of pressure; and in maxillae, full palatal coverage, even though many patients do not care for this feature.

TOTALLY EDENTULOUS INTERIM PROSTHESES

First Stage

The patient usually has a complete denture that has been used for the jaw requiring treatment. Chapter 20 describes the preparation of a new denture and a replicated clear template, which subsequently serve as radiographic indicators for computed tomography (CT) scans, a surgical template, and an interim prosthesis. These prostheses must be made with unfailing attentiveness to classic prosthetic principles. Vertical dimension, centric occlusion, incisal length, free-way space, tooth position and angulation, and patient-approved cosmetics must be satisfied. Except for retention, the final implant-borne prosthesis can never be better than the initial one, the characteristics of which govern implant locations and emergence angles.

After implant surgery has been completed and hemostasis has been ensured, a large, round, acrylic bur is used to aggressively ream out the tissue-borne surface of the denture to approximate the implant sites. The flange linings, as well as the ridge crest, are managed in this fashion so that when the denture is seated postoperatively, no rocking or instability exists. Relief of the acrylic must take into consideration the possible added bulk of bone created by expansion techniques or graft materials, the protrusion of healing screw heads (especially for external hex implants), the increased dimension caused by a bulky suture line (i.e., mattress closures), and edema. Use of the duplicate, clear, diagnostic, plastic base plate is beneficial for this critical step if it is ground until no surgical site mucosal blanching is noted. The correction experience then is simplified while the grinding in the interim denture is replicated.

Sufficient overcorrection is made to allow for a several-millimeter thickness of soft lining material. The dental surgeon then dries, lines, and seats the denture and closes the patient's mouth into centric position. Gentle muscle molding is performed, and the excess soft material is trimmed with a Bard-Parker (BP) No. 11 blade in a scalpel handle. Sharp shears are used to round the borders carefully to eliminate irritating irregularities.

Occlusal relationships must be precisely the same as they were before these alterations were made.

If vascular oozing continues, hemostasis can be facilitated by adding a 50/50 mix of denture adhesive and ferric chloride powders; the mix is sprinkled onto the moistened lining with a salt shaker reserved for this use. Additional retention accompanies the rapid coagulation.

Postoperative visits should be at 3-day intervals until wound stability is ensured. After this, visits are made at reasonable intervals for relining and ongoing occlusal adjustments.

Second Stage

The denture is a versatile appliance that lends itself to simple and innovative change as dictated by the patient's prosthetic needs.

Its progenitor, the surgical template (which should have been retained), is brought to the host area. With the assistance of the radiopaque markers and carefully made mapping notes, each implant, although not visible through the mucosa, can be located (see Chapter 9).

After the healing collars or abutments have been placed, the surgeon turns to the acrylic routing burs, this time to make deeper but more discreet modifications designed to accommodate the transepithelial abutments (TEAs) in a trauma-sparing environment.

The exact locations in contact can be revealed by touching the dried occlusal surfaces of the abutments or collars with pressure indicator paste (PIP) and placing the denture, now relieved of its soft lining, against them (Fig. 21-1). Concentration on eliminating these areas leads to a prosthesis that is totally relieved of directing pressure to the implants. Again, a soft lining of choice is placed. Definitive prosthetic measures are completed while this removable interim denture serves in its classically versatile manner.

At second-stage surgery, the dentist and patient may want to substitute a fixed interim prosthesis for the removable one. This decision is based on the same principles that govern the design of fixed prostheses (see Chapter 24). The following section presents advice on preparing such devices and may be followed with essentially no modifications.

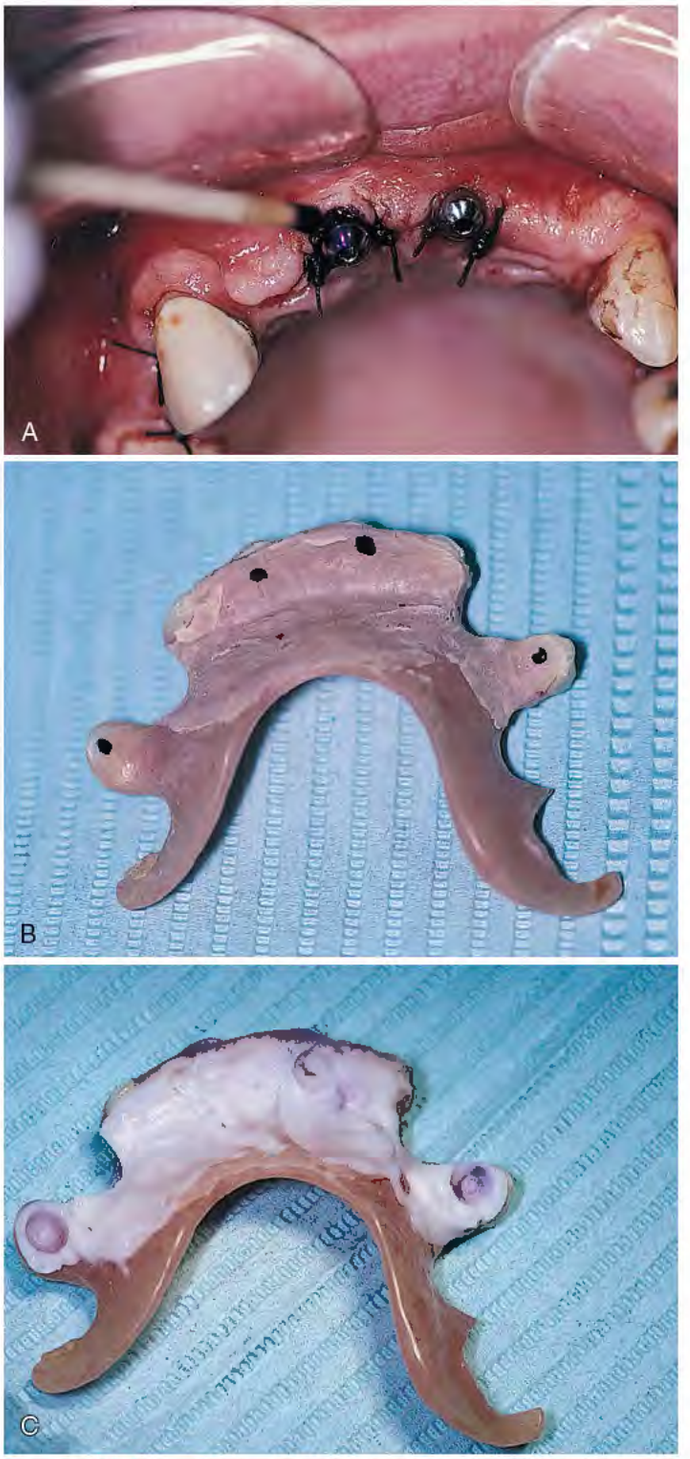


FIGURE 21-1. **A,** The first step in adapting a transitional denture to accommodate newly placed healing collars is to outline the collars with a Thompson marking stick or indelible pencil. **B,** After the denture has been seated and removed, the markings outlining each implant are transferred to its tissue-borne surface. **C,** After the denture base material has been reamed aggressively at the marking sites, the denture is relined with Coe-Comfort or TruSoft.

PARTIALLY EDENTULOUS INTERIM PROSTHESES

Implant-borne restorations range from single tooth (see Chapter 23) to more sophisticated, complex implant/tooth designs. The provisional prostheses may be removable or fixed, but they always must respect the recently submerged implants.

If a fixed provisional prosthesis is urgently needed, even when few or no potential abutments are available, the surgeon may plan to add some strategically placed implants at the time of first-stage surgery, in addition to those inserted for therapeutic use. Regions such as the tuberosities, pterygoid plates, or interimplant spaces may be suitable for placement of regular implants or mini-implants (see chapters 9 and 19). Although no significant expectations should be held for their long-range prognosis, some mini-implants succeed at osseointegration and may be kept for incorporation into the final prosthesis. Those that do not, because of mobility or bone loss or because they are not required for final superstructure stabilization because of location or angulation, can be shaved level to the gingivae or must be removed. Periodic radiographic and clinical observation of these interim implants is important, because peri-implant disease, if present, can affect adjacent teeth and implants. In such cases, immediate removal and repair are indicated (see Chapter 24).

Single-Tooth Implant Restorations

First Stage

The patient may have recently lost an incisor (or another esthetically critical tooth) as a result of trauma. Gingival tissues and bone may be intact or virtually so. In such cases, a temporary prosthesis should be supplied immediately. The following are possible surgical alternatives.

- The socket can be filled with graft material (e.g., tricalcium phosphate [TCP]), and primary coverage can be achieved by undermining. If vestibular integrity is inviolable, Alloderm may be used as an epithelial substitute.
- An implant can immediately be placed in the recently vacated alveolus, following the guidelines in Chapter 9.
- The injury is allowed to heal without treatment. A viable clot serves as the precursor to uncomplicated healing. Sometime before the completion of S, Roberts' 20-week bone healing sequence, an implant should be placed or the integrity of the labial cortical plate will be threatened.

In any event, the patient should be provided with a prosthesis that is not tissue borne.

As a simple alternative, the fractured crown of the tooth can be bonded, as long as the fracture is below the level of the cementoenamel junction (CEJ), or an esthetically acceptable acrylic denture tooth can be bonded to the adjacent proximal enamel surfaces. If occlusal forces appear threatening, an easily fabricated, all-acrylic, Maryland-type bridge may be prepared chair side (strengthened, if necessary, with steel mesh or wire) and bonded to the lingual and proximal surfaces of the abutting teeth.

Small, claspless partial dentures (flippers) should not be used, because they allow pressure to be directed to underlying edentulous sites. Postoperative examinations should offer assurance of continued stability of the temporary tooth and freedom from ridge lap pressure.

At each stage of treatment, from gingivoplasty to grafting and implant placement, the prosthesis may be removed, freshened, and seated again with new cement.

Second Stage

At the time of second-stage surgery, if an abutment has been placed or a contoured healing collar has been used, an ion crown facilitates temporization. The crown is lined with a composite and fixed in place with a noneugenol cement (Fig. 21-2).

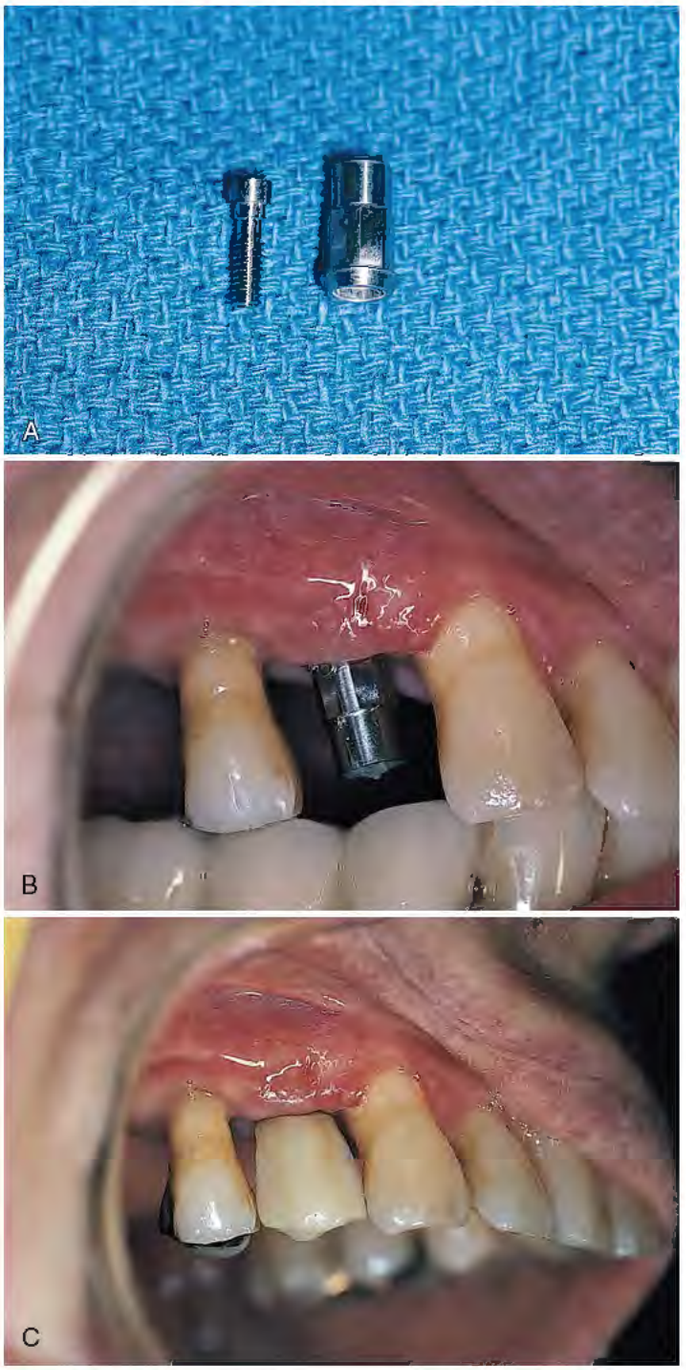


FIGURE 21-2. **A,** A hexed temporary cylinder from Implant Innovations uses a central retaining screw. **B,** The temporary cylinder is tightened into place by hand. **C,** An acrylic provisional crown may be relined over the temporary cylinder and then cemented into place, or the provisional restoration may be luted to the temporary cylinder to form a screw-retained provisional restoration.

Partially Edentulous, Multiple Implant Restorations

First Stage

Fixed Provisional Prostheses

Existing pathologic conditions are eliminated by periodontoplasty and endodontic therapy. At this point, certain teeth slated for extraction may be retained temporarily, prepared for crowns, and used as abutments for office- or laboratory-processed acrylic Artglass, BioTemps (Glidewell Laboratories), or nonprecious metal fixed bridges. Following this philosophy, teeth that are to be used as abutments for the final prosthesis can be managed in the same fashion. At each visit, such bridges are removed, and after the planned therapy has been completed (e.g., endodontics, periodontal surgery), they are cemented in place again with temporary cement. After the implants have been placed, ridge laps must be managed carefully to protect the host sites from injury.

If the condemned teeth are of such poor quality that they cannot be maintained on an interim basis, mini-implants are inserted into nonstrategic areas of the ridge to serve as partial or complete support mechanisms for temporary bridges (see Chapter 19).

Impression and record making for these implant foundations follow classic patterns, with try-ins, occlusal- and tissue-level adjustments, and insertion. Although metal and Artglass provide the most esthetic results, laboratory-processed acrylic bridges present the advantages of adaptability, chair-side repair and alteration, ease of construction, ease of adjustment, minimal cost, and simplicity of convertibility after the abutments have been placed.

Fixed provisional restoration is preferable to the removable type and may be used when fixed abutment support is available. Teeth, implants, or both may supply this support. The teeth that may require extraction can be kept to support the provisional restoration. If implants are used as abutments for provisional prostheses, they may be mature or can be placed recently for interim support. Although the prognoses for such implants is not as favorable as for those that are conventionally placed, many of them survive and contribute to the long-term foundation of the final restorations.

Fixed provisional restorations can be made in two designs: a full coverage bridge of acrylic or a composite with abutment preparations and support from nonprecious metals; or a Maryland bridge, made either of composite material or of base metal and acrylic.

Full Arch Fixed Bridge

For full arch bridges, strategic implants must be selected. However, these may have a poor prognosis. To be used for this purpose, they must be nonacutely infected and must not cause pain. The process for this type of prosthesis is described here.

1. Diagnostic casts of the operative jaw are made and mounted against a countermodel. If a change in the position of the maxillary teeth is planned for the provisional restoration, a facebow transfer is used to mount the maxillary cast.
2. Changes in tooth position, orientation, shape, or number are made in wax on the working cast. This is replicated in stone by flasking in alginate. A silicone labiomucosal index of the teeth is made to be provisionalized; this index should include adjacent teeth and gingival tissues.
3. All teeth are then prepared on the diagnostic cast. These preparations should be less than 1 mm deep. The altered cast is replicated in the form of a refractory model. The laboratory adds wax to the replicated model; the wax should wrap around the lingual surfaces of all the teeth and extend halfway through the embrasures. There should be no wax on the buccal or occlusal surfaces. The wax is continued over the edentulous areas to accommodate future implant abutments.
4. The frame is cast in a nonprecious metal, and its inner aspect is coated with a tooth-colored opacifier to prevent the final acrylic or composite from appearing gray.
5. The opaque metal frame is placed on the prepared cast and covered with the silicone index. Wax flows into the index, creating the planned restoration. The restoration is then flasked and boiled out, and acrylic in the proper shade is used to replace the lost wax.

6. After curing, the restoration is deflasked, trimmed, and polished.
7. The planned abutments in the patient's mouth are prepared in the same manner as for normal crowns, and the provisional restoration then is inserted and fitted. The provisional restoration is relined with self-curing acrylic. If the entire arch is being provisionalized, the patient's vertical dimension is preserved and maintained or modified appropriately (Fig. 21-3).
8. Temporary noneugenol cement (e.g., Trial) is used to cement the provisional prosthesis in place. It should allow easy removal but maintain its retention in a trouble-free manner. The prosthesis should be checked monthly for cement integrity and removed every third month for prophylaxis. Fluoridation is beneficial at these visits, as is the use of a dentifrice at home.

Composite Retained Fixed Provisional Bridge

The Maryland bridge is made either of composite material or of base metal and acrylic. The composite-retained fixed bridge is particularly beneficial when teeth adjacent to the edentulous area planned for implants are not going to be restored, and lingual enamel is available that does not come into contact with the opposing dentition in centric occlusion or any excursive movements. These lingual surfaces are fitted with Maryland-like wings that serve as retentive devices for provisional fixed restorations. The process follows the steps shown here.

1. Diagnostic casts of the maxilla and mandible are made and mounted, and wax is used to incorporate planned changes.
2. A stone cast replica of the wax-up is made, and the metal framework is waxed without preparation or alteration of the natural teeth. The wax is placed on the lingual surfaces of the teeth planned as abutments and extended halfway into the embrasure spaces, wrapping around the lingual surfaces of one to three teeth on either side of the edentulous area. The number of adjacent teeth required for abutment support depends on the size of the edentulous span. For an edentulous space of two or more teeth, at least two or more adjacent abutment teeth should be used.
3. The metal frame should cover as much lingual enamel as possible, but it should not interfere with centric supporting stops or excursive movements of the opposing dentition. The winged frame should be more than 1 mm thick. It is cast in a nonprecious metal, a silicone index of the teeth to be extracted and the adjacent teeth is made, and the condemned teeth are removed from the cast.
4. The metal frame is seated on the cast, the silicone index is placed over it, and wax flows into the index, which then is attached to the cast metal frame. The restoration is flasked, boiled out, and processed with appropriately shaded acrylic.
5. After the restoration has been trimmed and polished, two or three half round bur holes are cut through the lingual metal

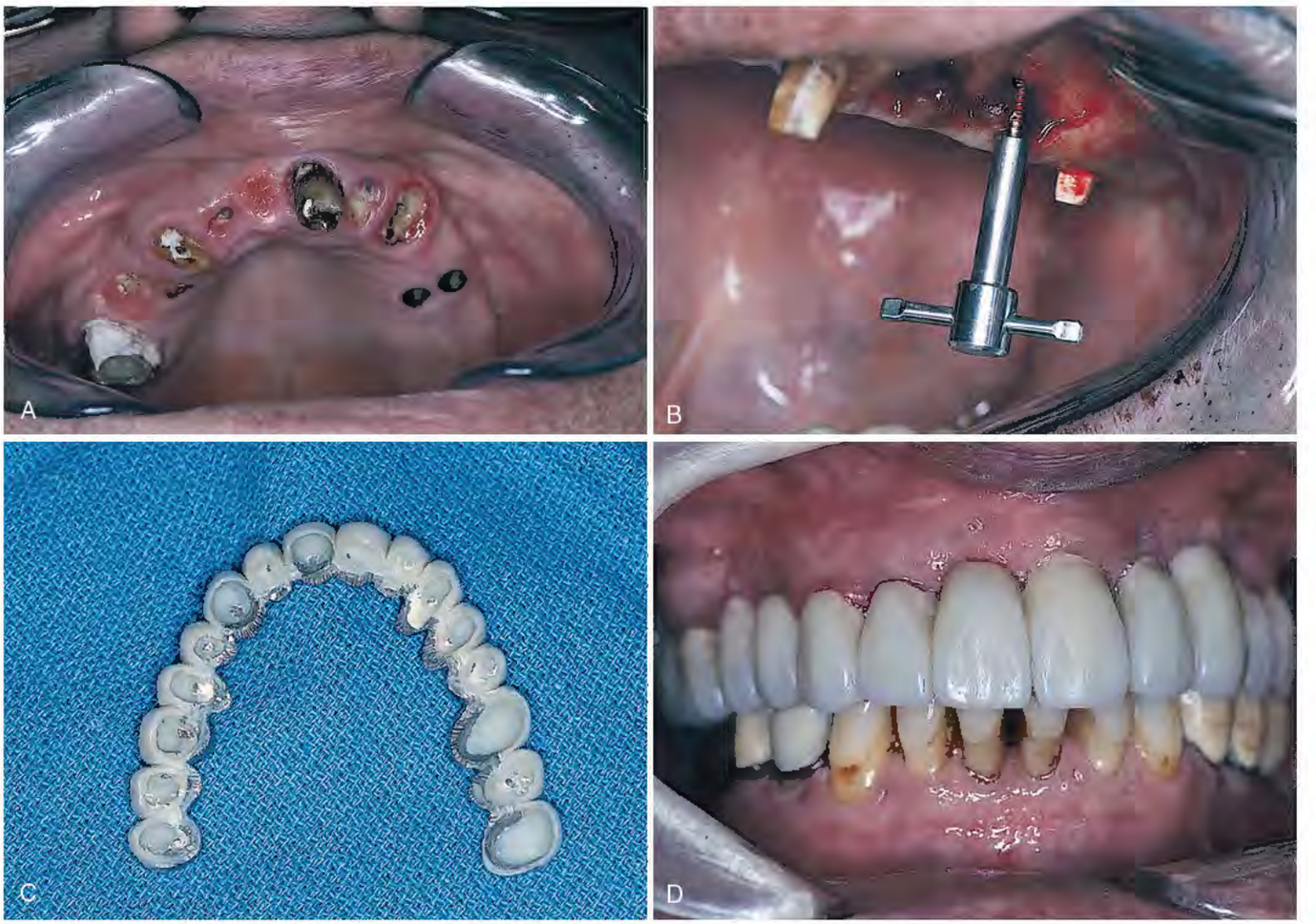


FIGURE 21-3. **A,** Teeth that are to be extracted but are not acutely infected or painful may be useful for provisional abutment support. **B,** Mini transitional implants are useful when inadequate teeth are present to support the provisional restoration. **C,** The fixed provisional restoration can be maintained for long periods if cast metal reinforcement is processed with the acrylic. **D,** The provisional restoration is relined with autopolymerizing acrylic.

wings that seat on the abutment teeth; the metal need not be etched. occlusal and esthetic adjustments are made. The abutment teeth are polished with pumice and then acid-etched in three spots.

6. The bridge is seated with firm pressure, and self-curing composite resin is allowed to extrude through the holes in the metal wings. The patient closes the teeth in centric occlusion and allows the composite to cure completely.
7. The excess composite resin is trimmed, leaving a button of protruding material at the site of each hole in the metal wings. These buttons retain the fixed bridge mechanically. Bridges made in this fashion can be removed by cutting off the composite buttons (Fig. 21-4).

Removable Provisional Prostheses

Although removable provisional prostheses are simpler to make, require much less preparation of the teeth, and eliminate the need to place mini-implants, they pose the risk of transmitting harmful forces to grafted or implanted sites. In addition, these prostheses are not appealing to patients; they are bulky and often troublesome.

To fabricate such a device, the surgeon casts Bonwill clasps with deep, effective occlusal rests. Full palatal or retromolar pad coverage offers effective support, and all saddles require thick, soft liners that must be changed frequently.

Abutments can be teeth that are to be removed, those that are incorporated into the final prosthesis, or other unsullied teeth that may require restoration to allow placement of deep rest seats and clasps.

Second Stage

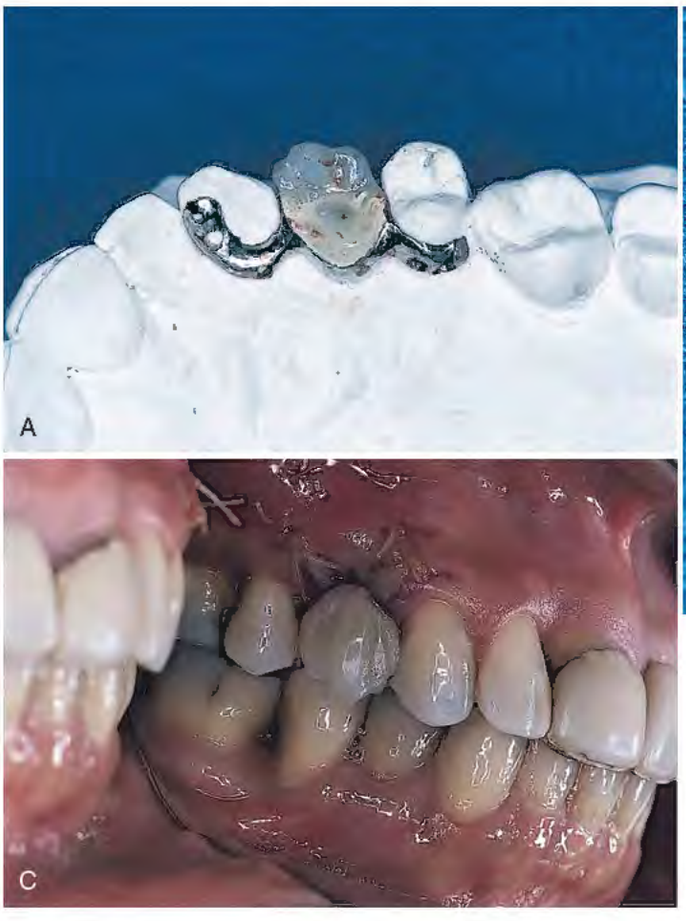
Fixed Provisional Prostheses

When implants are exposed for the placement of healing collars or abutments, the all-acrylic prosthesis serves the most useful role. This prosthesis is cut, sectioned, relined, or retrofitted to the TEAs by using PIP to transfer the locations of the implants. This is followed by hollow grinding of the prosthesis and then use of an autopolymerized resin (Fig. 21-5). At this juncture, the implants can contribute to the prosthesis support mechanism but to an extent not yet quantifiable. Because of its relative softness and compliance, acrylic, when used as a medium of construction, should be introduced at the earliest stage of progressive loading.

Progressive Loading

As weeks elapse during which final prosthetic manipulations are completed, the condemned teeth are extracted. They are removed one or two at a time, first from the areas offering the most peripheral support and subsequently from locations that contribute less buttressing. Each extraction and reaccommodation of the prosthesis should be accompanied by analysis and adjustment of the occlusion. These steps amplify the concept of progressive loading, which comes to an end with the delivery of the final prosthesis.

If the provisional prosthesis contains acrylic teeth, the successive occlusal burden is accepted in a subtle way. If porcelain is the occlusal material of choice, the loading is intensified abruptly. To buffer this latter step, a soft occlusal guard is supplied; or, more radically, the acrylic teeth can be changed to a composite resin



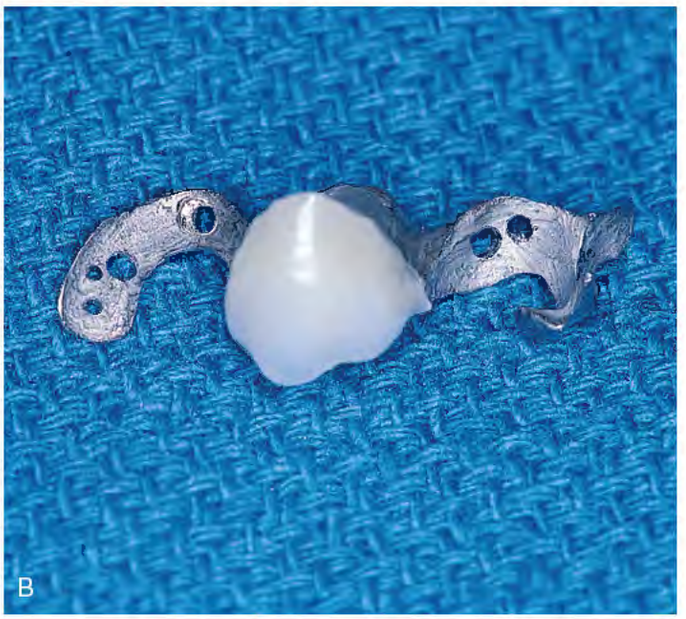


FIGURE 21-4. **A,** The cast metal frame should not interfere with centric occlusal stops. **B,** Two or three holes are cut through the metal wings to allow composite resin to extrude through them. **C,** The pontic is relieved to eliminate any pressure on the underlying soft tissue.

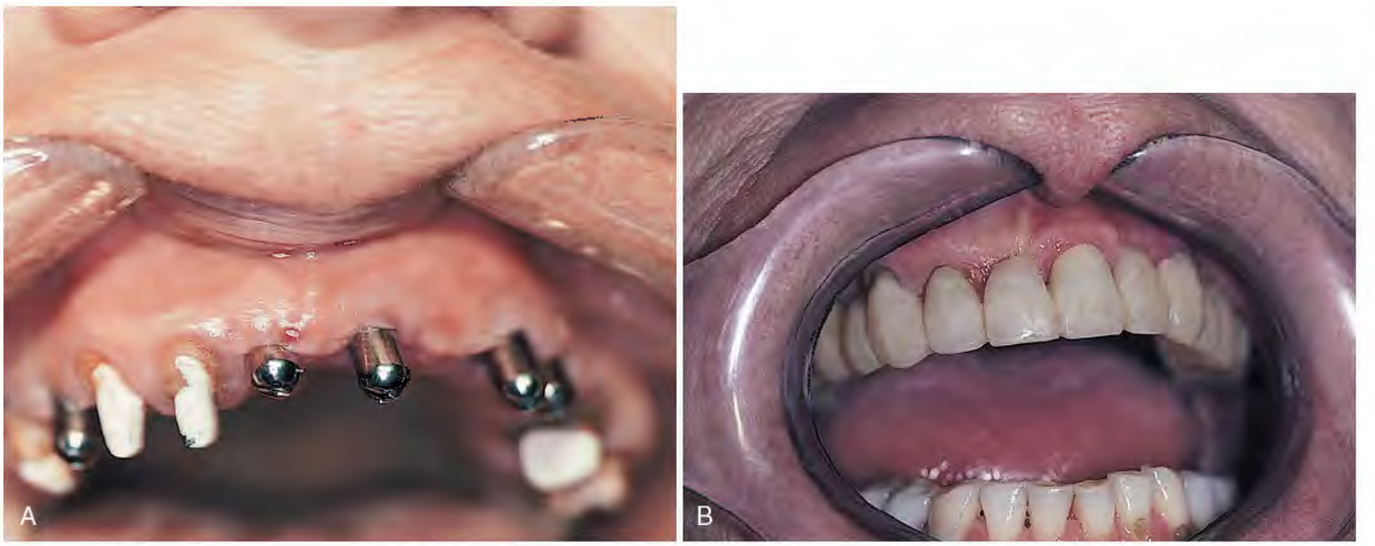


FIGURE 21-5. **A,** After gingival healing cuffs have been placed, an indelible pencil is used to outline the location of each. **B,** The existing fixed temporary acrylic prosthesis is hollowed to conform to the newly placed cuffs and may be placed with temporary cement (e.g., Nogenol).

(e.g., Isosit or Artglass), which offers a graduated step before the final insertion of porcelain. During these changes, the occlusion must be controlled and corrected, and the prosthesis must be removed for hygiene purposes.

Although many variables govern the process of progressive loading (e.g., the size and number of implants, density of bone, gnathodynamometry, patient compliance, and bruxism), a good result can be achieved by following the regimen described.

1. The surgeon must evaluate the implants, both traditional and provisional (or mini-implants), that had been placed as supports for the prosthesis after the first stage of surgery and that were designed to serve only during the period of osseointegration, after their original function is no longer required. If they have become integrated, have low Periotest scores, or demonstrate good bone support without significant saucerization, they can be left buried with a sealing screw. In this role (as "sleepers"), their contribution is to ridge maintenance and their availability for use as additives later if problems arise requiring additional abutment support.
2. If bone loss or fibrous encapsulation require removal of the implants, they are extricated with minimal trauma; the enclosed, invaginated epithelium, connective tissue, or granulomas are resected with sharp curettes and a scalpel with a BP No. 12 blade; and the osseous defect is filled with demineralized freeze-dried bone (DFDB) particles.
3. Primary closure should be performed. If inadequate mucosa is a problem, Alloderm or Regentex can be sutured peripherally to the surrounding gingivae.
4. Temporary fixed prostheses can be attached to abutments with fixation screws instead of cement. For this to be effective, the abutment must be well aligned, which may require the use of angled abutments. After the abutments have been put in position, a temporary cylinder is placed on each abutment. The fixed acrylic bridge is hollow-ground at the site of each abutment and relined with autopolymerizing acrylic over the cylinders. After an occlusal hole is made in each abutment to allow access to the retention screw, the prosthesis is affixed with several appropriately placed screws (Figs. 21-6 and 21-7).

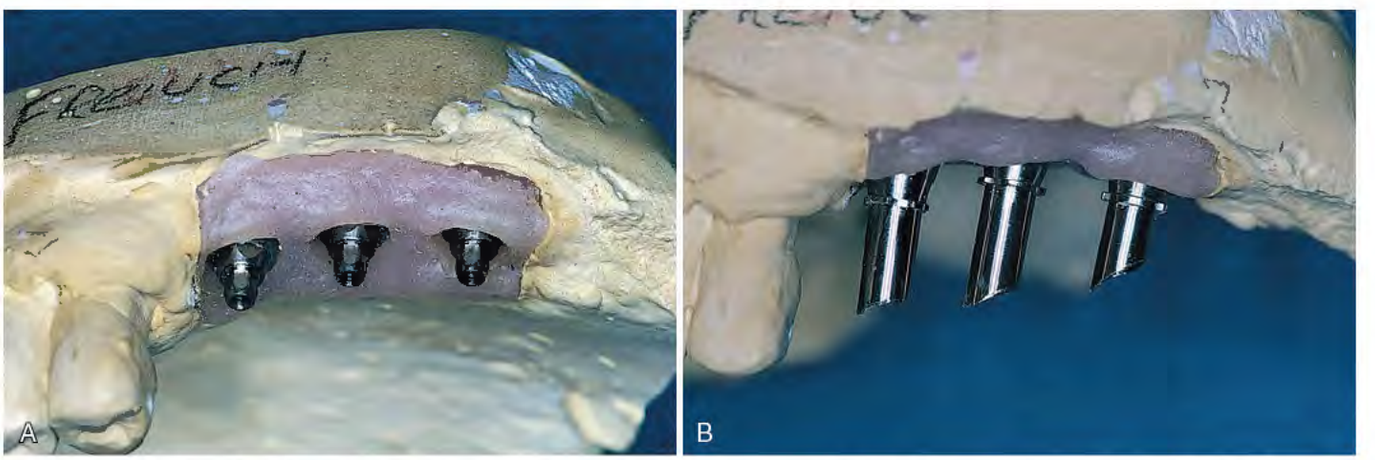


FIGURE 21-6. **A,** Conical abutments (Implant Innovations) are on the master cast. **B,** Temporary cylinders are placed on the abutments to form a screw-retained provisional restoration.

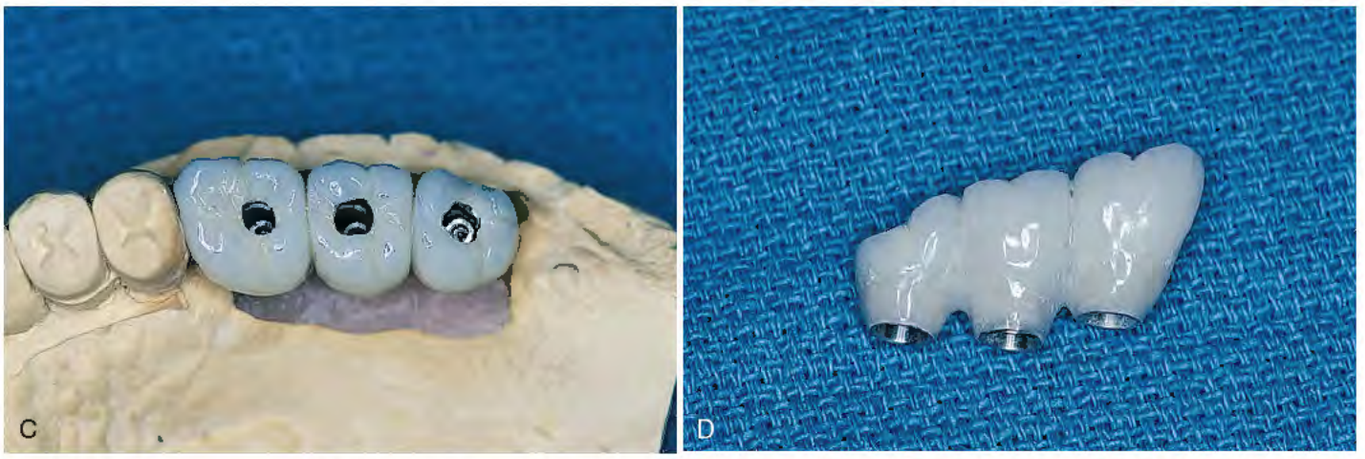


FIGURE 21-6, cont'd. C and **D,** The temporary cylinders are processed into the acrylic provisional splint with autopolymerizing acrylic resin.

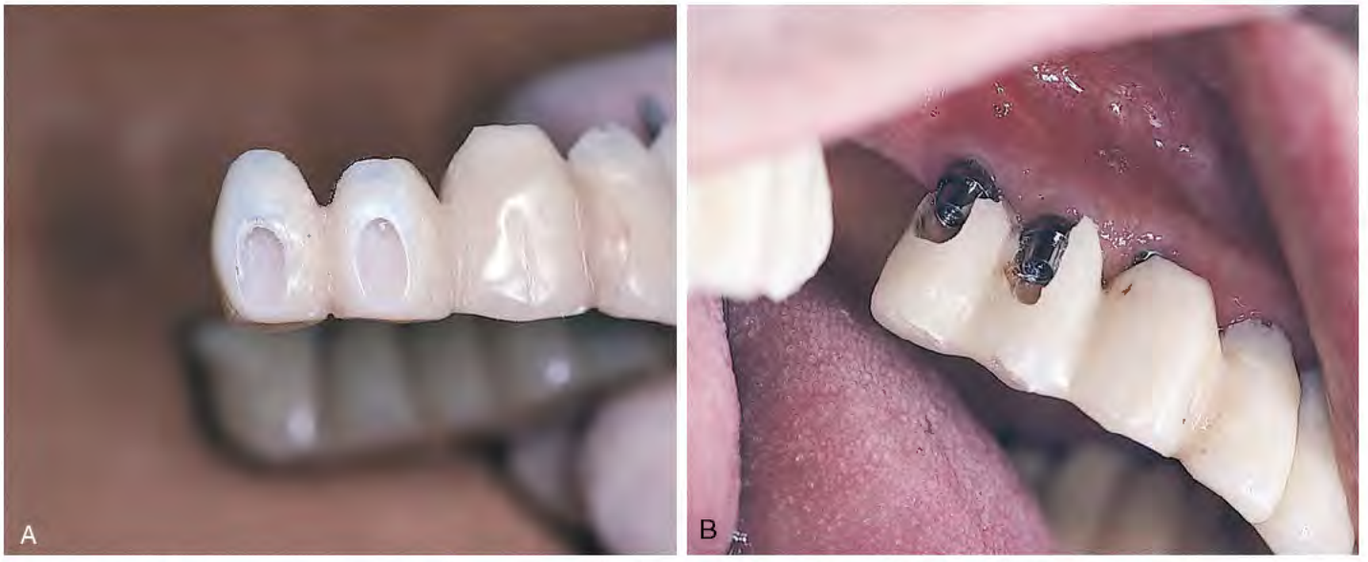


FIGURE 21-7. A, By preparing an anatomically correct, acrylic, temporary, fixed-detachable prosthesis, the surgeon can ascertain flawed angulation of the implants by noting their directions of emergence. **B,** Although the screws that appear through the buccal surfaces of the prosthesis can be masked with acrylic, a more satisfactory result is achieved by substituting angled abutments.

Removable Provisional Prostheses

When the implant infrastructures are exposed, abutments or healing collars are fixed to them with screws. The removable denture (which should not have been made with metal supports in the saddles) is marked with PIP transfers and reamed generously to accommodate the TEAs. These receptacles and the surrounding saddles are relined with Viscogel or another soft material. The full palatal or retromolar pad coverage should remain, with hard acrylic linings to offer continued support to the system. These prostheses should be adjusted regularly during the various stages of superstructure fabrication.

The patient may decide to convert to interim fixed prostheses at this juncture. In this case, a classic fixed prosthetic protocol is undertaken, leading to the fabrication of a cementable or screw-retained acrylic or composite appliance.

As an alternative, the interim denture may be reshaped as a fixed prosthesis by removing palatal and flange extensions, and fitted over the internally threaded abutments. Holes made in corresponding locations allow the use of fixation screws, which fasten the converted prostheses to the underlying implant support mechanism.

Simple removal and replacement are important factors that govern the design and method of attachment of interim prostheses, because these devices must be detached and reset on numerous occasions.

Root Form Implant Prosthodontics: Abutments

22 CHAPTER

After second-stage surgery has been completed, and the healing collars have been removed, the final restoration is started. To affix a final prosthesis to the implants, abutments must be used as intermediate devices. In most implant systems (two surgical stages), abutments are the components that extend through the gingival tissues overlying the implants. For implants placed in a single-stage procedure (e.g., implants by Nobel Biocare, BioHorizons, and Park Dental Research), the abutments, when attached, are positioned above the exposed gingival cuffs (see chapters 10 and 11).

Abutments may consist of a single unit (Fig. 22-1); two pieces (Fig. 22-2); or three pieces. The parts of the three-piece abutment, which may be separate or unified, are the *base,* which fits into the antirotational component of the implant; the *head,* which protrudes permucosally and serves as the prosthetic retainer; and the *retaining screw,* which affixes the other two parts to the implant.

Abutments can be obtained from the manufacturer in machined form, or they can be custom cast by a laboratory using manufactured gold or plastic components. Several recently introduced variations include ceramic, zirconium and other wide esthetic abutments. Tables 22-1 and 22-2 list the specific characteristics of each company's spectrum of available abutments for screw-retained and cementable crowns and copings. In this atlas, implant abutments are referred to as *transepithelial abutments* (TEAs).

The dental surgeon faces many options in the selection of abutments. The design of the prosthesis plays a major role in determining the types of abutments to be used.

Wherever esthetics allows, the margins of final restorations should be placed 2 mm above the gingival tissues. This provides easier access for oral hygiene and minimizes the risk of gingival inflammation, which can lead to implant pericervical saucerization. In such areas, a TEA is selected that will put the planned crown margin at an optimum location. This location is determined by placing a plastic periodontal probe along the gingival margin adjacent to the healing collar and down to the cervix, or by using the collar itself as a guide. The proper collar height is established by adding 2 mm to that measurement (Fig. 22-3). This can be done by the laboratory technician or the surgeon. (Chapter 24 presents the steps required to transfer an implant to a cast.)

If the implant's location requires that the margins be placed subgingivally, such as for esthetic reasons or because the patient wants the implant below the gum margin, the collar height is shortened commensurately.

In some cases, the cervix of an implant is already level with the gingival tissues or possibly slightly below them (Fig. 22-4), and no space has been left for a collar. In these cases, an esthetic restoration is made by fabricating a crown directly to the head of the implant. This commonly is done by using a manufactured gold or polymeric coping (described later in the chapter).

Another alternative, which allows cementation of the prosthesis, is to insert the abutment with a torque wrench and prepare the implant-abutment combination intraorally with a tapered diamond bur and copious irrigation, creating a subgingival margin. Some systems do not have an abutment or attachment designed to satisfy the surgeon's every requirement. A wide variety of abutments are made with internal thread patterns (Fig. 22-5) and matching antirotational bases that are compatible with implants made by several manufacturers. The abutments of different companies (e.g., Biomet-3i, BioHorizons), therefore, can be substituted if they provide a required angulation, dimension, or emergence profile.

CEMENT VERSUS SCREW RETENTION OF ABUTMENT-BORNE PROSTHESES

Cement Retention

The debate over cement versus screw retention of prostheses has sparked significant controversy in the implant literature.

Advantages of Cement Retention

Cement retention offers many benefits, including the following:

- Cemented, fixed restorations tend to loosen less often than those affixed by screws.
- Superstructures are more passive because of the space created for the cement.
- Occlusal surfaces remain intact because of the absence of screw holes; this allows better axial loading of the supporting implants.
- Esthetics are better because the occlusal surfaces are not marred by screw heads or the patches used to cover them.
- Fewer occlusal porcelain fractures occur because of occlusal surface integrity.

FIGURE 22-1. A one-piece abutment can be used to support a cement-retained prosthesis.

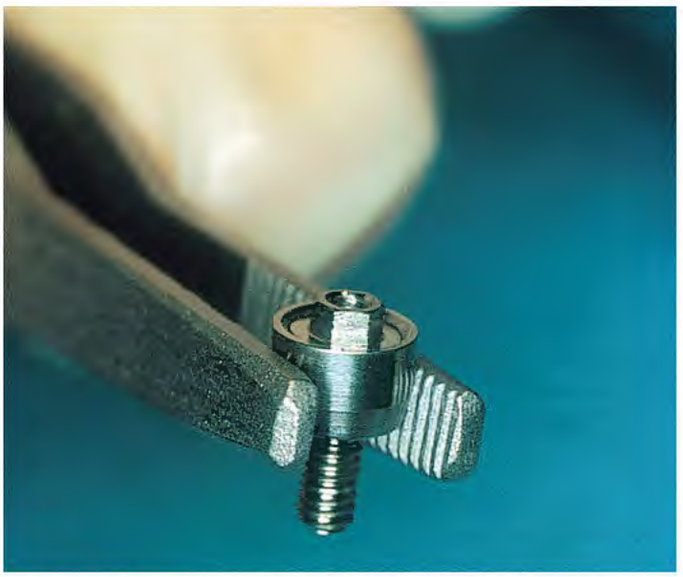


FIGURE 22-2. The Nobel Biocare abutment has a center screw and an outer housing that fits over the external hex of the implant.

- If cement washes out, it is easily replenished.
- Chair-side fabrication techniques are virtually the same as for conventional fixed prosthetic construction.
- Manipulation in posterior regions is easier with cement than with screws and a screwdriver.
- Cementation is an ordinary and familiar function in prosthodontics.
- Screw retention is more expensive, because additional components and more clinical and laboratory procedures are necessary.
- Inventories of small screw parts are more complex and costly.
- Loosening of fixation screws leads to mobility of implant components, which may cause related problems, such as soft tissue hypertrophy or ingrowth, loose or fractured screws in abutments, fractured porcelain, and disintegration of implant host sites.

Disadvantages of Cement Retention

Cement retention does have some potential shortcomings as well:

- Abutments sometimes must be prepared intraorally.
- Gingival retraction may be needed, which increases chair time and requires the use of local anesthetics.

Table 22-1 Abutment Options for Cement-Retained Prostheses

Name	Straight	Angled	Custom Cast	Esthetic	Other
Astra Tech	+	+	+	a, b, c, d	
Bicon	+	+	+		
BioHorizons	+	+	+		d
Biomet-3i	+	+	+	a	
Camlog	+	+	+	a	
Implant Direct	+	+	+		
Imtec	+		+		
Innova	+	+	+	a	
Lifecore	+	+	+		
MIS	+	+	+	a, b, c, d	
Neoss	+	+	+	a, b	
Nobel Biocare	+	+	+	c	e
Park Dental	+	+	+		
Sargon	+	+	+		
Straumann	+	+			
Zimmer	+	+	+	a	

+, A feature of this implant.
a, Wide emergence profile.
b, Tooth-shaped bioesthetic abutments.
c, Prepable ceramic inverse cone, allows for up to 20-degree angulation.
d, Prepable titanium inverse cone, allows for up to 20-degree angulation.

Table 22-2 Abutment Options for Screw-Retained Prostheses

Name	Flat Top	Tapered	Tapered Angled	Direct Gold
Astra Tech		+	+	
Bicon				
BioHorizons	+			+
Biomet-3i	+	+	+	+
Camlog	+	+	+	+
Implant Direct				+
Imtec				+
Innova	+			+
Lifecore	+	+		+
MIS	+	+		+
Neoss	+	+		+
Nobel Biocare	+	+	+	+
Park Dental		+		+
Sargon				+
Straumann		+		
Zimmer		+		+

+, A feature of this implant.

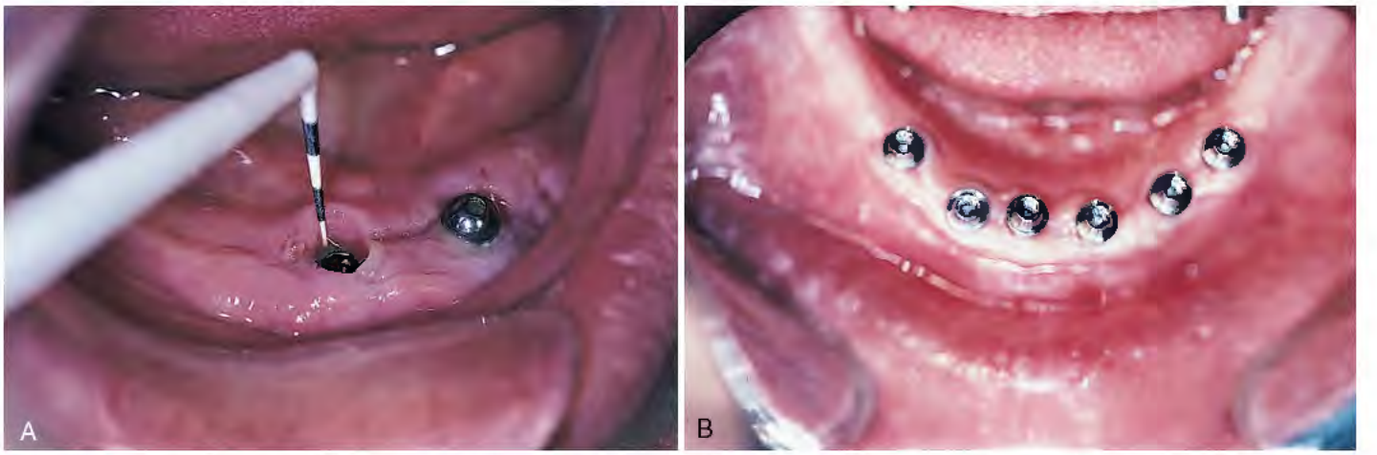


FIGURE 22-3. **A,** After removal of the gingival healing cuff, a plastic periodontal probe is used to measure the tissue height, which determines the selection of the transepithelial abutment (TEA). TEAs can accommodate a range of gingival thicknesses. **B,** After the soft tissue thickness has been measured, abutments with 2 mm of additional height are screwed into the implants.

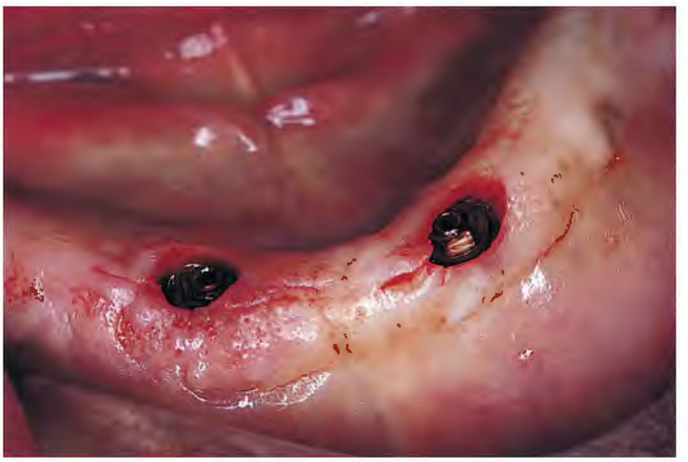


FIGURE 22-4. These implants have cervices at the tissue level and may require custom-cast abutments for an esthetic restoration.

FIGURE 22-5. A straight abutment is made with a threaded post.

- When permanent cements are used, evaluation and maintenance of the implant-abutment complex is difficult.
- Loosening of some components in permanently cemented bridges creates major problems when the entire prosthesis must be removed.
- Temporary cements may wash out prematurely. This causes improper loading, prosthesis dislodgment, a foul taste as a result of food impaction, and proliferation of endotoxin-forming organisms.

Screw Retention

Proponents of screw retention cite retrievability as this method's major advantage. Screw-retained prostheses also offer other benefits that deserve serious consideration. The primary advantage is greater prosthetic flexibility. Although cementation is used primarily for conventionally designed crown and bridge prostheses (whether single tooth or full arch), they lose efficacy if height is insufficient. In such cases, screw retention allows the use of short or low-profile abutments. In addition, screws provide reliable security when mesostructure bars (see Chapter 26) of limited vertical dimension are made quite close to the mucosa, and screws offer reliable support to hybrid prostheses, which must be removed for hygiene (see Chapter 24) (Fig. 22-6).

ATTACHMENT OF ABUTMENTS TO THEIR IMPLANTS

In most current systems, abutments must be attached to implants with retaining screws, which pass through the abutment and into the implant's threaded internal receptacle.

Abutments for Flat-Surfaced Implants

Abutment-implant interfaces vary, depending on whether antirotational devices are included. Implants that do not have antirotational elements are flat surfaced and usually require attachment of one-piece abutments (Fig. 22-7). Traditionally, these implants are used only when multiple units are to be splinted by connecting their overlying crowns or bars, which generally are cement retained, preventing abutment malrotation. However, flat-surfaced implants

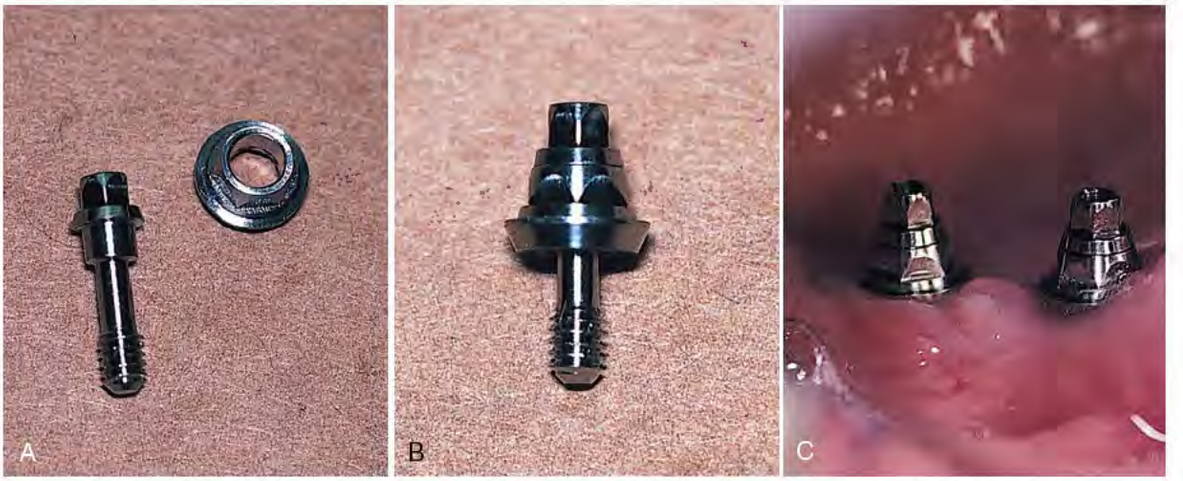


FIGURE 22-6. **A,** Nobel Biocare's Curvy system supplies its own abutment. It is similar in shape to other well-proven, esthetic abutments, except that it has a concave waist. The abutment is machined from titanium and works with NobelReplace and Brånemark System NP, RP, and WP implants and corresponding healing abutments. The Curvy abutment consists of a threaded central screw and a cone component, which is available in three heights to meet the esthetic requirements of a variety of clinical situations. **B,** Curvy components when coupled. **C,** The proper collar height brings the cervical margin of the abutment level with or just below the free gingival margin.

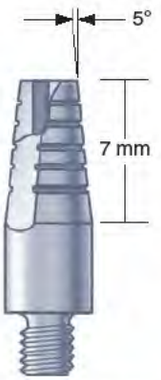


FIGURE 22-7. In a one-piece abutment, the screw and outer housing are one machined piece. An independent screw is required to retain a restoration in the top of this TEA.

should not be used for single-tooth restorations, because the lack of an antirotational feature results in persistent loosening of the abutment and prosthesis.

Table 22-3 Antirotational Connection Between Implants and Abutments

Name	External Hex	Internal Hex	Spline	Morse Taper
Astra Tech				+
Bicon				+
BioHorizons	+			
Biomet-3i	+			
Camlog	+	+		
Implant Direct	+			
Imtec	+			
Innova	+			
Lifecore	+			
MIS	+			
Neoss	+			
Nobel Biocare	+			
Park Dental	+		+ (internal)	
Sargon	+			
Straumann				+
Zimmer	+		+ (external)	

+, A feature of this implant.

Abutments for Implants with Antirotational Features

Antirotational Features of Various Implant Systems

Antirotational features on implants prevent unwanted movement of the overlying abutment. Antirotational features currently used include the external hex, the internal hex, the spline-type interface, the Park star, and the Morse taper. Table 22-3 shows the distribution of these features in the various implant systems.

External Hex

The external hex (Fig. 22-8) is the second most widely available antirotational feature in implants. This design offers a wide variety of restorative options because of the interchangeability of abutments among manufacturers. For example, the hexagonal geometry atop the Lifecore implant is compatible with the abutments available for Biomet-3i implants.

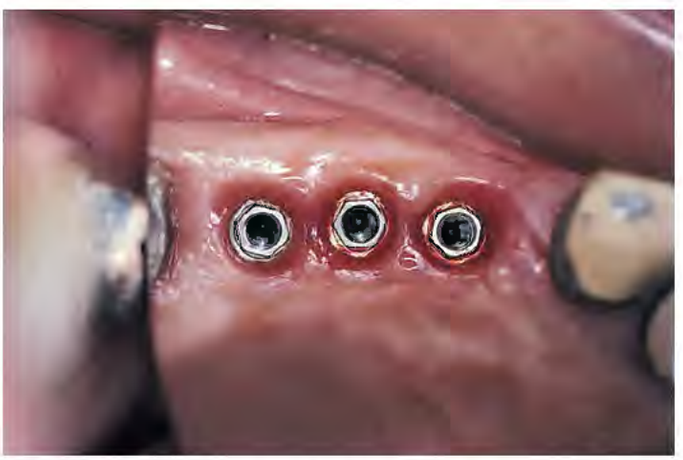


FIGURE 22-8. Abutments that require antirotation must engage the external hex on top of these implants.

Internal Hex

The internal hex (Fig. 22-9) is the most widely available antirotational design. This geometry offers several advantages. It provides a more precise implant-abutment interface and allows easier intraoral connection of the abutment. In addition, less abutment movement occurs once the implant is seated and fastened. Because of its meticulous fit, the internal hex has fewer screw-loosening problems. It also allows cover screws to be seated level with the top of the implant during first-stage surgery, in contrast to the external hex designs, which must incorporate cover screws that seat above the level of the implant. Internal hex implants, therefore, allow for simpler suturing and offer greater assurance of primary closure. In addition, because nothing protrudes above the bone, fewer opportunities arise for damage to the implant or its overlying tissues from prostheses.

Spline Attachment and Variations

Splines are fin-to-groove antirotational configurations that have a long, successful history in engineering. The Zimmer Spline implant is an extremely effective external source of antirotation. Each of the six external components, or *tines,* protrudes 1 mm from the implant, and the tines are matched to female components embedded in the abutment base. With this system, angled abutments from 15 to 25 degrees have rotational opportunities at 60-degree intervals, which allows six different angles. After final positioning, a torque wrench set at 30 Ncm is used for fixation (Fig. 22-10).

Some practitioners prefer the benefits of internal antirotational devices (see Chapter 23). Park Dental Research has designed an abutment keyed to implant complex, the Startech, which offers protruding extensions from the abutment base that fit precisely into six female components in the top of the implant. Six rotational directions are made available in the Startech when an angled abutment is needed (Fig. 22-11).

FIGURE 22-10. Zimmer's spline is a fin-to-groove design, which creates a successful extracoronal antirotational relationship.

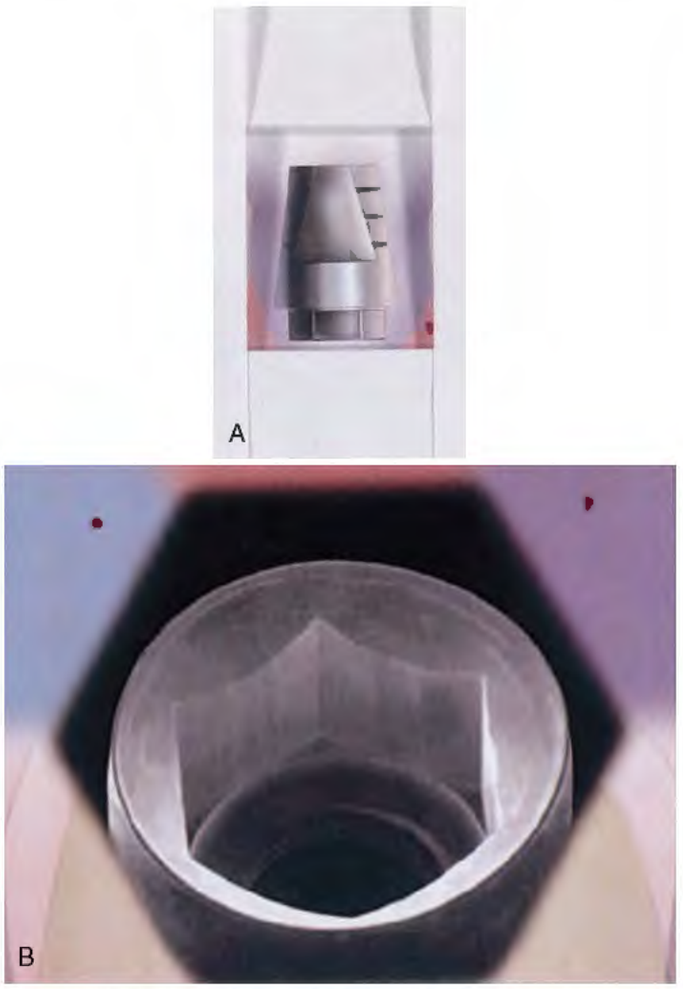


FIGURE 22-9. **A,** Abutments for internal hex implants seat *into* the hexagonal depression **(B)** of the implant. External hex abutments seat *onto* the implant.

FIGURE 22-11. Park Dental Research has designed an internal antirotational modification. The abutment has protruding extensions, which slide into female components in the top of the implant.

Morse Taper (Cold Weld) Attachment

Bicon (formerly Stryker) makes a finned implant fitted with a 5-degree, tapered-wall, one-piece abutment post (Fig. 22-12). With firm tapping, it provides almost unremovable stability in both straight and angled designs. Straumann and other manufacturers make two-piece Morse taper abutments. These also are straight or angled; they have the benefit of an infinite selection of angulations through proper positioning of the abutment within the implant (which has an 8-degree internal taper) and activation of the cold-weld feature by torquing down the fixation screw with 35 Ncm of force. More information on Morse taper abutments is presented later in the chapter.

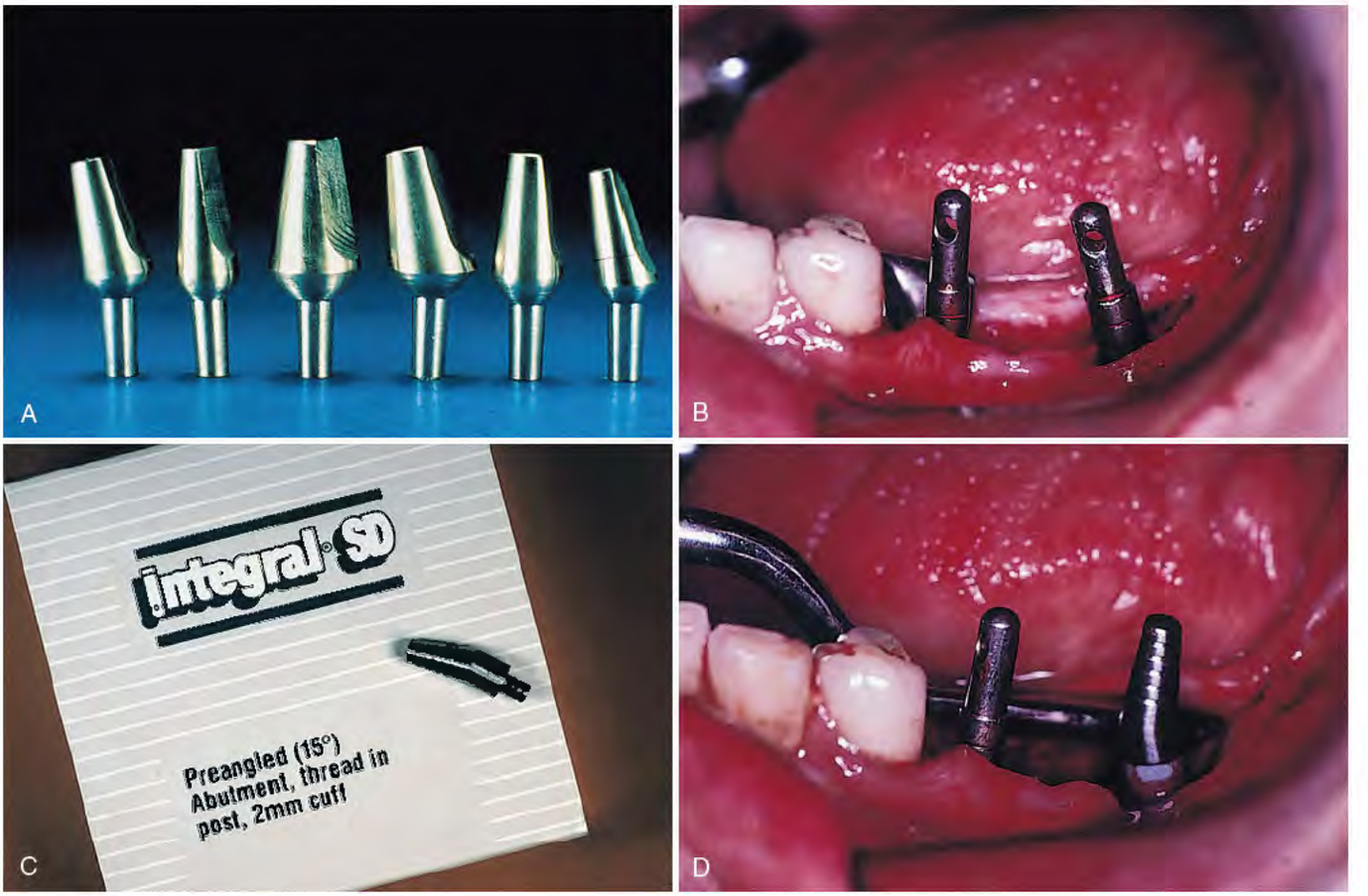


FIGURE 22-12. **A,** Some abutments, such as those supplied by Bicon, are referred to as *cold welded* or *Morse taper design*. Because the posts have a well-machined, 5-degree taper, tapping on them creates a tight relationship with the implant, which resists rotation and even removal. **B,** Submergible (two-stage) implants can be placed in a nonparallel posture, as is shown by the two trial-seating devices. **C,** Angled abutments are available in 15- and 25-degree inclinations. **D,** Alignment is ensured by correct angulation of the abutments, which must be placed in the implant before seating. **E,** Straumann's synOcta abutment. The internal Morse taper abutment produces a cold weld, which resists rotation.

Abutments That Engage the Antirotational Component

The antirotational components used for abutment stabilization commonly are available in two pieces; this requires seating of the abutment on the implant to engage the antirotational component. A retaining screw is then used to tighten the abutment to the implant (Fig. 22-13).

To ensure that the abutment is fastened securely to the implant, and after radiographic verification that the implant has been properly placed, the retaining screw is tightened with a torque wrench (Table 22-4) to secure the implant with a firmness not possible with finger force alone. Torque values typically range from 10 to 45 Ncm; the manufacturer's instructions should be consulted for guidance.

Another critical factor that requires consideration when a retaining screw is fastened is the phenomenon of thread stretch, which is caused by relaxation of the screw metal after the screw has been tightened. To ensure continuing screw tightness, the screw subsequently is retorqued with the proper force for up to four additional procedures over a 1-week period. Two-piece designs allow abutments, which engage the antirotational components of their implants, to be fabricated in either straight or angled designs from 10 to 30 degrees. Angled abutments may be placed in any one of six positions overlying the hexagon or spline, allowing 60-degree rotational variations to help achieve parallelism or to alter emergence profiles. As mentioned previously, three-piece designs are also available, which consist of an angled abutment, an interposed collar (each with its own antirotational component), and a fixation screw. The cervical element allows up to eight angulations, which adds to the versatility of the reconstruction when necessary. For example, by using abutments of 15, 20, and 25 degrees, 24 different choices become available. However, the added device increases costs, makes manipulation more difficult, and creates an additional potential site of failure (Fig. 22-14).

FIGURE 22-13. A central retaining screw is used to fix this Lifecore abutment to the implant after the abutment engages the external hex on the implant.

Table 22-4 Torque Wrenches

Name	Method	Torque* (Ncm)
BioHorizons	Hand torque wrench	20, 30
Biomet-3i	Hand-operated contra-angle	10, 20, 32
Camlog	Hand torque wrench	20, 30
Imtec	Hand torque wrench	20
Innova	Hand torque wrench	20, 30
Lifecore	Hand torque wrench	10, 20, 30
MIS	Hand torque wrench	10, 20, 30
Neoss	Hand torque wrench	15, 35
Nobel Biocare	Electric console/ handpiece	10, 20, 35, 45
Park Dental	Rachet	10-170
Straumann	Hand-operated contra-angle	10, 20
Zimmer	Hand torque wrench	20, 30

**Torque* is a force that acts through a moment arm. It can be expressed in units of Newton-centimeters (Ncm) or foot-pounds.

Custom-Cast Abutments

Custom-cast abutments (UCLA design) are made when precise angulations are required for proper prosthetic positioning. UCLA abutments are fabricated on models obtained from implant transfer impressions. Plastic patterns or manufactured gold collars engage the implant's hexagonal antirotational component and are augmented with wax or acrylic. The resulting casting creates an abutment of flawless size and angulation. The plastic patterns that engage the hex and that require casting offer a less precise implant to abutment interface than the cast-to-gold cylinders currently available (Fig. 22-15).

Abutments That Bypass the Antirotational Component

The surgeon can bypass the antirotational component of the implant by selecting one-piece abutments similar to those used on flat-surfaced implants. These abutments do not engage the antirotational hexagons of the implants, because the housings in their bases are hollow; therefore, they can be used only for multiple-splinted superstructures (overdentures; hybrid fixed-detachable prostheses; and multiple-tooth, porcelain fused to metal crowns) (Figs. 22-16, 22-17, and 22-18).

FIGURE 22-14. A multiunit abutment system by Nobel Biocare with its three components. The collar, which has a hexagonal base, is seated into the implant. The external hex protruding from the collar is octagonal and offers three angled abutments (17, 30, and 40 degrees) and eight potential positions. The entire system thus offers 24 possible combinations of angle and direction.

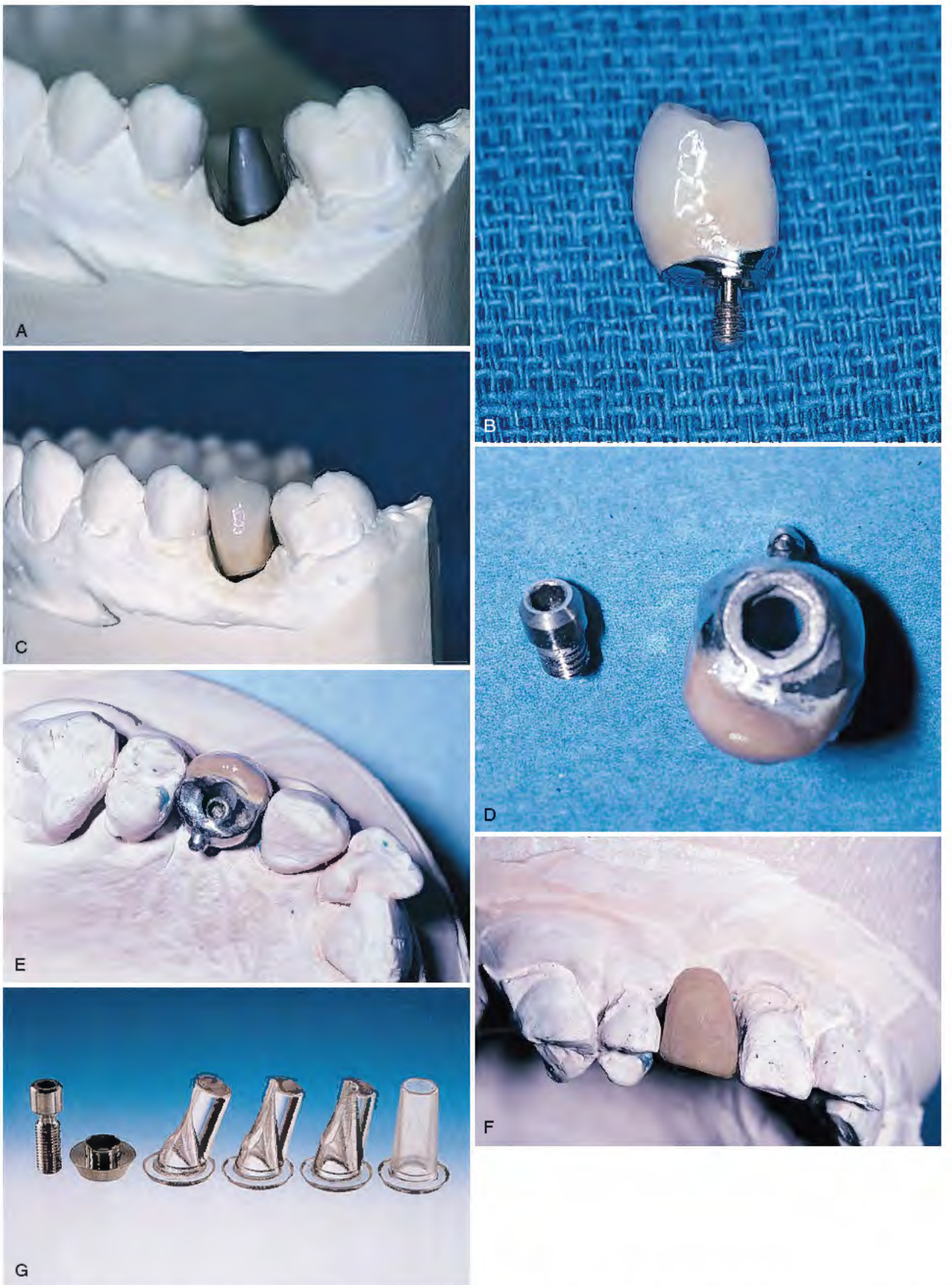


FIGURE 22-15. **A,** A custom-cast abutment can be made using a UCLA cast gold base. **B** and **C,** The UCLA abutment allows fabrication of a custom-cast abutment to ideal crown width and emergence profile. **D,** Single-tooth, implant-borne superstructures may be screw retained. An antirotational component, such as the hexagonal configuration, is required to ensure stability. **E,** The abutment is fitted over the implant's external hexagonal geometry. The screw hole should be easily accessible. **F,** When the screw is tightened, the abutment crown fits firmly in position without needing wings or rests on adjacent teeth. **G,** The Neoss multiposition abutment is available with a high noble metal base, to which any one of the included plastic heads may be press-fitted at virtually any direction. Angles are 0 to 20 degrees, and after the desired position and angulation are determined, the abutment may be cast in gold to the base. These abutments are screw retained.

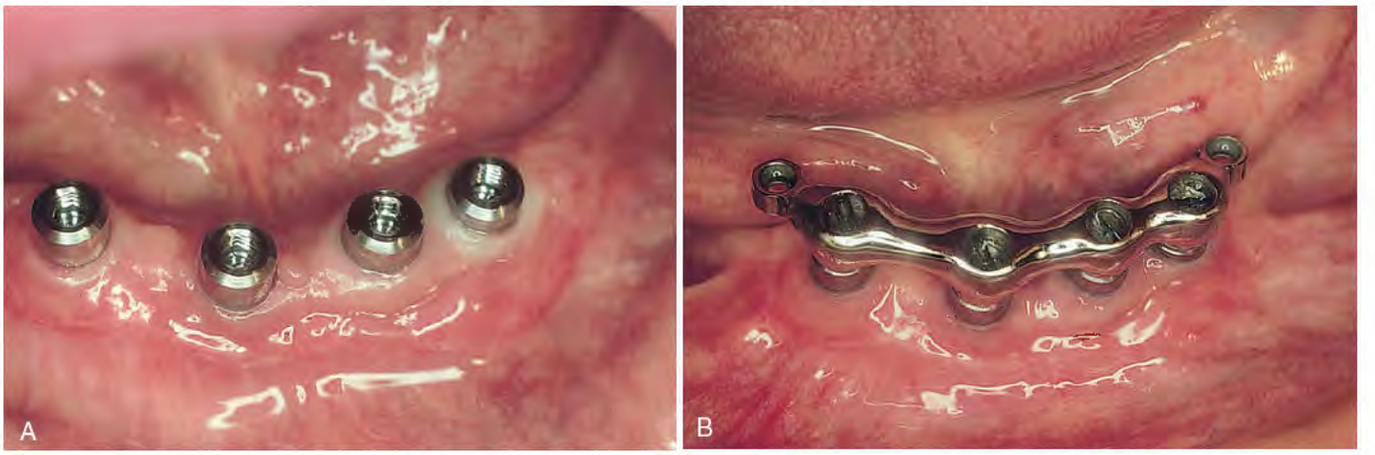


FIGURE 22-16. After placement of the TEAs, coping bar splints (see Chapter 26) are placed as a fixed-detachable system using distally cantilevered ERA attachments.

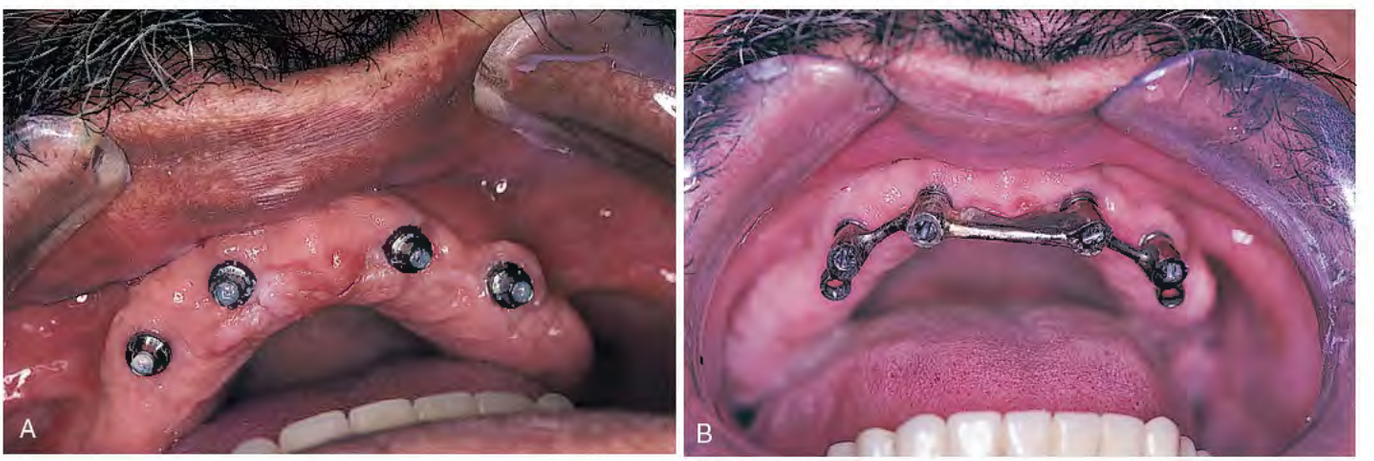


FIGURE 22-17. Maxillary root form implants can serve as retaining devices for fixed-detachable coping bars.

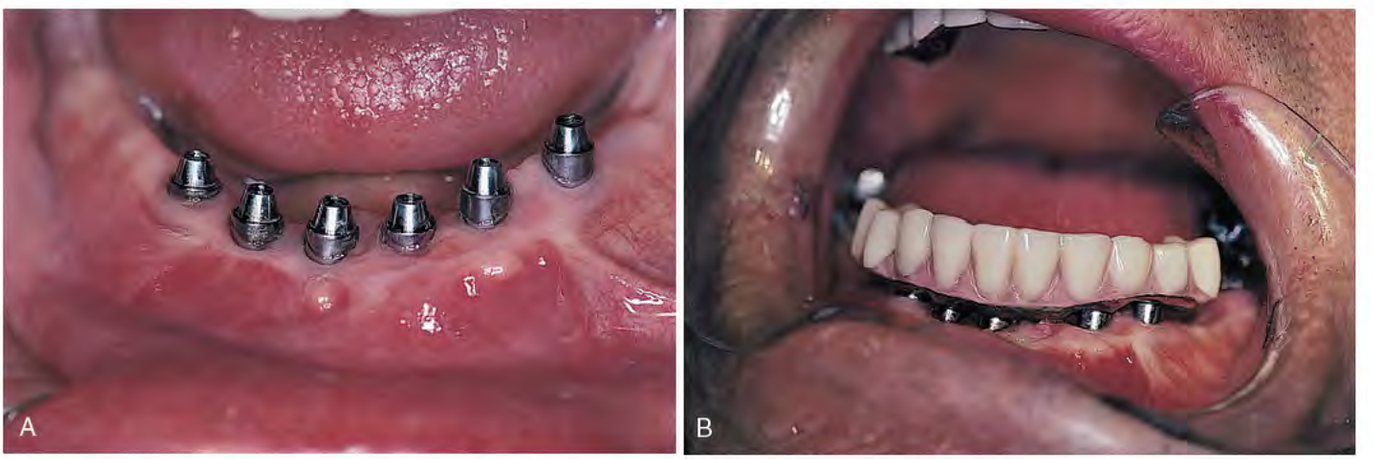


FIGURE 22-18. **A,** Lifecore's Sustain system was used for this mandibular rehabilitation. **B,** These six implants allowed the construction of a fixed-detachable, hybrid, high-water, full-arch splint with two bilateral cantilevered pontics (see Chapter 25).

Abutments for Implants with the Morse Taper Interface

To engage their abutments, implants with Morse taper interfaces use a 5-degree angulated, friction-fit internal wall, into which an abutment with a rounded male extension is placed (see Fig. 22-12, *E*). In some implant designs, fixation is further achieved by tightening a central screw. Manufacturers of these designs maintain that the abutments achieve antirotational properties as a result of the cold-weld phenomenon, which occurs after the abutment is placed and torqued. Straumann manufactures an 8-degree Morse taper abutment for its Bone Level implant, which allows standard crown and bridge fabrication procedures.

An alternative design that uses the Morse taper is the screwless, press-fit abutment (Bicon Implant System). These abutments are the one-piece type and are tapped directly into position, creating a cold-weld interface (see Fig. 22-12, *A*). Extreme care must be taken in positioning angled abutments, before they are tapped into place, because abutment removal for angulation or other adjustments is difficult.

ABUTMENT DESIGNS

Abutments That Require Crown or Coping Cementation

Cemented prostheses can be selected in all traditional porcelain fused to metal applications, ranging from single-tooth replacement to full-arch restoration (see Chapter 23). Cemented mesostructure bars also are used as alternatives to screw-retained overdenture bars (see Chapter 26). However, the screw-retained bar is used more frequently because of its low profile, which is required by the additional height of the overdenture. Cementation is not used for fixation of hybrid acrylic-metal prostheses (see Chapter 25), because they need to be removed for hygiene purposes.

Abutments for cementable prostheses offer classic fixed bridge tapers and gingival or subgingival finishing lines. After they are screwed to their supporting implants, the cemented superstructures are prosthetically managed in the classic fixed prosthodontic mode. When natural teeth and implants are to be used as abutments for cemented prostheses, cast gold copings are made, and one is cemented to each natural tooth to protect it. These copings are made parallel to the implant abutments to create insertion paths for long-span fixed prostheses. When completed, these prostheses function conveniently with temporary cement, which allows them to be removed without the complex, costly, and time-consuming problems caused by screw fixation. However, some question exists about the natural tooth root intrusion phenomenon, which has been reported when temporary cement is used. If the surgeon suspects this may occur, the bridges should be permanently cemented.

Abutments for Cement Retention

Straight Abutment

Straight abutments are indicated for replacement of single teeth and for larger prostheses, up to full arch, implant-borne reconstructions. However, they can be used only when their emergence profiles are or can be made parallel. Abutments that engage a requisite antirotational component of the implant are chosen for single-tooth habilitation. When multiple splinted or joined components are planned, less costly implants without antirotational components can be used.

If not quite parallel to one another, straight abutments can be prepared to proper contours by one of two methods. The first method involves direct preparation in the mouth after the abutment has been firmly seated with a torque wrench. Copious irrigation and a diamond bur are used to ensure that minimal heat is transmitted from the abutment to the implant and its host-site bone.

The second, and preferable, method is to make an implant transfer impression. A transfer coping is placed on each implant, and either an open or closed tray impression is made (see Chapter 23). Implant analogs are placed in the copings, a stone cast is poured, and the final abutments are selected and placed on the implant analogs (Fig. 22-19). The resulting articulated model allows direct bench preparation of the abutments with regard to size, shape, inclination, and parallelism. Another benefit of this technique is that it saves valuable chair time.

Straight Abutment Variations

Traditional straight abutments can be obtained with one or two components. Those with two parts engage the antirotational component in implants (internal or external hex or spline). One-piece implants that bypass the antirotational component should be used only in multiple implant reconstructions. One-piece designs also are used for Morse taper connections.

Other types of straight abutments include emergence profile designs, which have broad bases of varying heights and widths, depending on the gingival depth and the diameters of adjacent teeth (Fig. 22-20). They are intended to achieve an improved emergence profile, which gives a higher level of esthetics to the completed prosthesis or crown. This option is especially useful in single-tooth replacements of maxillary centrals and for molars being restored on single implants.

Nobel Biocare's Curvy abutments are designed to simulate the shape of teeth. These bioesthetic abutments are selected at the time of implant placement. However, this can be done only if the surgeon has acquired a costly array of abutments. The chosen abutments are retained and upon second-stage surgery are placed immediately to contribute to gingival contour.

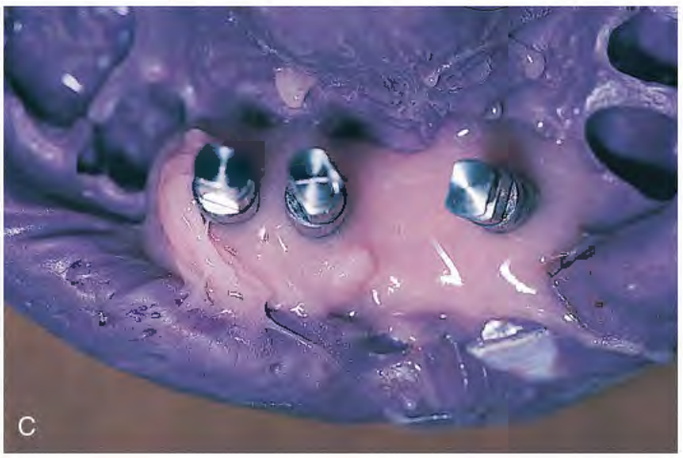
Angled Abutments

Abutments are available from implant manufacturers in angulations ranging from 10 to 30 degrees. One-piece designs (those without screws) are available only for those with the Morse taper, which are tapped into position (Bicon) (see Fig. 22-12, *A*), or for implants without an antirotational component (see Fig. 22-12, *B* to *D*).

Most manufactured abutments are available in the two-piece design (Figs. 22-21 and 22-22). This configuration allows the abutments to be seated on their implants and then tightened with the center screw. These abutments must engage the antirotational component of the implant before torquing (see Chapter 23).

Three-part abutments have separate bases, which, on their deep surfaces, engage the antirotational component that supplies an external hex. This allows six possible angulations in which the abutment component can be placed on the superficial surfaces; an additional antirotational component supplies an external hex, which allows six additional possible angulations in which the abutment component can be placed. Despite the many additional positions available with this design, it often is difficult to manipulate intraorally, and its multiple small parts pose a risk of component loosening.

Manufactured angled abutments can be further modified chair side or in the laboratory as described for straight abutments (Fig. 22-23).



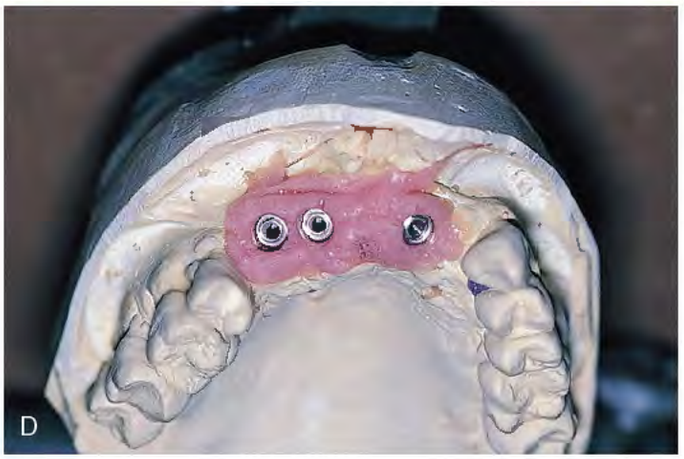


FIGURE 22-19. **A,** This Biomet-3i device is designed to transfer the hex of the OsseoTite implant to the working cast. **B,** The hex transfer copings in an Impregum impression are picked up, and a hex-bearing implant analog is placed over each. **C,** TruSoft polymeric material is placed at the base of the analog complex to a depth simulating the natural gingiva; this exteriorizes the analogs and allows easy placement and removal of prosthetic components. **D,** The poured "soft tissue" model has a compliant and readily manageable zone of TruSoft surrounding the implant analogs. Through each phase, the prosthesis can be completed using an articulated cast prepared like this one.

FIGURE 22-20. Camlog's natural profile Esthomic abutment is available in various widths to accommodate different tooth sizes.

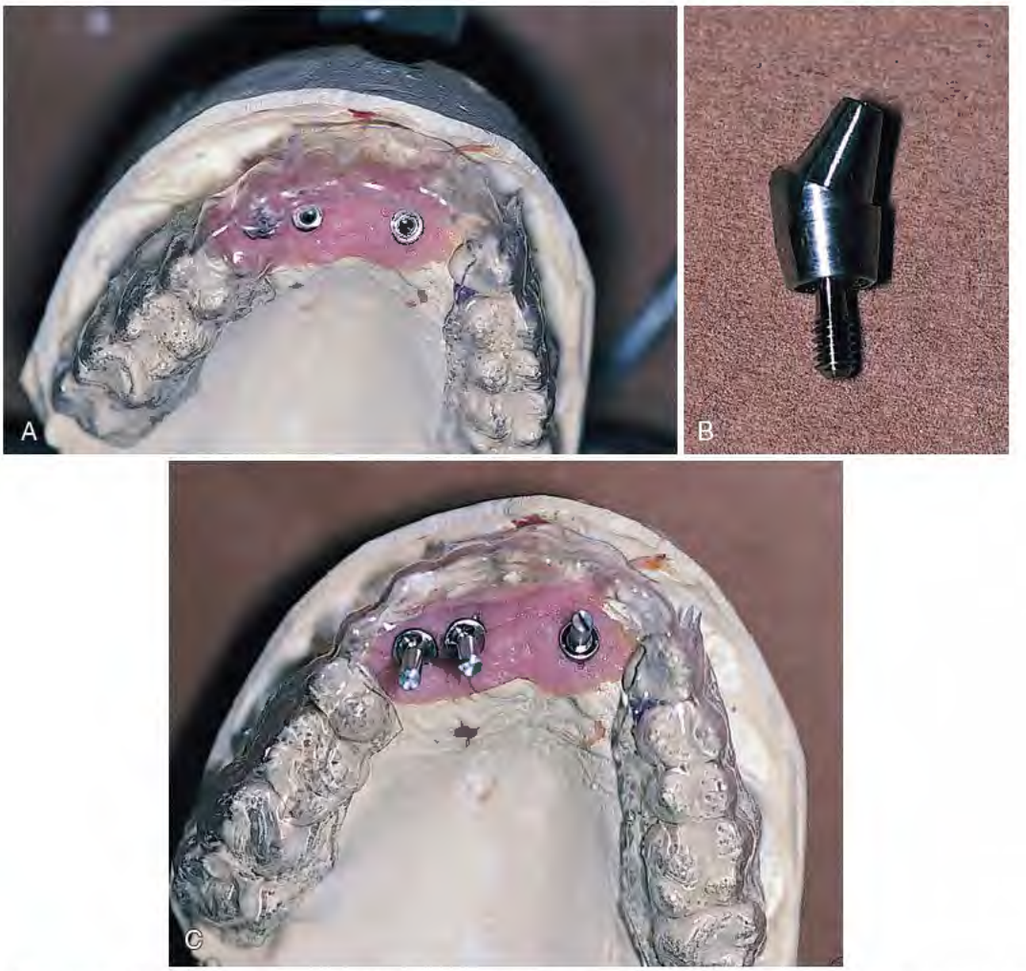


FIGURE 22-21. **A,** Three Nobel Biocare implants, of which the right lateral and canine implants show that their angulations will project straight abutments through the labial surfaces of those teeth in the template. This would create an unacceptable situation, because the fixation screws would appear labially in the final restorations. **B,** Nobel Biocare offers 17-, 30-, and 40-degree angled abutments to solve the problem of poor emergence angles. **C,** The problem of superlabial pronation is solved with 30-degree angled abutments.

FIGURE 22-22. Camlog makes both 15- and 20-degree angled abutments. Each is supplied with an offset screw that secures the abutment at the proper angle in any one of eight positions. The abutment is manufactured with an internal trispade cam tube design.

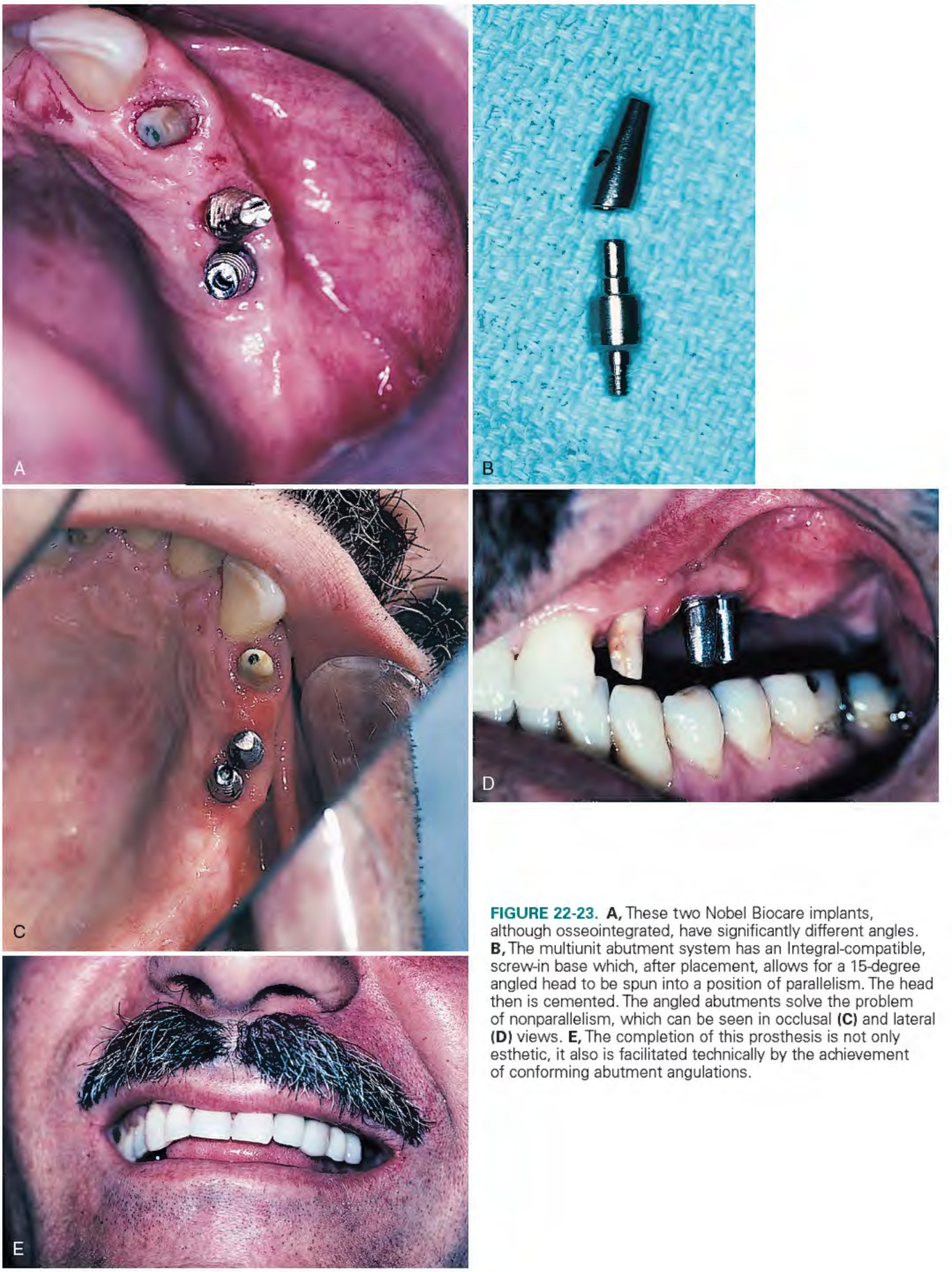


FIGURE 22-23. **A,** These two Nobel Biocare implants, although osseointegrated, have significantly different angles. **B,** The multiunit abutment system has an Integral-compatible, screw-in base which, after placement, allows for a 15-degree angled head to be spun into a position of parallelism. The head then is cemented. The angled abutments solve the problem of nonparallelism, which can be seen in occlusal **(C)** and lateral **(D)** views. **E,** The completion of this prosthesis is not only esthetic, it also is facilitated technically by the achievement of conforming abutment angulations.

Angled Abutment Variations

Angled abutments can be obtained with a variety of base widths and heights, which contribute to esthetics by improving emergence profiles and allowing placement of abutment margins subgingivally (Fig. 22-24).

In addition, custom-cast abutments can be made by the laboratory technician using plastic patterns to which wax or acrylic can be added (Fig. 22-25). The advantage of these abutments is that they can be tailor-made precisely to the situation at hand to provide directions and dimensions not available from standard designs. As previously discussed, the implant-abutment interface can be fabricated either from plastic burnout patterns or from cast to machined gold components. The latter choice offers a more precise implant-abutment interface.

The disadvantages of custom-cast designs include their expense and the possibility that the individually made components will have casting inaccuracies (Fig. 22-26). Particular concerns with custom casting are the antirotational component (in two-piece

FIGURE 22-25. Abutments can be custom cast for any implant system, whether threaded or not, and can be angulated precisely to satisfy the requirements of any case.

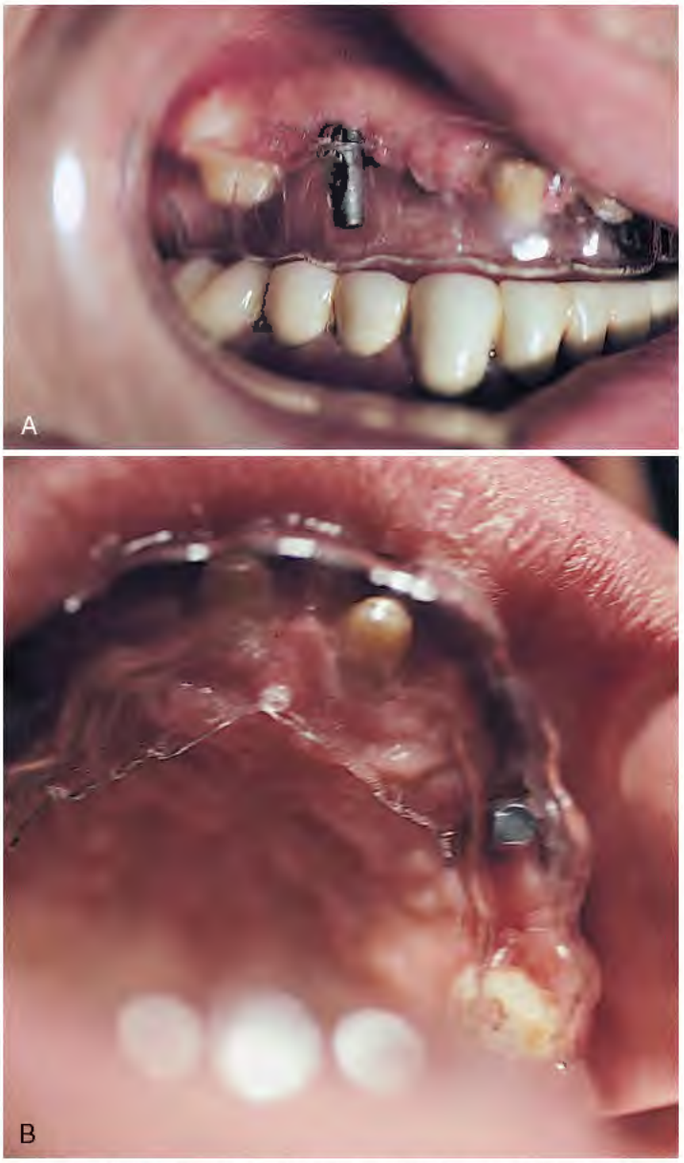


FIGURE 22-24. **A, B,** A satisfactory technique for achieving the correct angulation of an abutment is to use the clear prosthetic template as a guide. This should be evaluated both laterally and occlusally to check for accuracy in all directions.

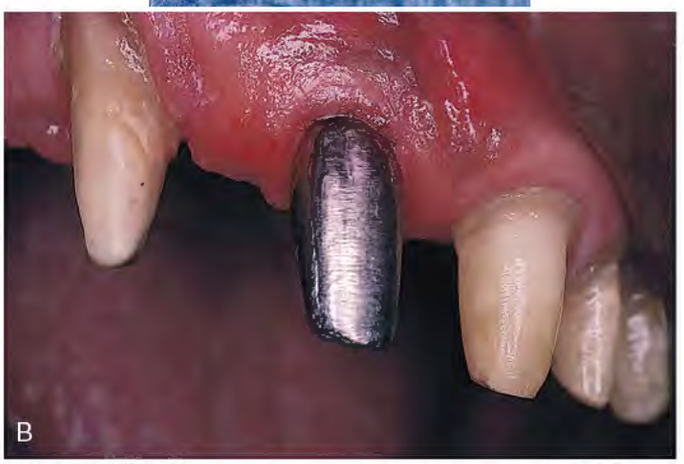


FIGURE 22-26. **A,** A custom-cast permucosal abutment. It was designed to be cemented into the implant body, has a highly polished cervix, and a matte-finished abutment, all in a single unit. **B,** After cementation, the custom abutment is seen to be parallel to adjacent teeth and is prepared to receive a conventional ceramometal crown, which is made in the classic manner.

abutments) or the screw (in one-piece abutments), which consistently require exquisite fitting and adjustment modifications.

Biomet-3i offers 15- and 25-degree angled abutments with straight or parallel cuff lengths from 1 to 5 mm. This design eliminates the need for a separate collar component, thereby contributing to simplicity (Fig. 22-27).

Nobel Biocare offers an array of esthetic abutments for crown cementation only. The Procera system provides a ceramic core to which porcelain is baked. The core engages the underlying titanium abutment, and upon completion can be cemented (Fig. 22-28). The Procera system allows the practitioner to use an all-ceramic abutment. This abutment provides a high level of esthetics but may sacrifice long-term strength compared with metal base abutments (Fig. 22-29).

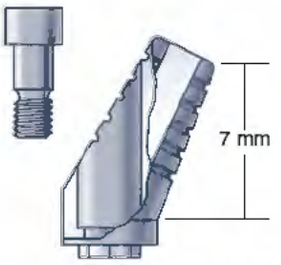


FIGURE 22-27. This angled abutment and collar is available as a single unit in angles of 15 and 25 degrees. The cuff height varies from 1 to 7 mm. This design simplifies angled abutment seating.

Abutments That Require Screws for Crown or Coping Retention

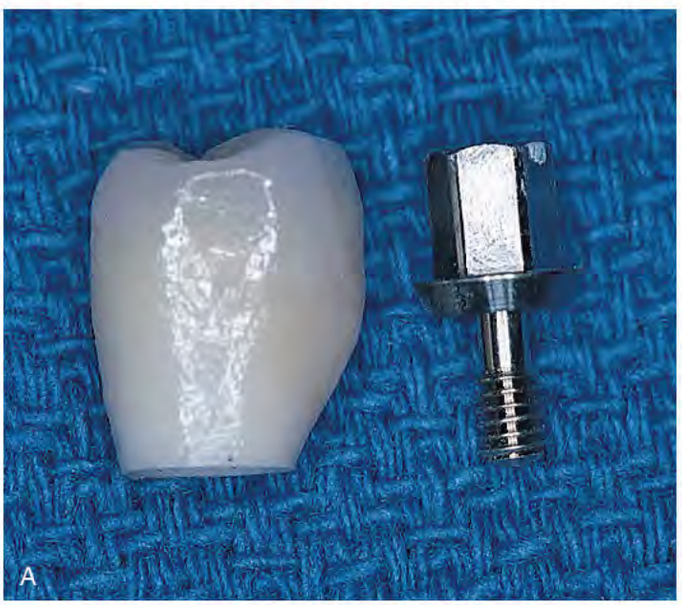
Screw-retained prostheses can be used to affix any type of implant, from traditional porcelain fused to metal replacements (single tooth or full arch), to mesostructure bars for overdentures and fixed-detachable hybrid designs. Although costly and more complex, this method of fixation is very versatile, particularly when the available height is limited.

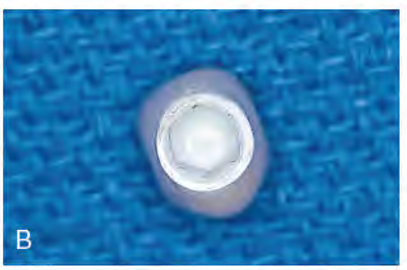
ABUTMENT TYPES

Flat-Topped Abutments

Flat-topped abutments are similar to the original Brånemark-style abutments used to support bars for overdentures or fixed-detachable hybrid prostheses. They do not engage the antirotational components of the implants. They therefore also can be used with implants that do not have antirotational components. However, because they do not engage antirotational components, these abutments must be used in multiple implant reconstructions. They are available in a variety of lengths, and selection is based on the height of the gingival tissue (see Fig. 22-27).

The benefit of this design is its simplicity. The disadvantage is that it does not have a means to resist counterrotational forces and therefore is unsuitable for single-tooth replacement. Because of its straight emergence profile, it often provides an unesthetic result in porcelain fused to metal applications, particularly in the anterior maxilla.





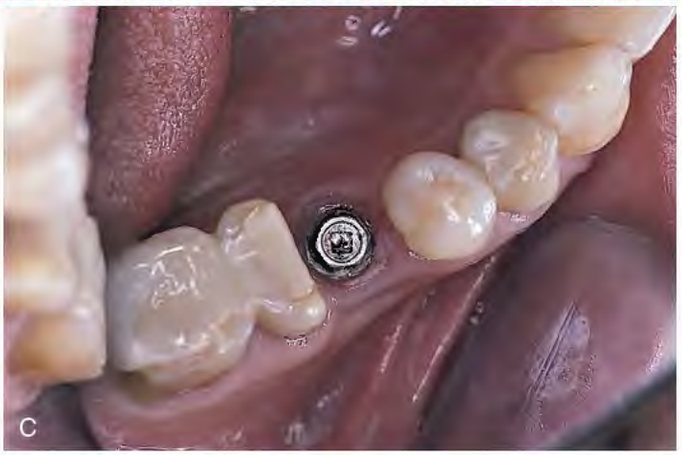


FIGURE 22-28. **A,** The Procera crown cements onto the Esthetic abutment (Nobel Biocare). **B,** Porcelain is baked to the CAM ceramic core. **C,** The Esthetic abutment is torqued down to 35 Ncm with a torque controller.

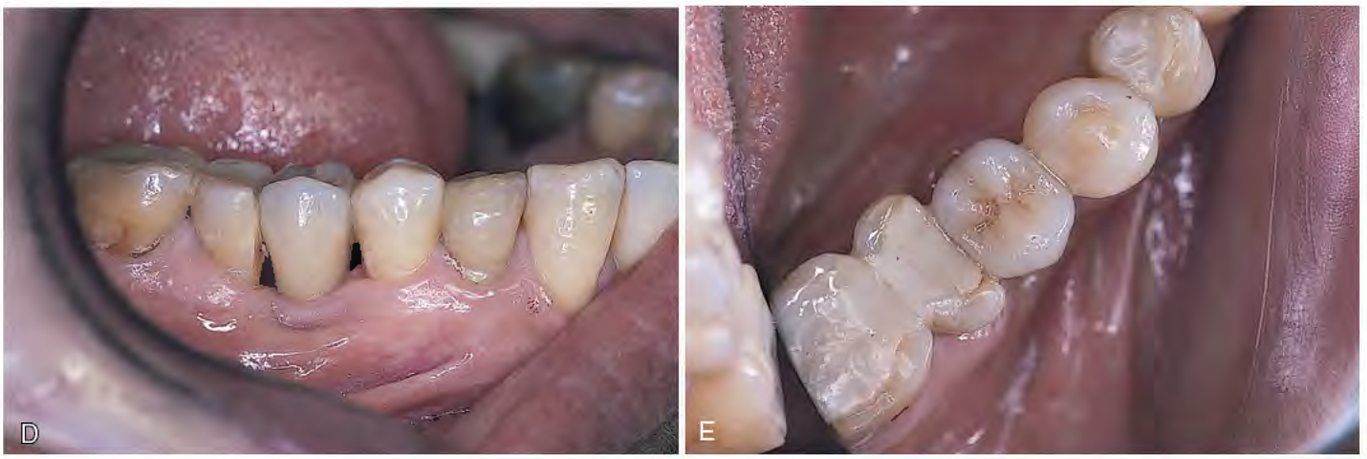


FIGURE 22-28, cont'd. D, A natural emergence profile is easily developed. **E,** Cementable crowns do not have occlusal screw access holes.

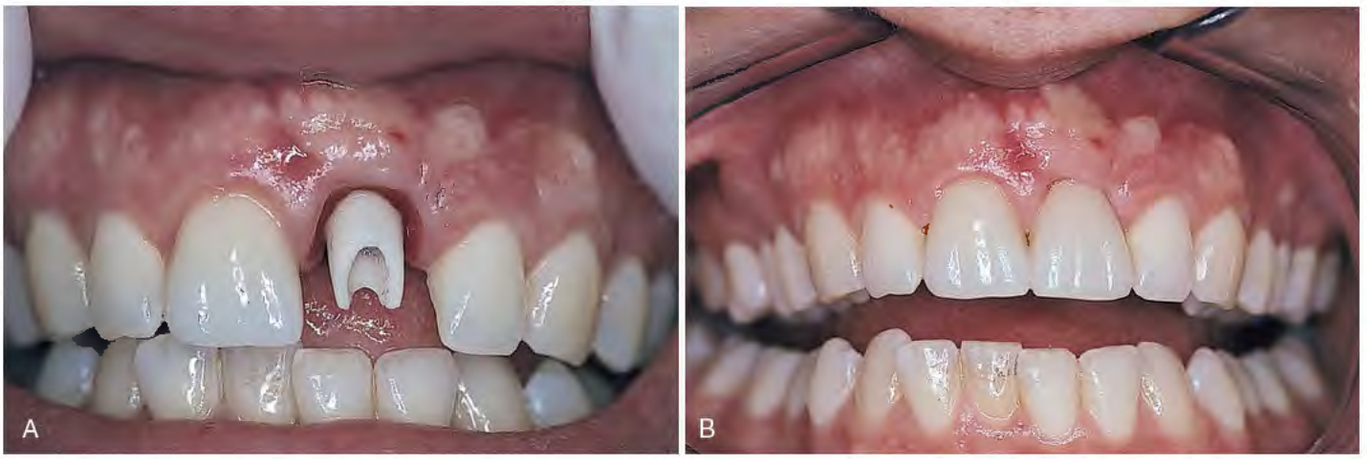


FIGURE 22-29. A, The Procera All Ceramic abutment is prepared with a diamond bur. **B,** The NobelRondo All Ceramic crown is cemented over the Procera abutment for ideal esthetics.

Tapered-Shoulder Abutments

Tapered-shoulder abutments are used in a variety of clinical situations, from bars to overdentures and hybrid overdentures to single-tooth replacements.

Because of their tapered-top designs, these abutments' resistance to lateral forces is enhanced, and a lower profile abutment collar is possible. The lower profile collar allows the clinician to place the margins of the abutment subgingivally, which can encourage the most esthetic restorative results. These abutments typically bypass the implant antirotational component and thus must be used in multiple-tooth cases. Compared with flat-topped abutments, less room is allowed for the divergence of implants. Typically, a tapered shoulder is angled at 9 to 15 degrees, allowing a divergence between implants of 18 to 30 degrees (Fig. 22-30).

Tapered-Shoulder Variations

Variations of the tapered-shoulder design include those that have an array of shoulder widths and heights to allow more esthetic restorations by subgingival placement and more natural appearing, graduated emergence profiles. Angled, tapered-shoulder abutments also are available, which allow correction of wide divergences of implant angulations and, more significantly, offer opportunities otherwise unavailable to allow retaining screws to exit through occlusal surfaces.

FIGURE 22-30. This implant's conical abutment engages an external hex and offers considerable flexibility in superstructure design and emergence profile.

Another alternative to this design is the addition of an antirotational component to the tapered top of the abutment. This feature allows application of single-tooth reconstruction. These designs must engage the antirotational component of the implant and therefore must have two parts. An exception to

this is Straumann's one-piece synOcta, which prohibits rotation by its cold-weld Morse taper (Fig. 22-31). Gold copings that key to the antirotational components are available for most systems and can be shaped by waxing to them and casting the combination. Impact Dental makes two gold-platinum abutments that can be used for a wide variety of implants with both external and internal hex designs. They are available in tapered and bulb-shaped configurations for screw retention or cementation. These POG abutments allow direct porcelain firing, which can be extended subgingivally.

Direct Gold Copings

Copings allow the implantologist to bypass the abutment entirely. They consist of two parts: the coping and the screw. Porcelain is baked directly to the coping, producing a crown, which attaches directly to the implant body. The coping is designed to engage the antirotational component of the implant. Direct gold-titanium-ceramic copings are fabricated from UCLA-type plastic burnout patterns or computer-aided design/computer-aided manufacturing (CAD/CAM) milling of the coping out of titanium or zirconia, which may or may not be used with a cast to gold cylinder. This type of abutment is used for single-tooth restorations that do not require any alterations or adjustments of angulation, which allows the screw to exit through the occlusal surfaces of posterior teeth and at the cingula of anterior teeth (Fig. 22-32). Because of the angulation at which most anterior implants are placed, this design has limited use in such applications.

This abutment is particularly useful in cases involving limited interocclusal space or minimal soft tissue thickness or that require placement of subgingival margins. The abutment also is useful in the fabrication of bars for overdentures or fixed-detachable prostheses. When interocclusal clearance is minimal, and neither flat nor tapered-shoulder abutments can be used, the solution is to create a bar that is cast directly to the implant heads by the use of plastic burnout patterns or cast to gold cylinders (see Chapter 25).

FIGURE 22-31. **A,** Straumann's synOcta abutment is a one-piece abutment that screws into its matching soft tissue level one-stage implant. **B,** The soft tissue cast allows easy access to the synOcta abutment analog. **C,** Ideal tooth contours can be made emanating from the synOcta abutment. **D,** The occlusal screw access holes must be closed with composite resin.

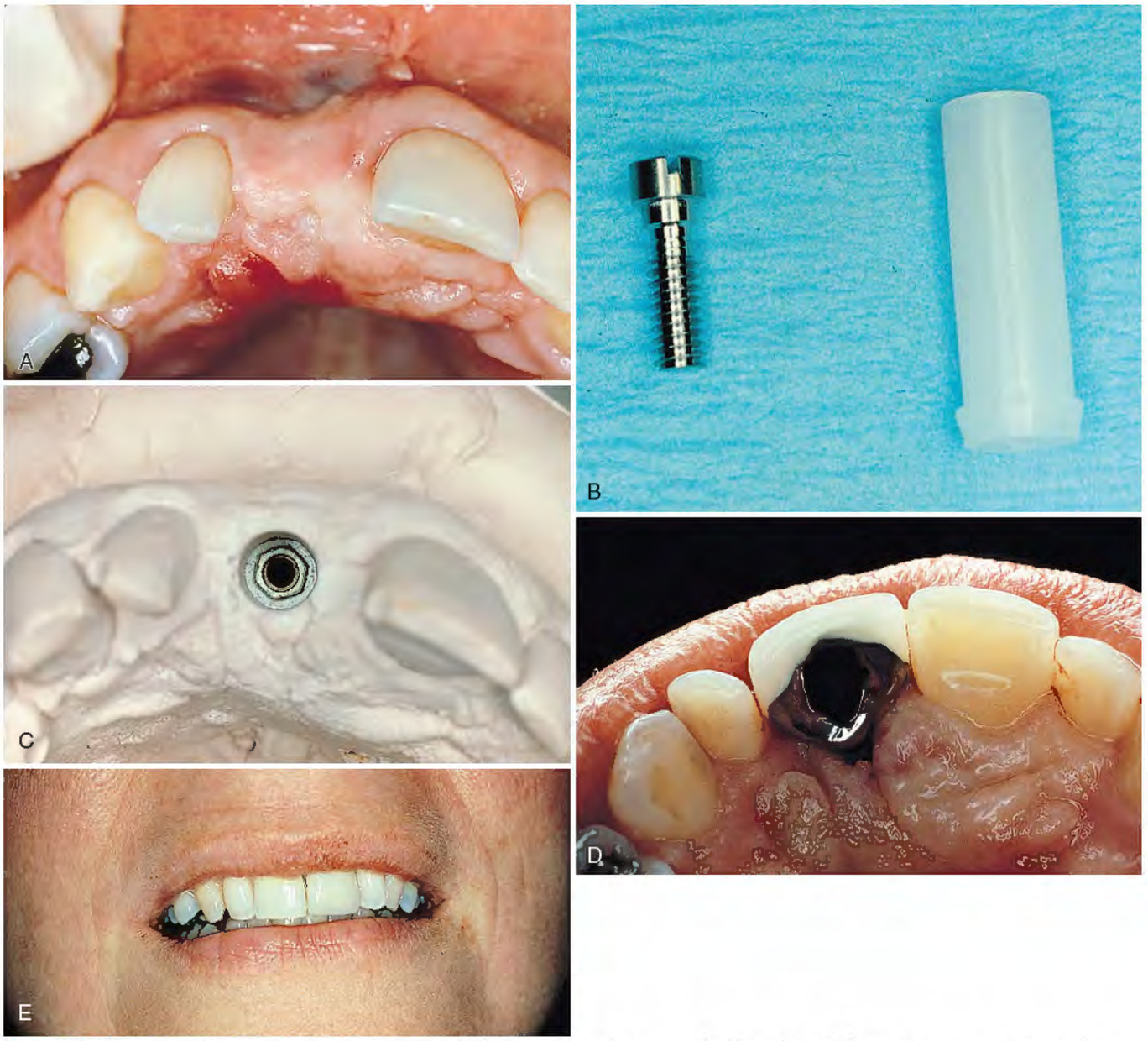


FIGURE 22-32. **A,** Areas in the anterior maxilla are a particular concern for cosmesis. Use of the Brånemark system often results in exposed cervical collars. **B,** To solve the problem of esthetics and rotation, Implant Innovations (Biomet-3i) made the UCLA abutment available. It consists of two parts: the plastic waxing sleeve and the centrally located fixation screw. **C,** This working cast shows a Nobel Biocare analog with external hexagonal configuration. **D,** This completed restoration fits over the hex, preventing it from turning. It is locked into position through the hole in the crown with a fixation screw. **E,** An esthetic result, as seen here, can be expected.

Abutments for Overdentures

Abutments for overdentures are used only for soft tissue–borne, non-bar-supported overdentures maintained directly by a minimal number of implants (two to four) in the mandible and four to six implants in the maxilla. These may apply to bar overdentures as well if the attachments are soldered to or cast as part of the bars (i.e., Locators, ERA, or O-ring components incorporated into mesostructure bars). Dentatus' Spheroflex ball abutments key into metal-based female components processed into overdentures. These abutments are available for use with natural teeth in the form of endodontic posts.

Overdenture abutments typically are available from implant manufacturers and most often consist of a male component, which is screwed directly into the implant head, and a female component, which is processed into the denture. Additional abutments include the Lifecore O-ring, Della Bona, and three-sized snap abutment products. BioHorizons' one-stage overdenture implant also offers a ball screw for overdenture retention.

Exceptions to the conventional design are the Locators, Zest/ZAAG, and ERA systems, in which the male component is in the denture, and the abutment serves as the female component. The male components pivot up to 10 degrees and can be changed in less than 1 minute. These abutments are available in one- or two-piece configurations, are angled at 15 and 25 degrees when necessary, and come in various lengths (3, 4, and 5 mm), allowing supragingival abutment placement. A simple armamentarium is needed to attach the devices (see Table 5-2 for a list of attachments commonly used for these applications and Chapter 26 for insertion instructions). When considering the use of these anterior-based systems, the surgeon must makes sure the attachments will allow rotation of the denture posteriorly to avoid overloading of the implants (Fig. 22-33).

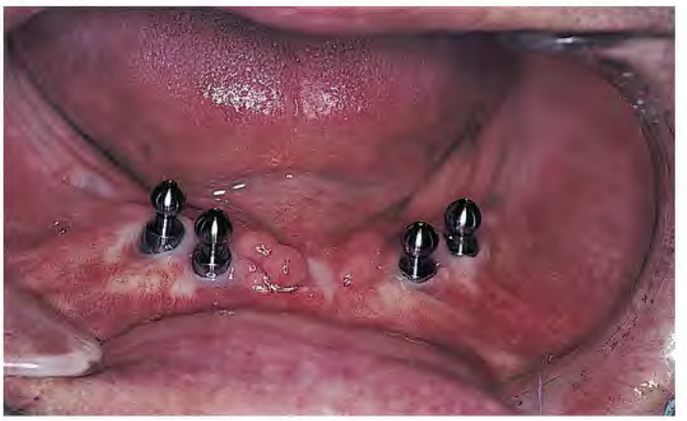


FIGURE 22-33. Abutments need not be splinted in an osseointegrated reconstruction, as can be seen with these four trailer-hitch designs used for O-ring fixation of an overdenture.

Immediate Impression Implants

Zimmer Dental (One-Piece, 3-, 3.7-, and 4.7-mm diameters and 0- and 17-degree integral abutment), BioHorizons (One-Piece, 3-mm, 0-degree abutment) and others have introduced implants with attached abutments that are designed for immediate postinsertion impression making. These extension pins are shaped to be seated into an elastomeric impression material onto which implant analogs are fitted. The resulting model allows very early provisional restorations (ideally to be made in the laboratory), which are inserted on the day of abutment placement. These abutments help produce well-controlled and predictable soft tissue healing (Fig. 22-34).

One-Stage, Two-Piece Implants

Using the concepts of the tissue plasma spray (TPS) screw (Straumann, Park Dental) and the Brånemark implant, a number of manufacturers are making a two-piece implant for immediate exposure after insertion. Biomet-3i has a threaded implant of the hybrid variety (different apical to cervical textures) to which a cap screw is attached just before suturing (Fig. 22-35). The cap screw or an esthetic abutment (to influence gingival contouring) is left in position for the entire period of osseointegration. One-piece implants have a number of benefits (also see Chapter 11):

- Second-stage surgery is eliminated.
- The seam between the abutment and the implant is supragingival.
- Osseointegration accompanies healing, and the prognosis is the same as with two-stage implants.

FIGURE 22-34. This Zimmer One-Piece Implant allows the impression pin to be picked up by an elastomer at the first-stage implant insertion visit; this facilitates early placement of interim prostheses (see Chapter 23).

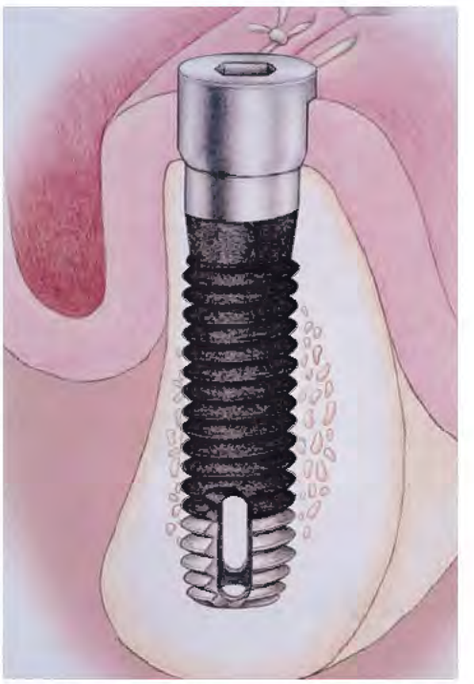


FIGURE 22-35. For Biomet-3i's nonsubmergible, two-piece, one-stage implant, the dental surgeon affixes the cap screw or an esthetic abutment to the implant body with a screw before suturing. Many manufacturers make similar designs.

Root Form Implant Prosthodontics: Single-Tooth Implant Restorations

23 CHAPTER

Patients should always be informed of all treatment options for replacing missing single teeth. The following are indications that should be considered when an implant-supported crown is used to replace a single missing tooth.

The teeth adjacent to the edentulous span may be minimally restored or unrestored. Recent restorations placed in or on them may be satisfactory, and using these teeth as abutments for a fixed prosthesis then would be unnecessarily invasive. On the other hand, the adjacent teeth may be compromised and have a poor prognosis but might not require immediate removal. If bone loss or active disease is noted nearby, however, the surgeon must be convinced that the planned host site will not be compromised.

PROVISIONAL RESTORATIONS

A single-tooth edentulous area requires a provisional restoration to maintain esthetics and function and to prevent movement of adjacent or opposing teeth during osseointegration (see Chapter 21). The provisional restoration can be a removable partial denture (flipper) or a fixed prosthesis. The latter requires a pontic supported by adjacent teeth; this should be done only when the teeth require significant restoration. In such cases, a pontic may be cantilevered from one adjacent tooth with a full-coverage acrylic/composite restoration or supported bilaterally. However, when such peripheral care is required, the need for an implant should be reconsidered. The patient should be discouraged from choosing removable appliances, because their tissue-borne saddles may cause ischemia or in some other manner injure the implant host site.

Composite-Retained Provisional Restorations

As an alternative to removable appliances, teeth adjacent to an edentulous anterior area can be used to support a composite-retained bridge (Maryland-type bridge).

Surgical Templates

Surgical templates are required for the placement of all implants, including the single-tooth designs. The simplest and most effective type of template for limited surgical sites is the Omnivac style (see Chapter 20).

IMPRESSIONS AT FIRST-STAGE SURGERY: IMPLANT PLACEMENT

When conventional, two-stage implants are placed, the surgeon may elect to make an impression of the implant after it has been seated. This allows fabrication of a master cast with an implant analog in position. Provisional or even final restorations can be fabricated on this master cast and will be available for insertion when the implant is exposed (second-stage surgery). This allows the soft tissues to heal in an ideal contour as influenced by the restoration. In addition, treatment time is shortened. Biomet-3i provides a design that facilitates this procedure.

After insertion of the implant, an impression coping is seated. This coping is accommodated by the implant's hexagonal (or other) antirotational characteristic (Fig. 23-1, *A*). If the implant comes with a carrier attached to it, the carrier can act as an impression coping to register the timing of the hexagonal or other antirotational characteristic.

The coping, which is tapered or has the square-locking design, has a center screw, which is turned clockwise until it engages the implant. Before full tightening, the coping is turned until it drops into a nonrotational mode by nestling over the hex. The center screw then is tightened completely (Fig. 23-1, *B*). Using a paralleling technique, a radiograph is taken to verify complete seating of the impression coping.

A polyether or similar semirigid impression material should be used in a standard stock tray. If a square-locking impression coping is chosen, an open style impression tray is required. Tapered copings, on the other hand, can be accommodated by conventional trays.

Open trays require a window directly over the copings. This is achieved by modifying a stock tray. When the tray is seated, the center retaining screw of the coping must protrude through the opening. A square of pink base-plate wax is heated and placed over the opening. It is sealed with sticky wax, closing the tray over the coping (Fig. 23-1, *C*).

The tray is seated in the patient's mouth while the wax is still warm. This allows the center retaining screw to leave an indentation in it. After the proper adhesive is used, an elastomeric impression is made using a syringe, followed by seating of the tray.

When the impression material has set, the pink base-plate wax is peeled back. The center screw, which is visible, is turned counterclockwise until it completely disengages from the implant. The impression tray now may be removed. The coping will come away with the impression (Fig. 23-1, *D*). The appropriate implant analog is secured to the square-locking impression coping in the impression material, and a stone cast is poured.

If a nonlocking, tapered impression coping is used in a closed tray technique, it will remain attached to the implant upon removal of the impression tray. It is removed from the implant, and the proper implant analog is attached to it. The coping is reseated with the analog in the impression. To prevent errors in orientation, these tapered copings must be placed accurately. The copings have flat sides or similar identifying characteristics, so that the implant analog in its model occupies a position that exactly replicates the posture of the dental implant that has just been placed surgically. A stone cast is then placed.

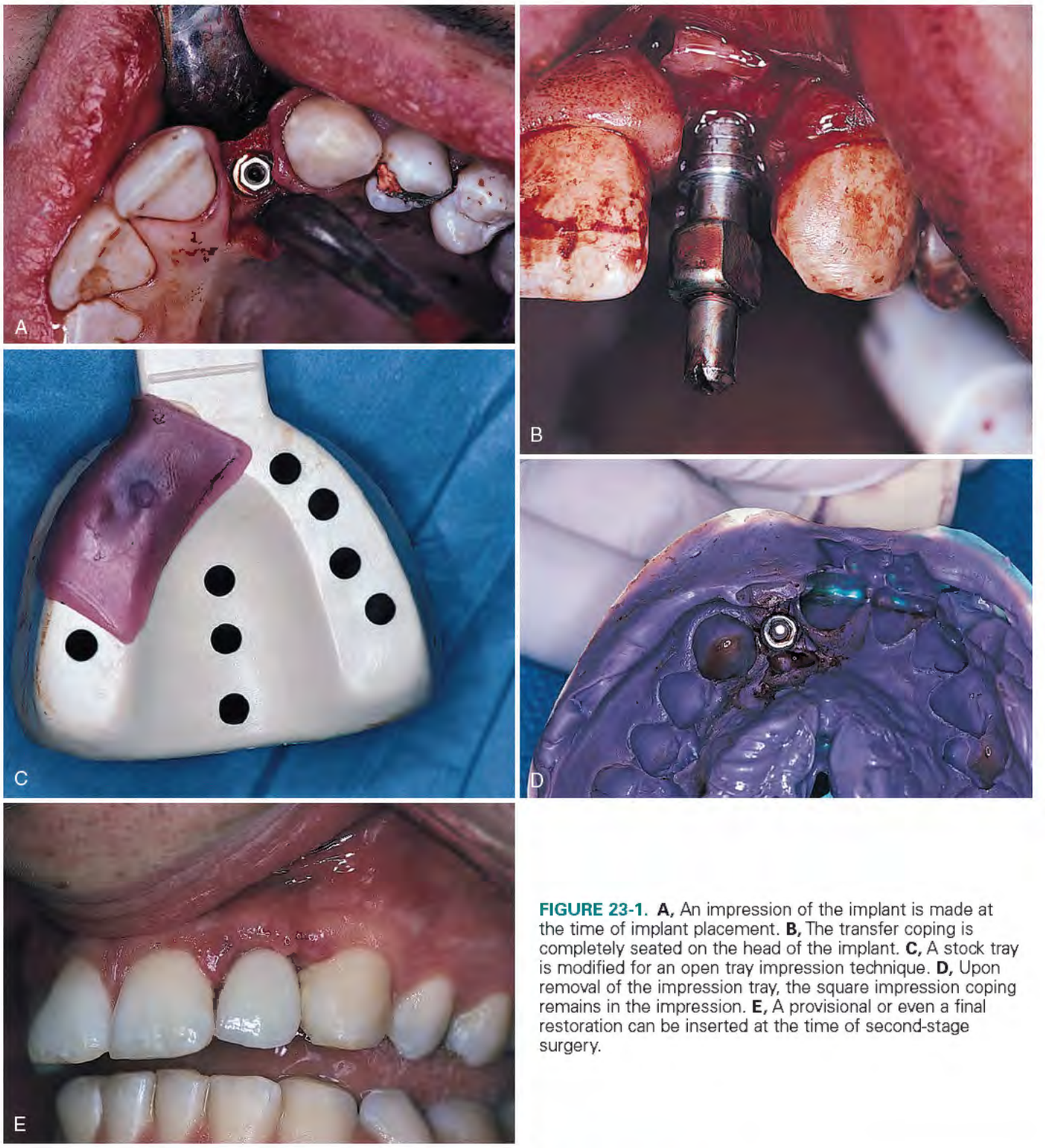


FIGURE 23-1. **A,** An impression of the implant is made at the time of implant placement. **B,** The transfer coping is completely seated on the head of the implant. **C,** A stock tray is modified for an open tray impression technique. **D,** Upon removal of the impression tray, the square impression coping remains in the impression. **E,** A provisional or even a final restoration can be inserted at the time of second-stage surgery.

The healing screw is placed in the implant and tightened. It should not be allowed to rotate. If it does, it has not been placed to its full depth, and such movement will require a new impression. If placement is satisfactory, suturing can be completed.

The master cast made from either of these impressions allows the dental surgeon to select and complete an abutment; also, a provisional or final restoration can be made to ideal tooth contours during the osseointegration period. The abutment and restoration can be inserted at second-stage surgery with the expectation that the soft tissues will heal to their outlines (Fig. 23-1, *E*).

ABUTMENTS

Two types of abutments are available (see Chapter 22); those that receive screw-retained restorations, and those that receive cement-retained restorations. Abutments must always be detachable from these implants. Most abutments are themselves screw retained, although a few other designs are fastened by a Morse taper (or cold weld). These do not require antirotational devices or a cementing medium, and they often are retrievable.

The type of abutment is selected before implantation, because it may affect the positioning of the implants. Screw-retained crowns

can be fabricated using prefabricated abutments, which are screwed into the implant. These abutments are supplied with copings, to which the complete crowns are cast. Center screws pass through these crowns and engage them to the abutments.

UCLA-type crowns also are made to be screw retained. These crowns are seated on the implant and are cast abutment-to-crown as a single entity (see Chapter 22). The unit is affixed to the implant with a center screw (Fig. 23-2).

Cement-retained restorations fit over abutments that are screw retained to their implants. These abutments are available in prefabricated form or can be custom cast. Many prefabricated abutments are supplied with machined copings that fit precisely over them. When these copings are picked up with an impression, the laboratory can wax and cast a crown to it. When positioning or the emergence profile requires a custom coping, it is made by fitting a machined coping to the implant. The laboratory can transform the impression transfer into an abutment casting fabricated from a wax-up.

All abutments should be selected or made so that their crown shoulders seat no more than 1 mm below the free gingival margin (Fig. 23-3). This allows for effective removal of cement and facilitates oral hygiene procedures.

All components chosen by the restorative dentist must be designed for use with single-tooth restorations. These must be characterized by antirotational features, such as hex configurations in or on the implants, and matched with the correct abutments.

Custom-Milled CAD/CAM Abutments

Custom-milled computer-aided design/computer-aided manufacture (CAD/CAM) abutments are anatomically designed to the individual patient. Robocast technology eliminates the need for implant-level impressions and the associated component inventory (Fig. 23-4).

Working above the gingiva helps preserve soft tissue. With the CAD/CAM technique, no impression copings are needed. The following features aid in the production of a patient-specific abutment and final restoration:

1. An impression of the coded healing abutment and the opposing arch, the bite registration, and the shade selected for the prosthesis. Codes on the occlusal surface of the healing abutment (e.g., Encode) communicate the implant depth, hex orientation, platform diameter, and interface (e.g., certain internal connection or external connection).
2. Because the dentist does not need to remove a healing abutment or seat an impression coping for an implant-level impression, soft tissue is spared the trauma of traditional techniques. As a result, soft tissue levels may be preserved and bone remodeling potentially minimized.
3. The devices are custom designed with precision robotics. The implant analog is inserted into the cast made from the impression, resulting in an anatomically designed final abutment.

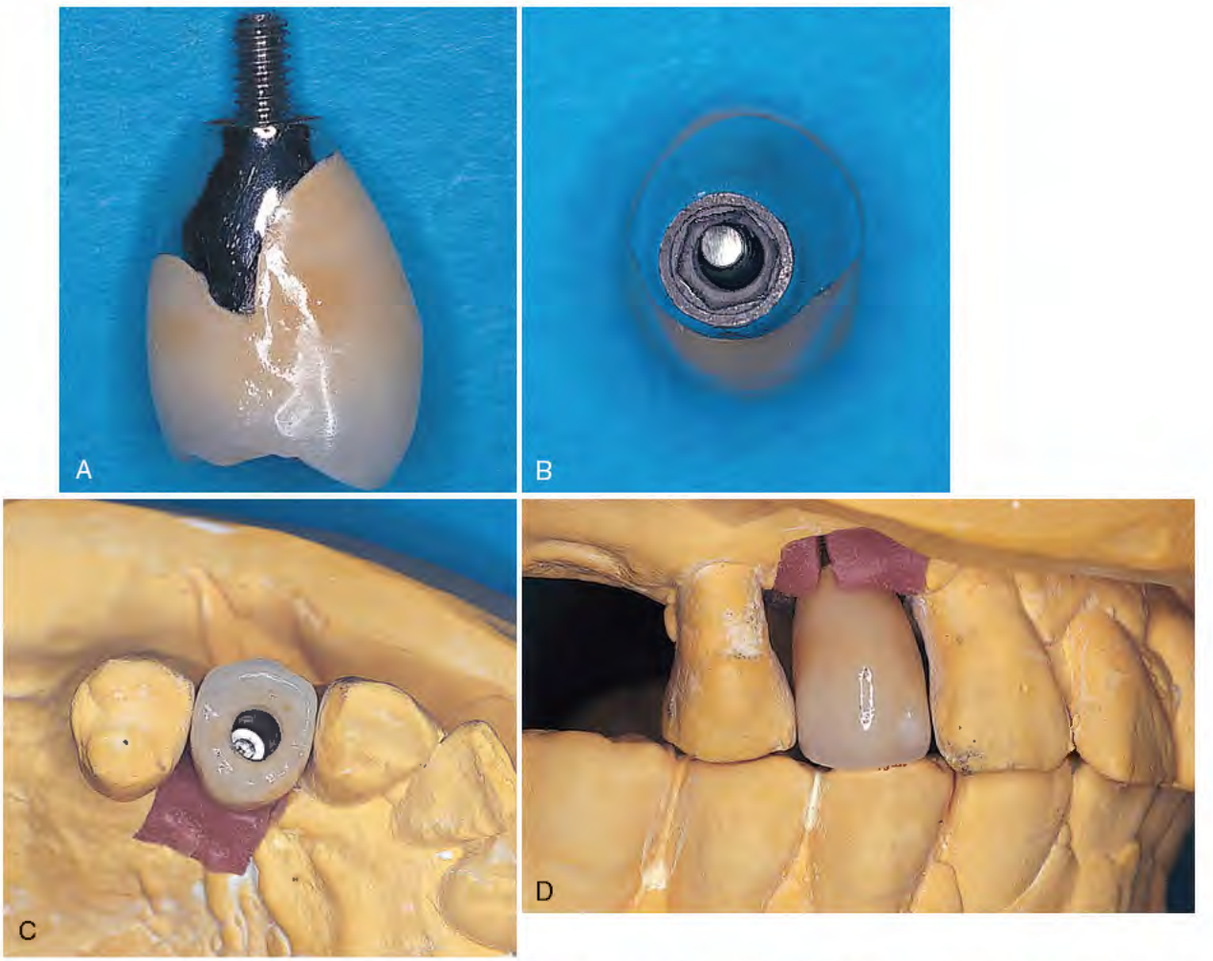
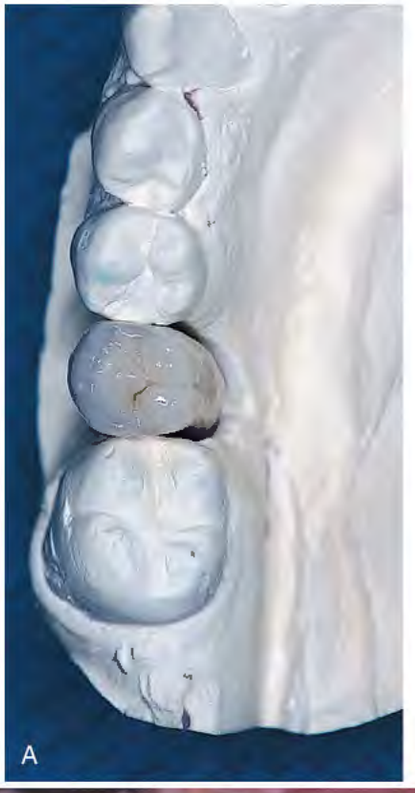
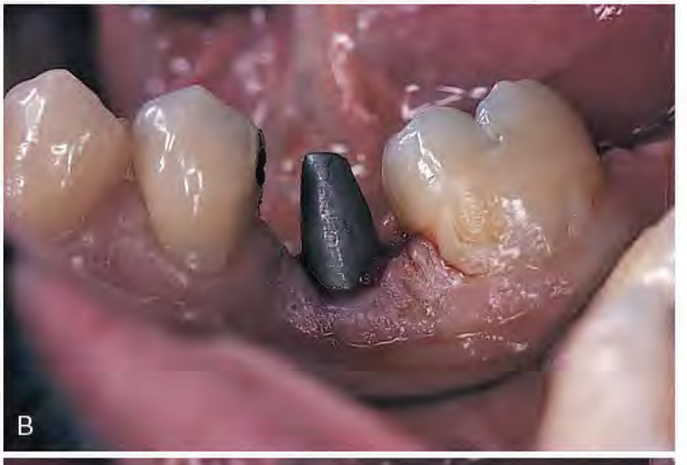


FIGURE 23-2. **A** and **B,** A one-piece abutment and crown (using an externally hexed UCLA abutment) is designed with an emergence profile that flows from the implant head. **C,** The implant is placed in the appropriate prosthetic position to allow fabrication of a screw-retained, one-piece UCLA abutment and crown. **D,** The restoration is shaped and characterized to match the adjacent teeth.





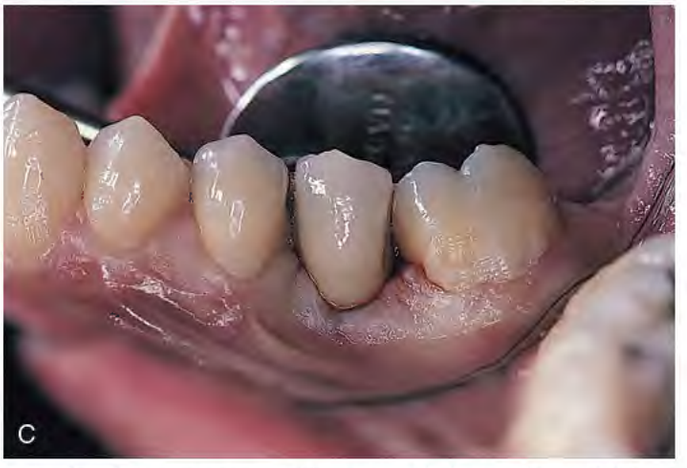


FIGURE 23-3. **A,** A cementable crown eliminates the unsightly occlusal screw access hole. **B,** An abutment for a cementable crown can be prefabricated or custom-made using an UCLA abutment as the base. **C,** The crown is cemented with a light, temporary cement.

4. The margin, contour, taper, and emergence profile are custom crafted by dental technicians from titanium nitride, titanium, or zirconium to the specifications supplied, with consideration given to the surrounding gingival architecture and dental structures.

IMPRESSION TECHNIQUES

As mentioned earlier, essentially two impression techniques can be performed. One uses the square impression coping, which locks into the impression material and is removed with the tray. The other uses a tapered coping, which remains in place after removal of the impression tray.

The technique of impression making varies slightly, depending on which coping design has been chosen. After the healing abutment and the temporary restoration have been removed from the implant, the impression coping is placed on it. As described previously, after the coping is properly engaged to the hex, the center screw is tightened firmly, and seating is verified radiographically.

Depending on whether the square or tapered abutment is used, an open (when using square abutments) or closed tray (when using tapered abutments) is selected. An open tray can be made from a stock stray simply by cutting a fenestration the top directly above the implant coping. This opening is sealed with pink baseplate wax secured by a periphery of sticky wax.

Next, the tray is seated. The protruding coping is allowed to mark its presence in the soft pink wax. Impregum or another form polyether is used as an impression material. Accuracy can be fostered by using a syringe before seating the tray. After an interval of 7 minutes to allow for stable setting of the elastomer, the pink wax is peeled away, and the fixation screw is exposed. The screw is removed by turning it counterclockwise, thereby disengaging the square coping.

The impression is removed, and the coping comes away with it. After removal of the impression, an implant analog is screwed to the coping, and a model is poured. The laboratory then can proceed with fabrication or selection of the abutment and crown.

The tapered coping remains on the implant after removal of the impression tray. It must be unscrewed and seated in the Impregum. Accurate seating is facilitated by keying the flat side of the coping into its matching impression.

The second technique (i.e., use of a regular closed tray), although similar, is not as accurate in transferring the components from mouth to model.

Digital Impressions

Impressions for a cementable crown made of vacuum-pressed porcelain blocks or titanium can be taken digitally with an intraoral imaging camera. The laser or infrared scanning camera takes overlapping images of the screw-retained abutment and adjacent teeth, and even of the impression of a bite in place for occlusal registration. A virtual model is fabricated, and with the help of the accompanying CAD software, a digital abutment-supported crown is created virtually. The data are then transferred to a CAM milling chamber, where the crown is milled, usually out of a porcelain block. After the proper disinfection protocol, the crown is fitted and cemented using standard fixed prosthetic techniques and materials.

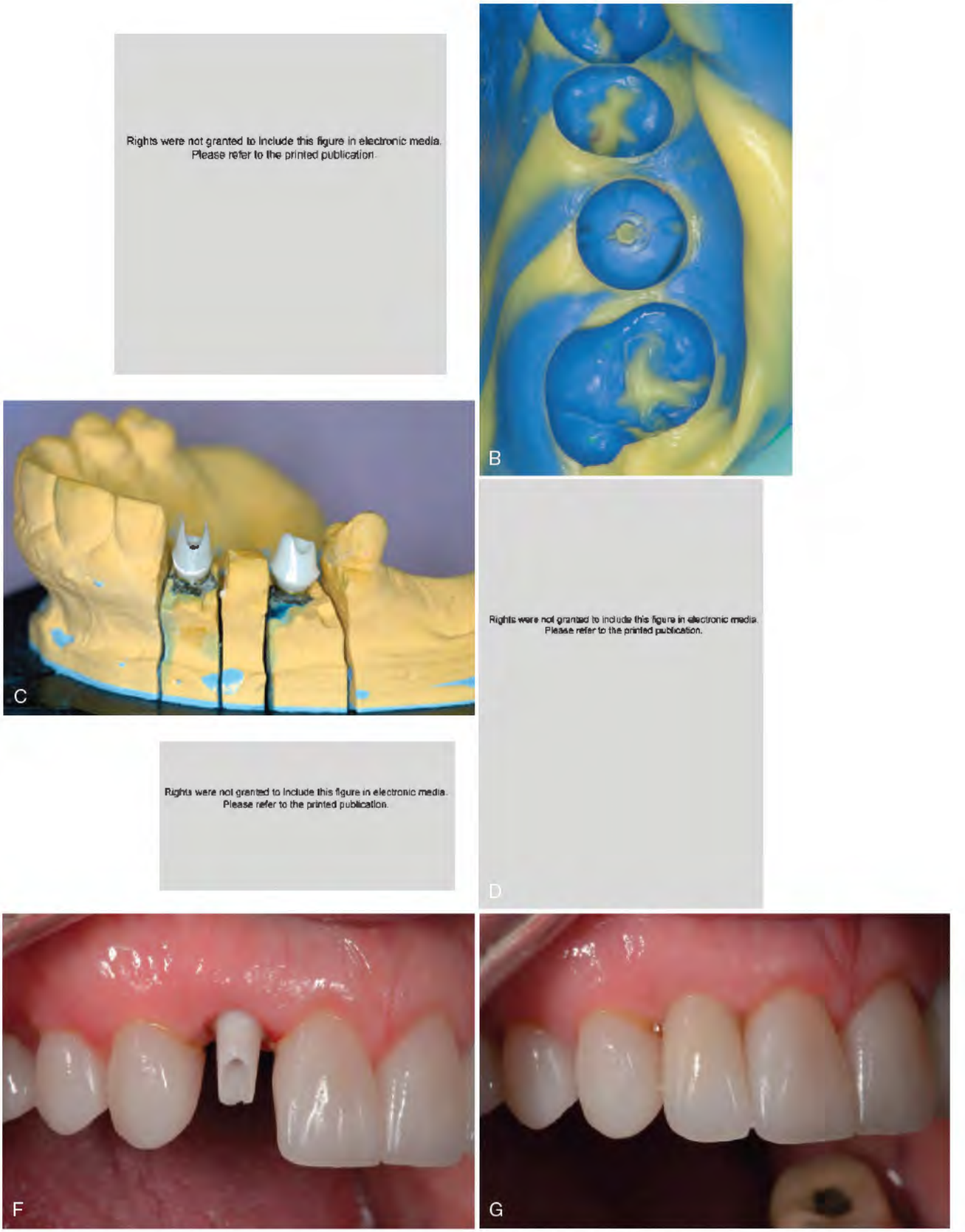


FIGURE 23-4. **A,** Biomet-3i's Encode abutment has patterns etched into its surface that provide the scanner with data on the emergence profile and the height of the sulcus. **B,** A PVS impression of the Encode abutment. **C,** A stone model poured from the PVS impression. **D,** Computer-aided design/computer-aided manufacture (CAD/CAM) milling of the implant's position on the stone model. **E,** CAD drawing of the anatomic prosthetic abutment. **F,** Facial view of the Encode zirconium abutment secured in place. **G,** Facial view of the ceramic crowns cemented in place. (**A, D,** and **E** courtesy Biomet-3i, Palm Beach Gardens, Fla; **B** courtesy Dr. Chris Ramsey, Jupiter, Fla. **C** from Fonseca RJ, Turvey TA, Marciani RD: *Oral and maxillofacial surgery,* ed 2, St Louis, 2009, WB Saunders; **F** and **G,** courtesy Dr. Robert Ritter, Jupiter, Fla.)

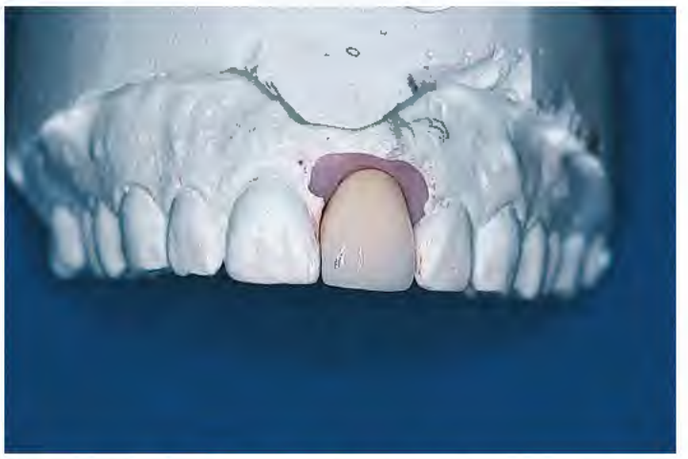


FIGURE 23-5. A soft tissue model made with Vestogum allows access for contouring of the cervical and subgingival portions of the restoration, regardless of the existing gingival anatomy.

Soft Tissue Model

A soft tissue model is made if the impression coping is found to be seated below the free gingival margin. A soft tissue material loaded in a syringe (e.g., gingival mask, Vestogum-Espe) is injected around the portion of the coping that protrudes from the impression. The coping and at least 2 mm of the implant analog are covered with the soft tissue material. After the material has set, it is trimmed evenly with a sharp knife, and stone is poured into the impression to form a cast. Because the gingival tissues on the cast are soft, their resilience allows for accurate subgingival shoulder adaptation (Fig. 23-5).

The impression techniques and creation of the master cast are the same if an abutment is selected and inserted before the final impression is made.

PROVISIONAL RESTORATIONS USED DURING PROSTHESIS FABRICATION

The provisional restoration fabricated for service during implant healing may be used during the restorative phase of treatment as well. However, if no provisional restoration was used during the implant healing phase, a provisional fixed restoration to the implant may be desirable to sculpt and mold the soft tissues (Fig. 23-6, *A* and *B*). This interim restoration is designed to look like the final restoration. It may be cement or screw retained and made on the stone cast or directly in the patient's mouth. The final abutment is used to anchor it (Fig. 23-6, *C* to *G*).

Crown Design

The crown is designed with an emergence profile consistent with the outline and cemento-enamel junctions of the adjacent teeth. Screw-retained crowns should have machined copings as their bases to retain them to their abutments, or attached directly to the implant (as for a UCLA-type crown). Screw access holes are made through the cingula for anterior teeth and through the central fossae for posterior teeth.

Cementable crowns should have abutments with a 6-degree taper for support. The abutment should be as long as possible for better retention of the crown. For anterior teeth, abutments are shaped toward the projected incisal edges. Crowns on posterior teeth are designed to project toward the central fossae.

Adjacent embrasure areas are blocked out as much as practicable to inhibit food impaction. Surfaces of adjacent teeth that are contact areas with the implant crown must be modified. Flattening these surfaces allows broader contacts and prevents excessive embrasure spaces while still allowing good oral hygiene. Metal in crowns must be of the precious variety. All components mating with the implant should be premachined. Porcelain, composite materials, or acrylic can be applied to the metal substructure.

Abutment Insertion

After the healing abutment and provisional restoration have been removed, the interior of the implant is rinsed with saline or chlorhexidine from a syringe. The abutment is inserted, and the center screw is tightened by turning it clockwise. Correct orientation of the abutment may be recorded from the master cast before the screw is tightened completely.

The abutment is rotated in the implant site until it drops into place. When it is completely seated, the center screw is tightened and the seating is verified radiographically (Fig. 23-7). When proper seating has been confirmed, the abutment is torqued down to the manufacturer's suggested preload level. The abutment should be stabilized with a cone socket pliers or a manufacturer-designed antitorque device.

Crown Insertion

After the crown has been seated, the mesial and distal contact points are adjusted. If a cementable crown fails to seat completely and the contact points have been relieved, manual pressure is applied to seat it with a cottonwood bite stick. Screw-retained crowns are seated by slowly tightening the center screw, turning it clockwise. If pressure is encountered, which can be seen as blanching of the gingival tissue, tightening should stop until the blanching dissipates (2 to 5 minutes). Then, tightening proceeds slowly until complete seating is achieved.

A measuring torque driver is recommended for applying torque to all screws. Also, all screws should be a hex or other internal engaging design for easy use of a screwdriver. If a cementable crown has been used, a light temporary cement should be applied that allows the crown to be removed about once a year. Judgment and experience contribute to the selection and change of thin cement, when necessary. A radiograph confirms complete seating of such crowns.

The restorative dentist should consider fabricating a removable cosmetic gingival prosthesis in the following situations:

1. The final result demonstrates a crown that is longer than its neighbor in a patient with a high lip line.
2. The emergence profile of the implant at the abutment junction presents overly narrow contours that cannot be resolved by a custom-cast abutment or a therapeutically contoured crown.
3. The distance from the contact point to the alveolar crest is greater than 5 mm, which means that a natural, realistic papilla may not materialize.

A removable cosmetic gingival prosthesis can be produced by replicating the completed case using an accurate elastomeric impression material (a polyether is recommended). This impression is sent to the laboratory, along with a close-up, non-color-distorted photograph of the area. The laboratory technician surveys the cast, establishes a path of insertion for the prosthesis, and fabricates

it from cured pink resilient Gingivamoll (Preat Corporation) (Fig. 23-8). Slight undercuts are left, which allows both positive retention and removal of the prosthesis.

After a try-in is done to assess fit, contour, color, retention, and ease of manipulation by the patient, and after corrections are made by the restorative dentist, the prosthesis is returned to the laboratory for completion. The prescription should offer advice about the basic shape and shade deficiencies, if any. The photograph emphasizes additional characteristics by pointing out factors such as blanching, pigmentation, gingival notching, melanosis, and other salient characteristics of the adjacent natural gingivae (see Fig. 23-6).

Several prostheses should be made at the same time in case of loss, breakage, or color change. Each is kept in a hydrated environment when not in use. The intraoral prosthesis is removed daily for cleaning and proper oral hygiene routines.

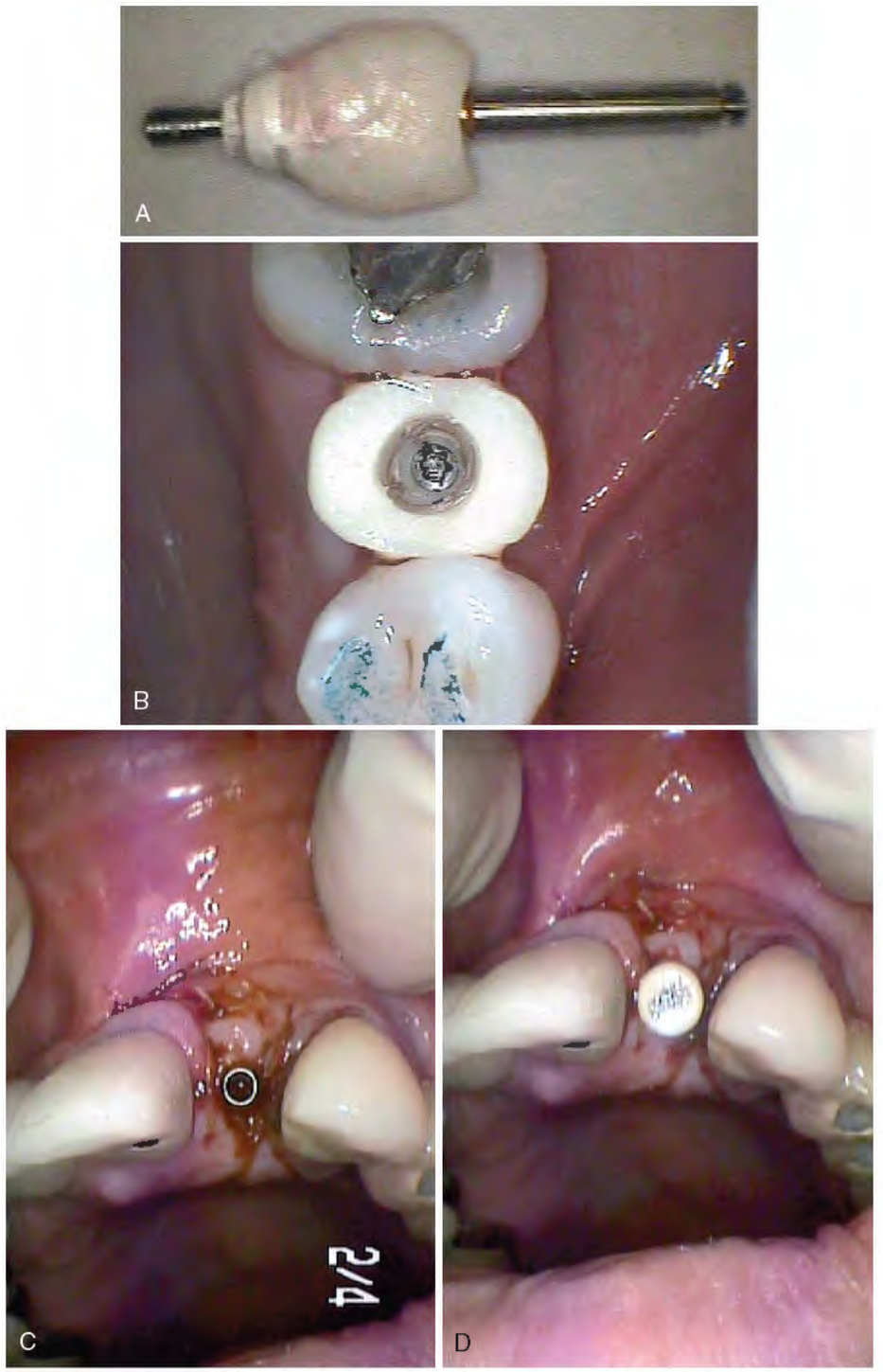


FIGURE 23-6. **A,** Screw-retained provisional acrylic crown made with a polyetherether ketone (PEEK) plastic temporary abutments. **B,** Screw-retained provisional crown inserted at the time of implant placement. **C,** Abutment in place at the time of surgery. **D,** Plastic coping over the abutment.

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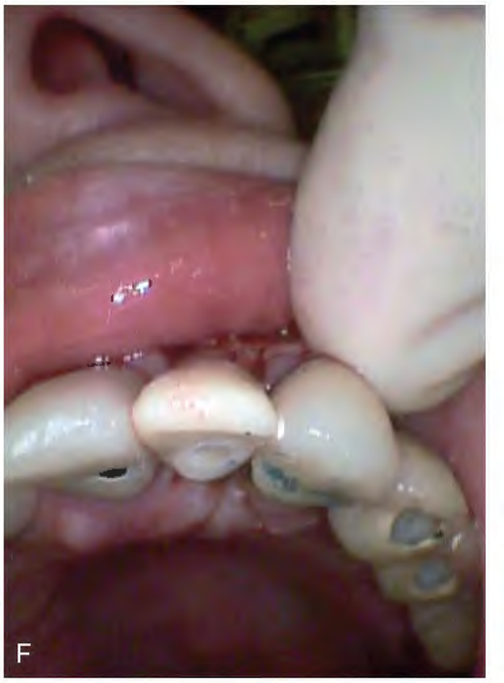


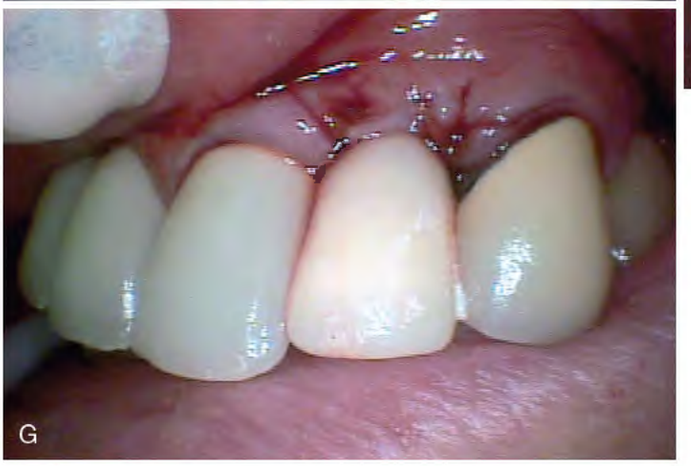


FIGURE 23-6, cont'd. **E,** Cementable immediate provisional crown with the plastic coping as an understructure. **F,** Incisal view of the cemented immediate provisional crown. **G,** Facial view of the cemented immediate provisional crown.

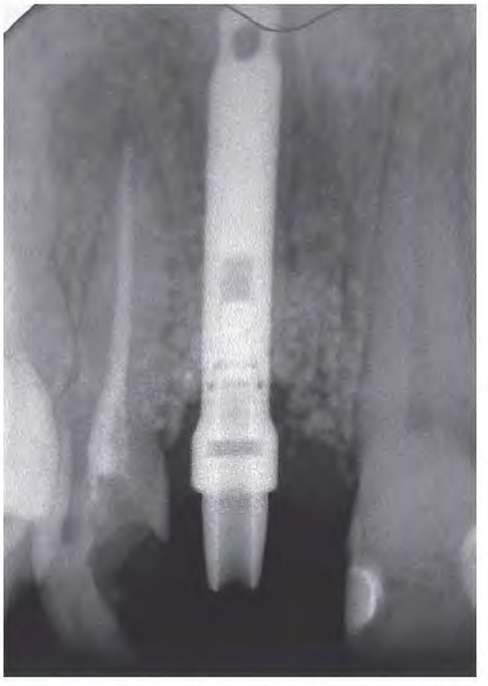
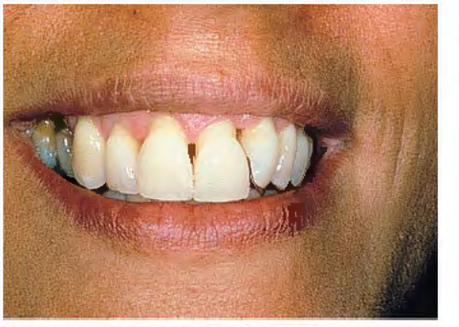


FIGURE 23-7. The radiograph must parallel the implant and abutment to be perpendicular to the implant-abutment interface. This confirms complete seating of the components.



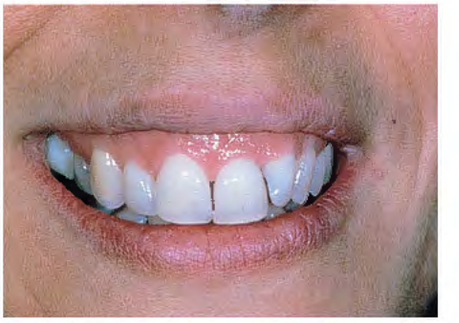


FIGURE 23-8. Soft, cosmetic gingival prostheses (Gingivamoll) serve very effectively as masks to cover unattractive embrasures. In addition to being beneficial for single-tooth restorations, they can be adapted for use with high-water full arch splints (see Chapter 24).

OCCLUSION

When placement of the restoration is satisfactory, the occlusion is adjusted for light centric contact (see Chapter 27). Excursive contacts are eliminated using adjacent teeth for guidance. Light protrusive contact is acceptable for anterior teeth.

The crown is polished and reinserted and screwed into place using the manufacturer's recommended level of torque. A cotton pellet is placed on top of the screw to protect it. An easily removable soft, light-cured material (e.g., Fermit) or Cavit is placed on top of the cotton pellet to fill the screw access chamber to within 4 mm of the top of the chamber. The metal is etched, and a primer and bonding agent are placed. A light-cured composite material is then placed, filling the screw access hole. It is finished in contiguity with the adjacent occlusal restorative material. The occlusion then is rechecked, and the composite polymer is polished.

Implant Prosthodontics: Fixed and Fixed-Detachable Prosthesis Design and Fabrication

24
CHAPTER

Several options are available for the patient who requests a fixed prosthesis. The appliance can be made so that it cannot be removed (cemented), or it can be fabricated so that the practitioner (but not the patient) can remove it by backing off its fixation screws; this is known as a *fixed-detachable prosthesis.*

PROSTHESIS SUPPORT REQUIREMENTS

When root form implants are to be used for a full arch fixed or fixed-detachable prosthesis in the mandible, the implantologist should follow some general guidelines. If usable bone is available only between the mental foramina, a minimum of five properly spaced root form implants must be inserted. A full arch fixed prosthesis in the maxilla requires a minimum of six properly spaced root form implants, because the bone is not as dense as in the mandible.

The dental surgeon must always keep in mind that the length of the implant plays a significant role in determining the amount of allowable cantilever extension. Implants 18 to 20 mm long are much more resistant to failure than those that are 8 or 10 mm long. For this reason, maximum distal extension is allowed only with longer implants (i.e., 15 mm in mandibles).

Submergible blade implants are inserted instead of root forms if anatomic conditions dictate their use. In a few cases, their abutments have attachments that are compatible with root forms of the same manufacturer.

Single-stage implants are one-piece devices that protrude through the gingival tissue. Abutments may be attached to them. The implant's head projects into the oral cavity immediately upon insertion. Such implants are available in both blades and root forms (e.g., Zimmer's and BioHorizon's one-piece implant; Straumann's one-stage design), as well as subperiosteal implants. In general, these implants are used as distal or pier abutments for fixed (cementable) bridges rather than for the detachable types. (The ITI design may be used for detachable designs.) Along with adjacent natural teeth, they also are used for coping bar overdentures.

The best design for a restoration often is one in which the superstructure occupies a position high above the tissues to allow easy access for oral hygiene ("high water" design); or, for a more esthetic result, the restoration may rest directly on or even below the gingiva. Patients often are unwilling to accept the latter design because of problems with speech, saliva, and food lodging. However, the ultimate benefits of this design justify the practitioner's efforts to persuade the patient.

The surgeon must give special consideration to oral hygiene when planning a low-rise prosthesis (see Chapter 29). The patient's manual dexterity plays an important role in the amount of home care that can be done, and the practitioner must consider this factor when selecting the type and design of the superstructure.

The UCLA abutment (with or without a metal collar), zirconium abutments, and similar custom-cast abutments should be used when reorientation, reangulation, or esthetic demands require that no metallic implant, collar, or transepithelial abutment (TEA) material be seen at the gingival margin. If, for example, less than 1 mm of gingival tissue overlies the implant, when the implant is uncovered, the standard TEA (1 mm or more in height) places the margin of the restoration supragingivally. In such cases, a specially designed abutment is attached to the implant, solving the cosmetic problem (Fig. 24-1).

PREPARATORY PHASES

Staging

Submergible (Two-Stage) Implants

Abutments (TEAs) for submergible implants are designed to be attached after integration has taken place. Implants are allowed to integrate for 4 to 6 months after surgery, depending on their location. If desirable, existing or new removable or fixed prostheses are used during this period; the surgeon should opt for a design that spares the operative sites from contact. If this is not possible, the ridge laps over the implant sites are relieved and relined with a soft material. (Chapter 20 presents the details of temporization.) Once the integration period has been completed, each implant is ready to receive its TEA. (The proper selection and methods of attachment of abutments are presented in Chapter 22.)

Restoration of Single-Stage Implants

Single-stage implants (implant heads that are allowed to protrude from the time of insertion) succeed best if they are allowed to remain in a trauma-free environment for a 12-week healing period. If the surgeon places them in a position that requires coverage for esthetic reasons, the permucosal restoration should be relieved so that the implant heals free of trauma, including occlusal prematurities and parafunctional habits, such as tongue thrusting, nail biting, and bruxism. Implants that require it can be stabilized with a temporary splint, which should be fabricated before surgery. When the splint is removed, classic single tooth restorative procedures should be performed. A number of single-stage systems (e.g., Nobel Biocare's NobelActive) can be placed to function immediately.

Provisional Prostheses

After the TEAs have been placed, they require a temporary prosthesis. This protects the abutment heads, provides the patient with a more stable interim prosthesis, and adds comfort. It also establishes esthetics, tooth form, and occlusal stability. The temporary prosthesis sometimes is referred to as a *provisional prosthesis.* Detailed instructions on the selection, conversion, and fabrication of interim prostheses are presented in Chapter 20.

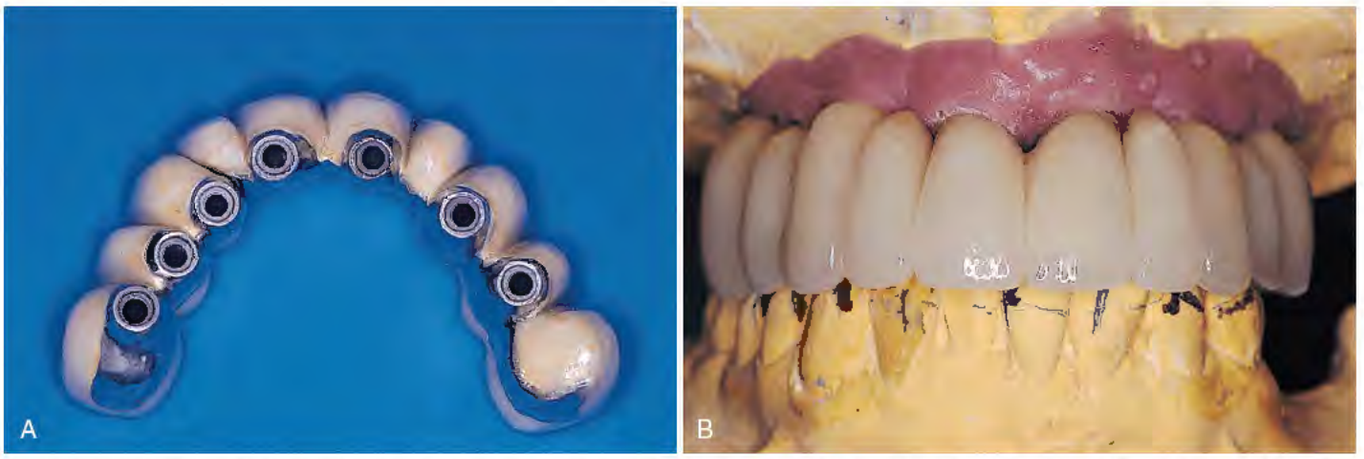


FIGURE 24-1. **A,** The UCLA one-piece abutment and crown can be used for multiple units of fixed screw-retained bridgework. **B,** The UCLA abutment allows the most room for developing an esthetic emergence profile.

Temporary Removable Prostheses

If the patient wears a complete denture, it should be modified at the same appointment during which the abutments are inserted. An indelible pencil is used to mark the positions of the abutments on the tissue-borne surface of the prosthesis. These areas are relieved with an acrylic bur to create space for each abutment. When the denture seats completely over the abutments, it is relined with a temporary soft relining material (e.g., Coe-Soft). The denture is now secure, stable, and comfortable.

Conversion Prostheses

Other interim prosthesis options are available. One logical approach is to create a fixed-detachable temporary prosthesis from a denture. The positions of the abutments are transferred to the denture using pressure indicator paste (PIP) or Thompson's sticks, and holes are drilled completely through the acrylic base at each site. This allows the denture to be seated passively over the abutments.

Plastic waxing sleeves or temporary metal copings provided by the manufacturer are attached to each abutment by their fixation screws. If plastic waxing sleeves are used, they are scored and roughened with a bur to create mechanical retention, because acrylic does not bond to them. All areas adjacent to the metal TEAs are blocked out with periphery wax before the fenestrated denture is seated. Pink self-curing, hard relining acrylic is painted around each plastic waxing sleeve or notched metal coping to ensure reliable adhesion.

After the acrylic has set, the fixation screws are removed from each abutment, the denture and luted sleeves are removed, and final curing is completed in a pressure pot. The denture is used to reconfirm passive seating. Excess acrylic is trimmed from the undersurface to leave space around each abutment for proper oral hygiene.

All flanges to the crest of the ridge are cut away, creating a convex, highly polished undersurface. The posterior saddles of the denture are reduced distally so that no more than 15 mm of denture extends beyond the distal portion of the most posterior abutment. Flanges and soft tissue ridge lap contact are important in these areas for additional support.

This technique has converted the denture into a temporary fixed-detachable prosthesis. The screws and denture must be removed from the patient's mouth at each prosthetic visit.

Provisional Fixed Prostheses

If planning simple fixed prostheses, make a temporary acrylic bridge on natural and implant abutments in the classic manner and cement it into place with a soft, noneugenol cement (e.g., Trial).

IMPRESSION MAKING

Fixed Cementable Prostheses

Single-Stage Implants

In single-stage implants (e.g., blade, subperiosteal, and Zimmer's one-piece root form implants), the abutments are attached. A working or master cast is created so that a final prosthesis can be fabricated. To make this cast and its dies, an impression of the abutments is made using any comfortable technique. First, alginate is used in a stock tray. A cast is poured, and a custom resin impression tray is prepared. Any conventional technique can be used, with judicious application of gingival retraction cord around teeth and, if necessary, around implants. Elastomeric impression materials are recommended. All dies are poured in epoxy resin for strength (Figs. 24-2 and 24-3).

Two-Stage Implants

Morse-Taper (Cold-Weld) Abutments

Morse taper (cold weld) abutments include traditional root form implants and single-stage implants, such as some Straumann models and Zimmer's Screw-Vent (which, although considered a single-stage implant, has attachable abutments). If a system with non-screw-attached abutments is used (e.g., Bicon models), they are inserted so that a classic impression procedure can be performed.

Threaded Abutments: One-Piece (Without Collars)

Threaded one-piece abutments without collars are rarely used. To produce a working cast for this type of abutment, the abutments, which have one flat side, are screwed into their implants. Their alignment and relationships of fit are checked clinically and with bitewing radiographs; if necessary, the alignment is corrected with cooled diamond stones.

If the alignment of the TEAs is acceptable after initial placement, each is scored with a ¼-inch round bur at the gingival margins. This level is important to record in areas of esthetic concern. The TEAs are numbered with the same bur, returned to the mouth, and

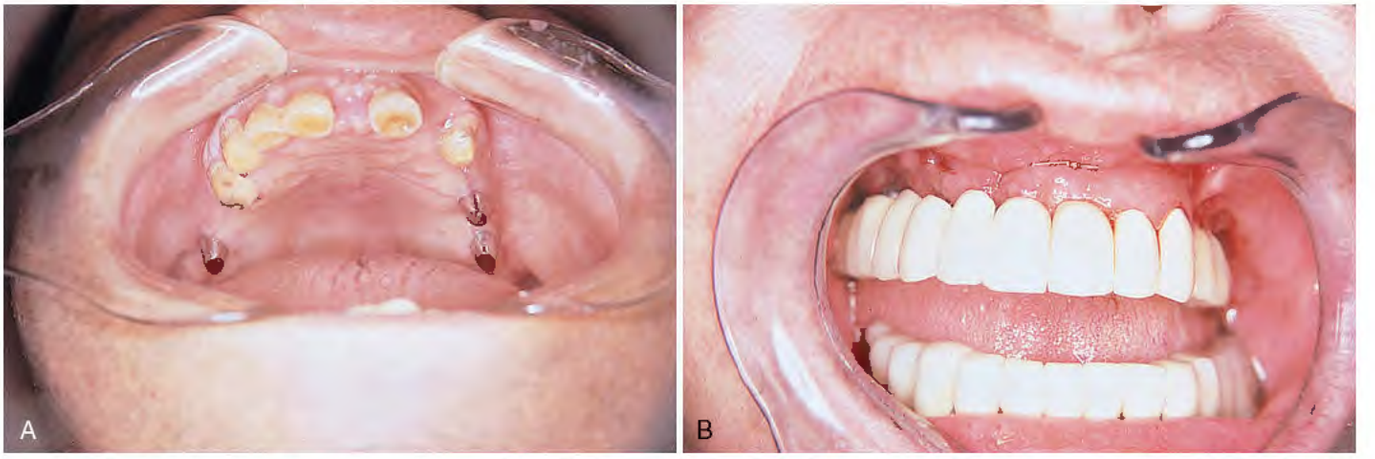


FIGURE 24-2. **A,** A fixed prosthesis sometimes is desirable for restoration of a universal subperiosteal implant combined with natural abutments. **B,** This composite-veneer gold coping bridge is both functionally and esthetically acceptable as a final prosthesis. If temporary cement is used, gold copings are provided for the natural teeth.

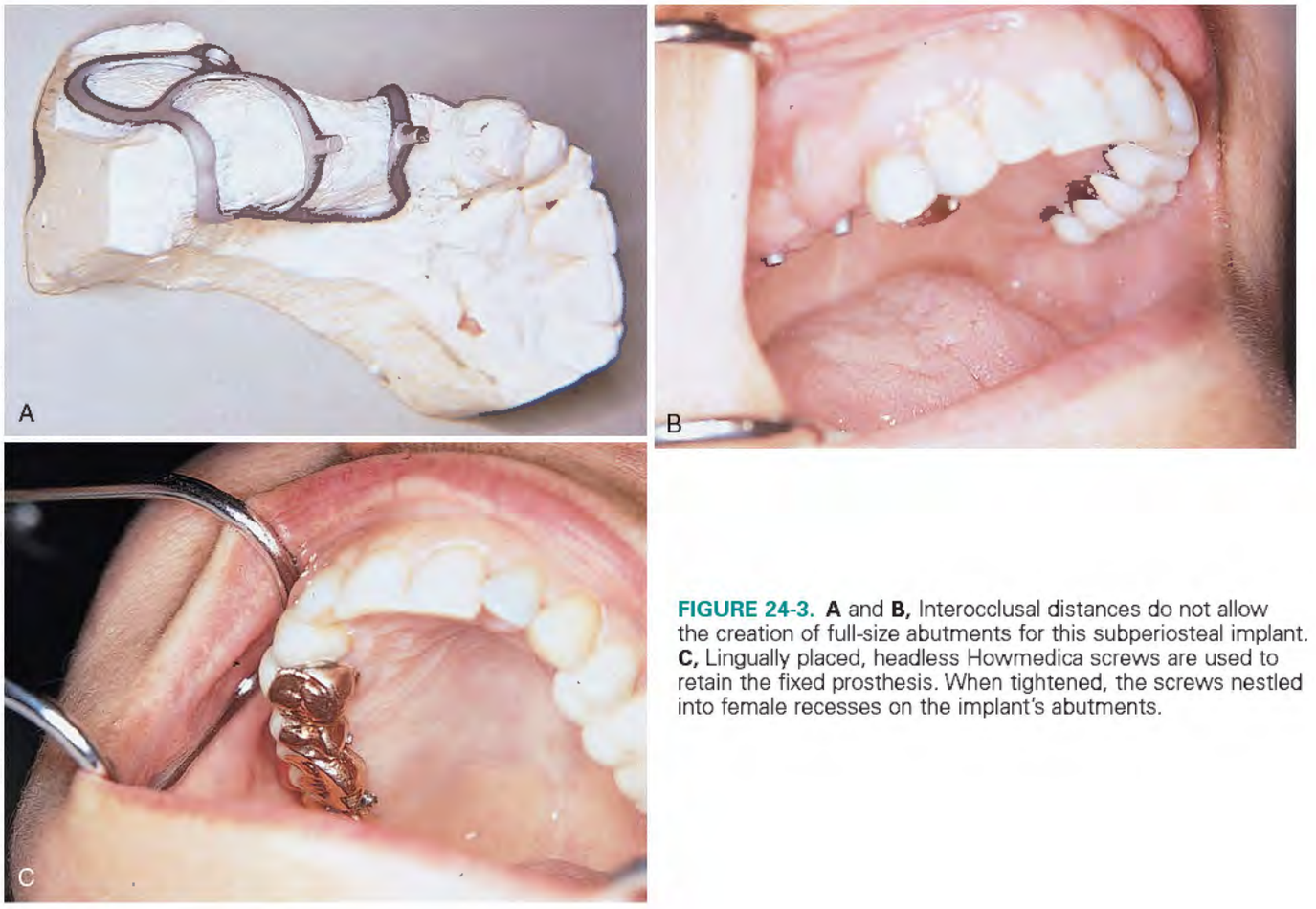


FIGURE 24-3. **A** and **B,** Interocclusal distances do not allow the creation of full-size abutments for this subperiosteal implant. **C,** Lingually placed, headless Howmedica screws are used to retain the fixed prosthesis. When tightened, the screws nestled into female recesses on the implant's abutments.

packed with retraction cord. An impression is then made in the conventional manner.

The scoring shows the laboratory where to end the restorations, or the laboratory can shorten the margins and return the abutments for a new master impression. One of these strategies is necessary, because this device has no shoulders or finishing lines to indicate where the crowns must terminate. The laboratory should pour the impression in epoxy resin and then proceed with fabrication of the superstructure (Fig. 24-4).

If the location, angulation, or emergence profile presents a problem, the solution is best worked out on a master cast rather than directly in the mouth. To accomplish this, a transfer of the relationship of the implants to their surrounding tissues and teeth is obtained; transfer copings may be used. Tapered copings have at least one flat side to ensure that they seat accurately in the impression.

After the abutments have been tightened securely to the implants and complete seating has been confirmed radiographically, the appropriate transfer copings are screwed to the abutments. As

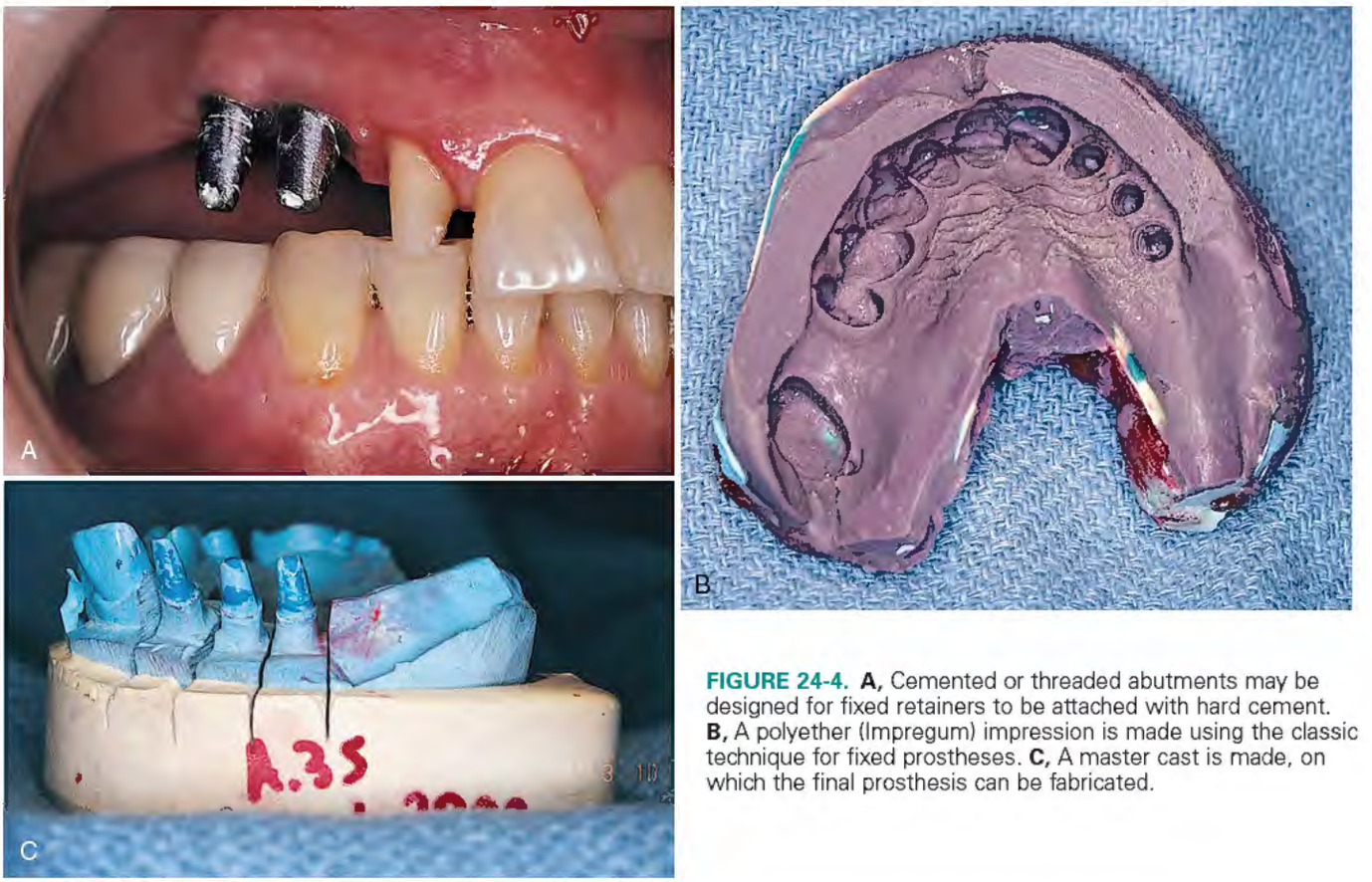


FIGURE 24-4. **A,** Cemented or threaded abutments may be designed for fixed retainers to be attached with hard cement. **B,** A polyether (Impregum) impression is made using the classic technique for fixed prostheses. **C,** A master cast is made, on which the final prosthesis can be fabricated.

an alternative, direct impressions of the implants can be made. This requires acquisition and placement of abutment analogs for each implant. Impressions are made with either a closed or an open top tray, depending on the design of the transfer device. The procedure for doing this is as follows (Fig. 24-5):

1. After removal of the impression, the copings or abutments are unscrewed from the implants and seated into the impression. Their flat sides ensure accurate placement.
2. An implant analog (nonprecious replicas of the implants are available from each manufacturer) is attached to each TEA that is accurately lodged in the impression, and a final master cast is produced. The analog appropriate for the specifically chosen TEA should be used. For example, if the TEA serves as an abutment for a cementable fixed bridge, the analog represents the implant only. With this type, the TEA is placed in the analog in the master cast to allow fabrication of the bridge. However, if the TEA is to be used to create a fixed-detachable restoration, the impression is made with a transfer coping on the TEA. The TEA is left in the patient's mouth after the impression while the transfer coping is removed.
3. After removal, the transfer coping is inserted into the impression. An analog representing the TEA and implant is attached to the transfer coping, and the impression is poured in die stone. The heads of these analogs serve as the TEAs and are used as such by the laboratory.
4. After separation, a master cast has been created with each implant placed precisely as it is in the mouth. The master cast is articulated to the countermodel with an appropriate interocclusal record using wax or polyether.
5. If the abutments are poorly aligned, angled types should be selected and inserted into the analogs (see Chapter 22). If the angulation cannot be corrected with manufactured abutments, the laboratory can make custom castings. If the prosthesis involves both natural teeth and implants, one of the following options should be chosen:
   - Natural teeth are covered after preparation with cemented copings; this is followed with a full arch of porcelain fused to metal crowns, which splints the teeth and implant abutments together. Such splints may be attached safely with temporary cement (Fig. 24-6).
   - Interlocks are placed between natural teeth and implants, and permanent cement is used for the natural tooth segments (Fig. 24-7). A trial fitting is done at each step. Passive seating of the metal substructure is imperative.

Fixed-Detachable, Unit-Type (Anatomic) Fixed Prostheses

Many patients request fixed-detachable restorations, which more closely resemble the appearance of natural teeth and do not give the artificial appearance of the high-water hybrid design with its pink acrylic base. This is a particularly significant factor for patients with high lip lines.

If the implants are located in acceptable anatomic positions, the laboratory provides a restoration designed with individual crowns, each over its own TEA, and with classic pontics representing any teeth missing between them. This technique requires that the laboratory be supplied with the preprosthetic index, articulated casts, waxing sleeves, and fixation screws. If the implants have been placed in the proper position and correctly angulated and spaced, the prosthesis may be screwed down directly. The result is far more realistic but less easily cleaned than the hybrid design.

Development of a proper emergence profile is essential. To accomplish this, each implant is placed 3 mm below the level of

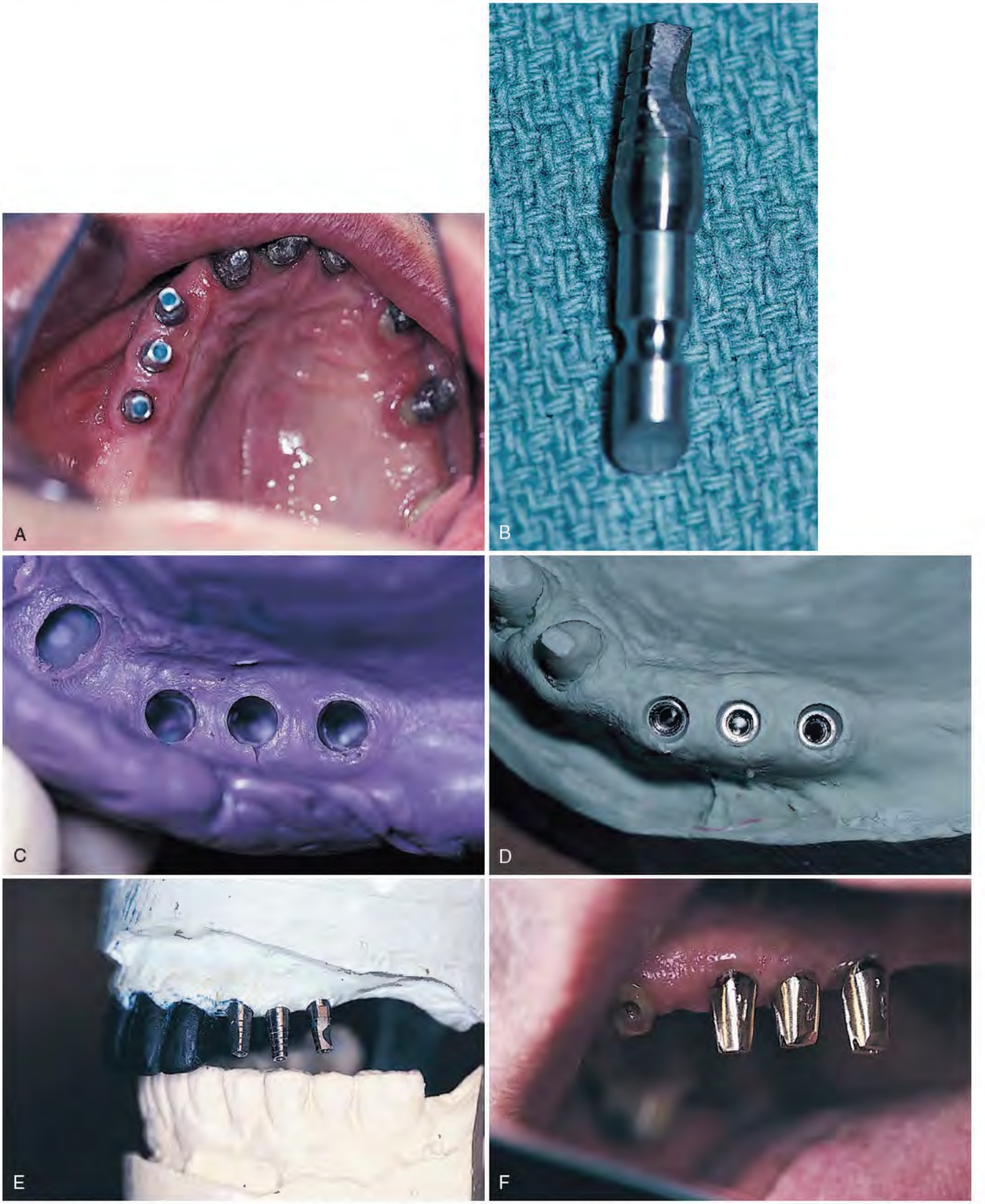


FIGURE 24-5. **A,** Three maxillary Integral implants have become integrated, allowing placement of threaded abutments. Because of malalignment, the abutments will be used only for transferring locations and angulation of the implants. **B,** Flattening one surface of its coronal morphology modifies each coping; this ensures positive seating in the pickup impression. A prosthetic implant analog is attached to this altered coping. **C,** A polyether impression is made by picking up the three modified abutments. **D,** The master cast is poured with each analog accurately placed to represent its anatomic location. **E,** After the casts have been articulated and the abutments screwed into place in the analogs, the malalignment of the implant bodies can be seen. **F,** The lack of parallelism is so significant that proper relationships are achieved only with newly constructed, custom-cast abutments.

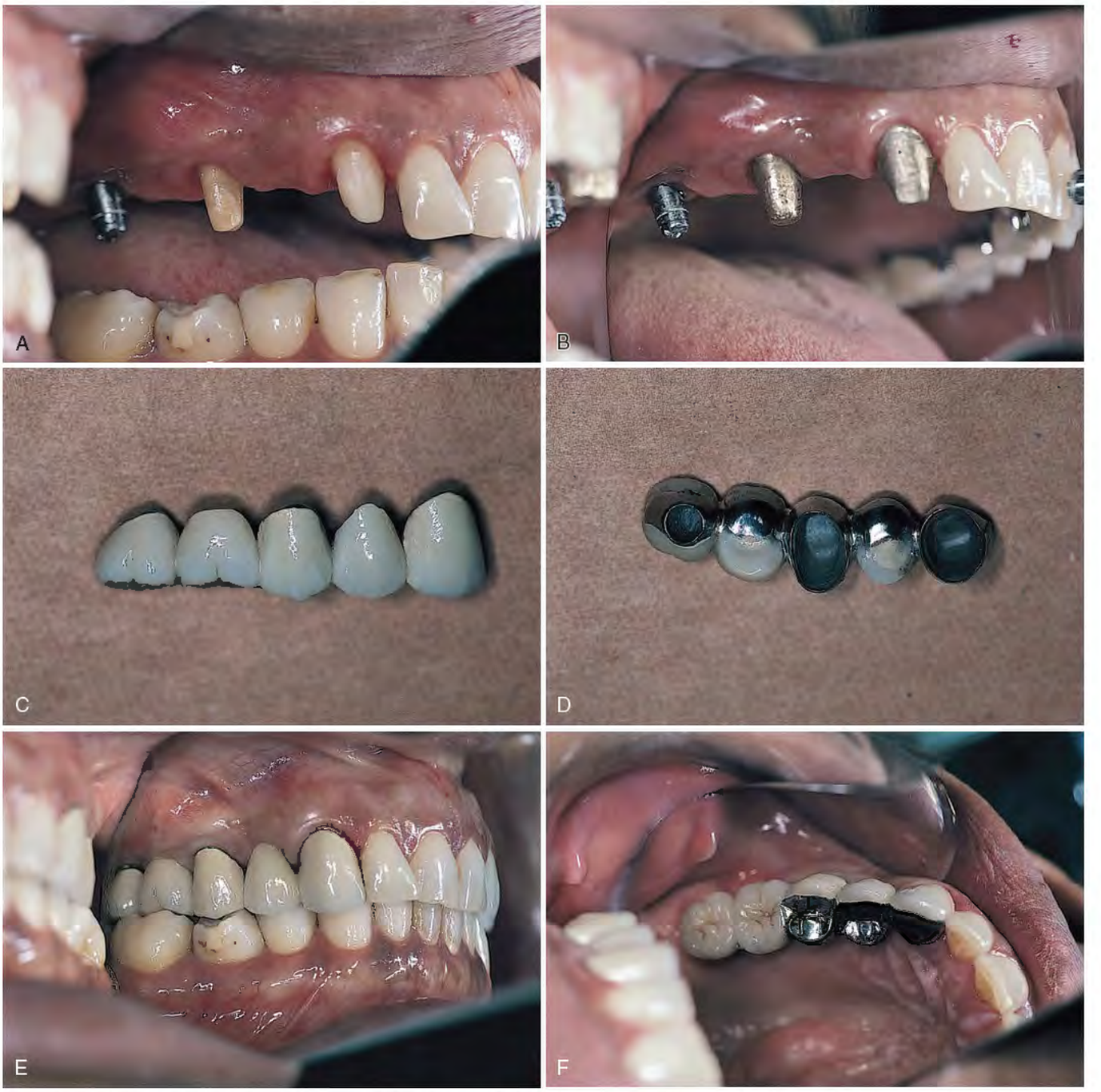


FIGURE 24-6. **A,** A fixed implant abutment is placed in parallel configuration with two anterior natural abutments. **B,** Each tooth is protected with a cemented gold coping. **C,** The protected natural abutments enable the practitioner to make a one-piece casting without fear of caries if temporary cement failure occurs. **D,** The design allows easy cleaning of the prosthesis. **E,** Temporary cement is used for this five-unit fixed prosthesis without fear of caries. **F,** For an occlusal view, the buccolingual tables are designed to deliver forces with minimal trauma to the supporting abutments. Because temporary cement was used for this ceramometal prosthesis, making it retrievable, subsequent adjustments, repairs, and prophylaxes will be easier to perform.

the cementoenamel junctions of the adjacent teeth that are part of the planned final restoration. Individual castings are made for the implant abutments, and pontics are attached to them in appropriate segments. Impressions for assembly are made only after the individual seatings are satisfactory. The particular implant system used determines the positions of the crown margins. The crowns are completed at the gingival levels, or the castings are extended slightly below them. For thin gingivae, TEAs with commensurately narrow cervical zones are chosen. If allowing the margins to be supragingival does not create an esthetic problem, it certainly facilitates oral hygiene measures and contributes to the health of the investing tissues. The pontics should be designed with modified ridge laps to make hygienic measures easier.

Although fixed-detachable superstructures can be made with single-stage implants and even with subperiosteal and transosteal implants, the surgeon usually uses the classic, two-stage submergible type for fabrication of these versatile prostheses. When submergible implants are used, impression techniques may vary. An open tray or a closed tray technique may be used.

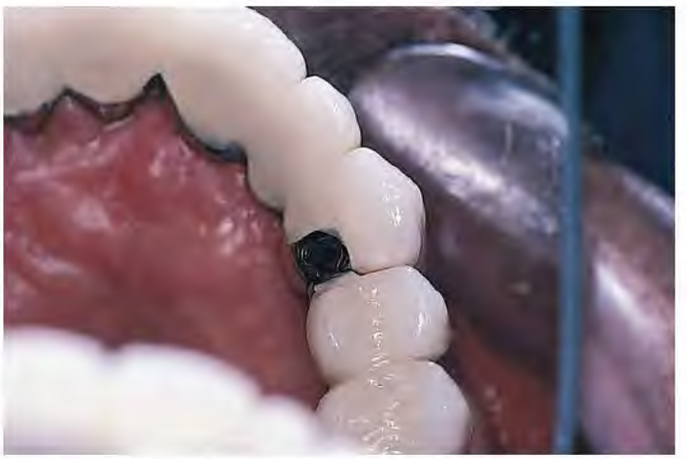


FIGURE 24-7. If gold copings are undesirable because of dimensional restrictions, interlocks between natural and implant abutments can be made, so that permanent cement can be used to protect the natural teeth.

Closed Tray Technique

The closed tray technique requires a custom impression tray. An alginate impression is made with the healing collars in position. After pouring, the implant locations are evident on the cast. Each healing collar is blocked out on the cast with a tube of hard wax 5 mm in diameter and 15 mm in height. Aluminum shells or annealed copper bands function well as matrices. The tubes are lubricated with petroleum jelly, and a self-curing resin tray is molded over them. The wax spacer provides the tray sufficient relief to allow room for impression posts that must be placed in the TEAs.

The intraoral healing collars are removed (no local anesthesia is needed) and replaced with TEAs. An impression post or coping is inserted into the threaded receptacle of each TEA.

The final impression is made with a rigid, elastic polyether impression material (Impregum) to ensure that the impression posts or copings remain firmly placed in their correct positions. The head of each impression post is examined for a thin slot or a small depression, which is used when the post is screwed into place. This slot or depression is blocked out with wax before the impression is made, because recording it interferes with accurate reseating of the posts or copings in the impression.

After removal of the impression, the posts or copings are unscrewed from their TEAs and attached to the implant analogs supplied by the manufacturer (Fig. 24-8). These combined units are placed in the impression, boxed, and poured in a hard dental stone (e.g., Vel Mix). The laboratory uses the resulting cast to complete construction of the prosthesis.

If subgingival margins are required, soft tissue models are required. A soft tissue material (e.g., GI mesh) is inserted around each abutment analog in the final impression before the pouring with stone is done.

Open Tray Technique

The open tray impression technique uses square impression posts around which elastomeric materials lock, making it impossible to remove the impression before the retaining screws are backed off. To allow this maneuver, these systems require a specially constructed impression tray that must be supplied with a window on its occlusal surface.

To fabricate such a tray, the surgeon makes a study model with the TEAs in position in the implants. A chimney of wax 15 mm high is built around each. Next, pink base-plate wax is softened, and one layer is pressed over the abutments and adjacent edentulous ridges to serve as relief for fabrication of a tray. Resin is placed over the wax in all areas except over the chimney.

After the tray has been cured and trimmed, access to the TEAs is available from above. The square impression posts are attached to the TEAs with specially supplied long screws. Dental floss is tied in figure-8 patterns to join the impression posts, and Duralay or GC Pattern resin is painted incrementally over the floss, forming a solid matrix.

When the custom tray is tried in, it must not be encumbered by the splinted complex. A piece of softened base-plate wax is placed over the open window and pressed until the heads of the impression posts make indentations into it. The tray is removed, and the wax roof is sealed to the housing with sticky wax. The indentations made in the wax by the impression posts are excised through the full thickness. The tray is replaced, and the surgeon must make sure that the top of the screwed impression posts can be seen through the holes just made.

The final impression is made using a standard elastomeric technique. Impression material is expressed from a syringe around all of the TEAs before the tray, which is filled with the

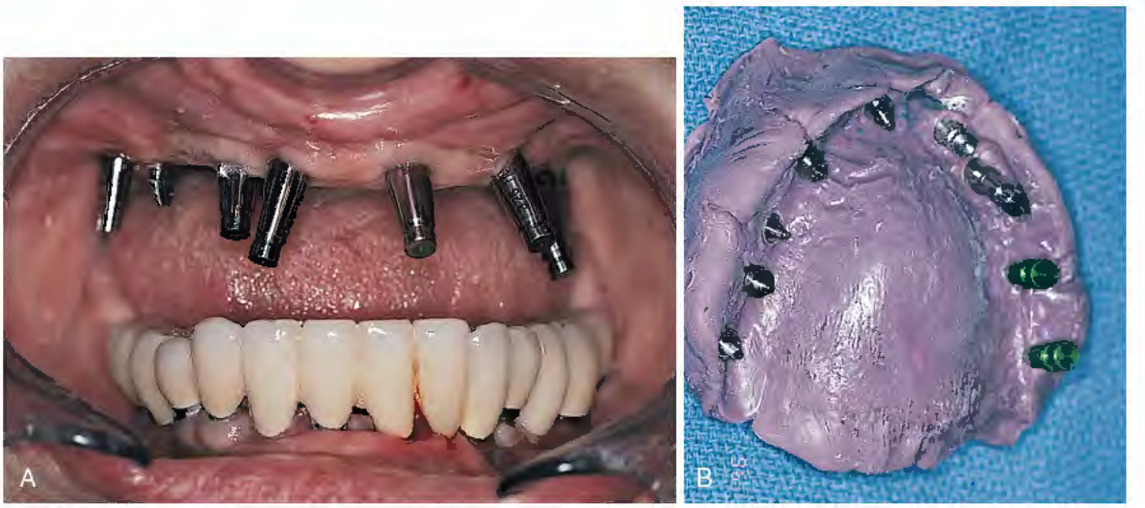


FIGURE 24-8. **A,** Tapered impression copings are seated on the abutments. **B,** The tapered impression copings are inserted with the appropriate analog immediately after the impression is removed from the patient's mouth.

same material, is seated. If seated accurately, the tray shows impression material extruding through the holes just cut in the wax. After the impression material has set, the extruded material is excised with a scalpel using a Bard-Parker No. 11 blade, revealing each of the long screw heads. These screws are backed out, allowing removal of the impression. The square posts are retained in the impression. The appropriate implant analogs are attached, and the model is poured in die stone.

A working model has been produced that allows the construction of a fixed-detachable prosthesis (Fig. 24-9, *A* to *C*).

Interocclusal Record Making

Recording of the correct maxillomandibular position is critical for establishing the proper occlusion and design of a prosthesis. Standard record-making techniques can be used for all but fixed-detachable bridges, which require the highest level of accuracy and therefore an alternative technique.

A record base is made on the master cast by relieving it with a single layer of base-plate wax, which should be placed around each of the implant sites. The implant analogs and abutments should be visible through the wax. The surgeon need not use every implant

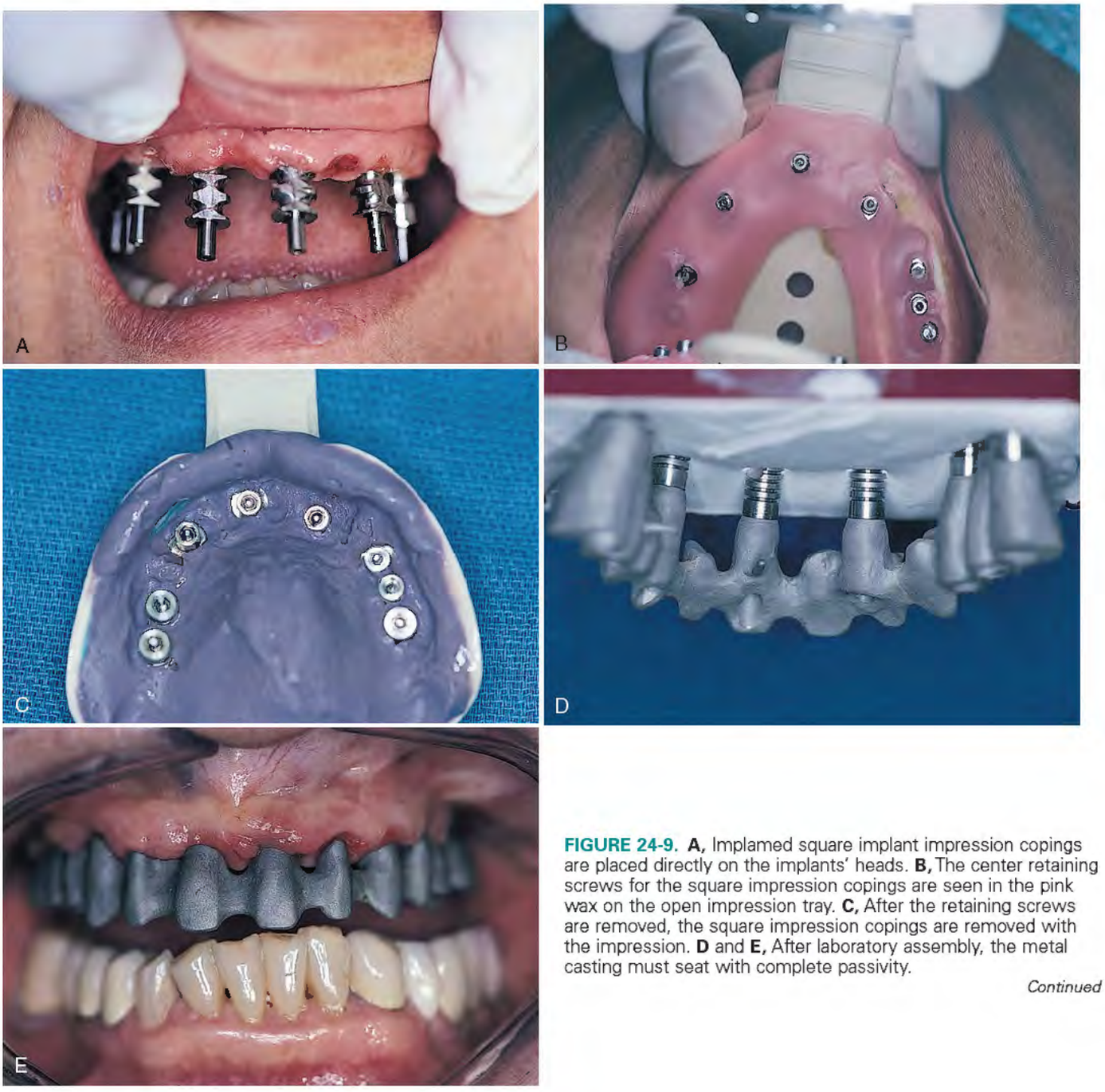


FIGURE 24-9. **A,** Implamed square implant impression copings are placed directly on the implants' heads. **B,** The center retaining screws for the square impression copings are seen in the pink wax on the open impression tray. **C,** After the retaining screws are removed, the square impression copings are removed with the impression. **D** and **E,** After laboratory assembly, the metal casting must seat with complete passivity.

Continued

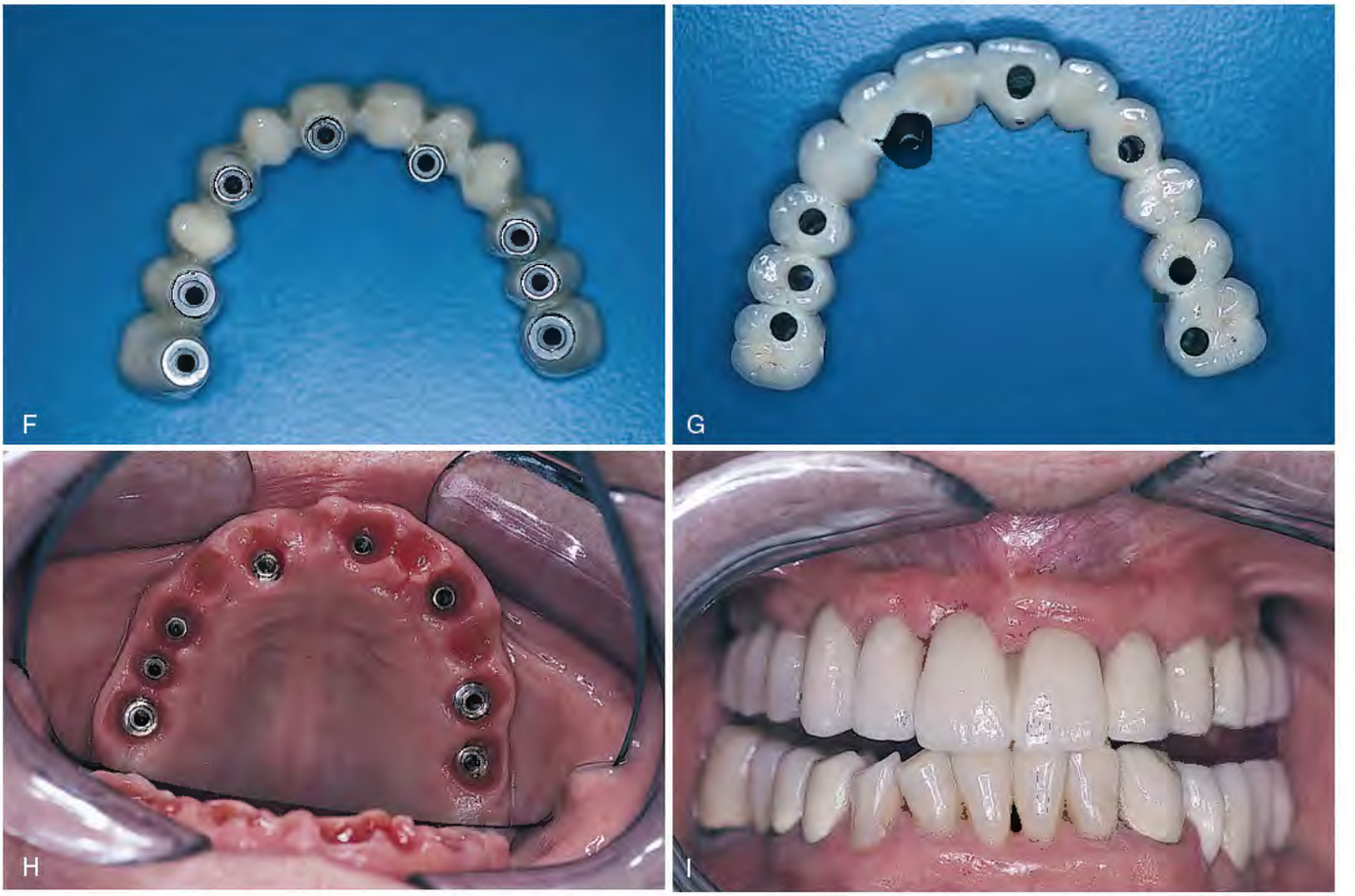


FIGURE 24-9, cont'd. **F** and **G,** After porcelain has been applied, the restoration is rechecked for passive seating. **H,** The implants' interiors are debrided carefully. **I,** The prosthesis is seated and checked again for passivity by affixing only one screw at a time.

to stabilize the base; alternate ones are adequate, as long as tripodal stabilization is achieved. A fixation screw is placed in each of three disparate implant abutments, and the cast is lubricated with a thin layer of petroleum jelly. A self-curing resin record base is made over the base-plate wax, and the fixation screws are incorporated into it.

A base produced in this manner should not have any tissue contact except on the edentulous saddles. When screwed into position, the base should be rigid and stable. The wax bite blocks used as a recording medium are placed on the base just before it is inserted. The screw holes are left uncovered so that the base can be removed. The maxillomandibular position is registered in the usual manner, a facebow transfer is taken, and the cast is mounted on a semiadjustable articulator (see Chapter 4). This prepares the cast for the laboratory phases.

SUPERSTRUCTURE FABRICATION

Casting Materials

A precious alloy with a low level of in-solution ionic activity (e.g., palladium, platinum, or gold alloys) is preferable for the fabrication of all implant-borne castings. Nonprecious metals should never be used. All castings should be tried in to ensure passive seating. If any doubt arises about the passivity of the fit, the casting can be sectioned and a relationship taken for soldering. A computer-aided design/computer-aided manufactured (CAD/CAM) zirconium or titanium one-piece framework or cast metal framework can be milled from titanium and precious metals. All bare interface joints are evaluated clinically, and if they are not easily visible, they also are inspected radiographically. When passive seating is satisfactory, porcelain, acrylic, or composite material is used to finish the prostheses (Fig. 24-9, *D* and *E*). Consideration of the occlusal materials in the opposing arch helps guide the selection of veneering substances.

CAD/CAM Milling of the Fixed and Fixed-Detachable Framework

CAD/CAM milling is a relatively new but highly accurate method of fabricating a jointless, one-piece zirconium or titanium substructure for a fixed, screw-retained or cementable bridge or a screw-retained bar overdenture. Misangulation of implants can be easily corrected, and a solderless, nonporous, one-piece framework can be made (Fig. 24-10). This technique requires a traditional approach for creating pickup or transfer-type impression abutments that are highly accurate and rigidly connected to each other with hard acrylic (e.g., GC Pattern resin) (Fig. 24-11).

The implant analogs are attached to the impression copings, and a master cast is made. The cast is then scanned, and a CAD program is used to create a digital cast. Virtual analogs are created on the virtual cast and connected virtually until a framework is designed to the restorative dentist's specifications (Fig. 24-12). The data then are transferred to a CAM milling chamber, where a solid piece of the framework is milled from either a titanium or zirconium block.

The laboratory technician checks the fit of the framework on the plaster cast and then sends it to the dentist for intraoral verification of the fit, which should be passive (Figs. 24-13 and 24-14). If the

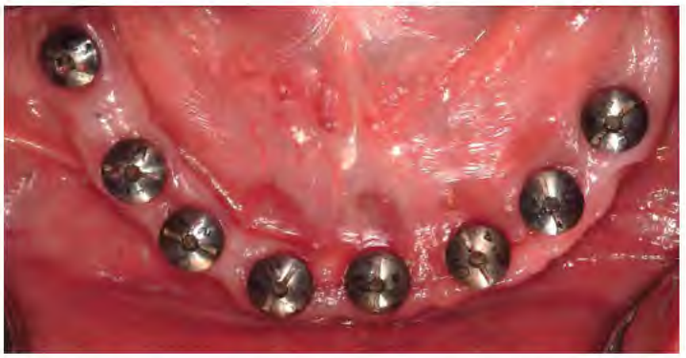


FIGURE 24-10. Eight implants placed in the mandible for a fixed restoration. (Courtesy Dr. Carl Drago, La Crosse, Wisc.)

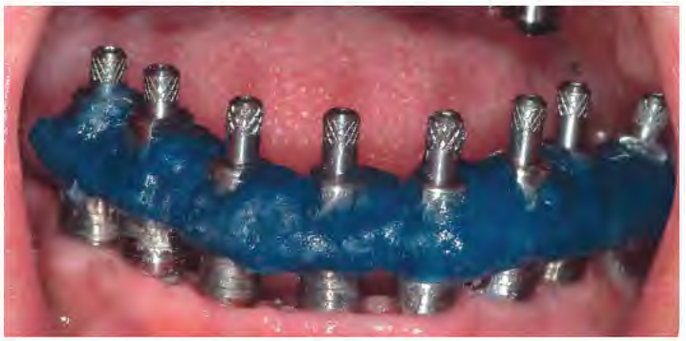


FIGURE 24-11. The verification index is fabricated on the cast by luting the impression copings together with a low-expansion resin. If the index does not seat passively, it can be sectioned and luted in the correct position intraorally. (Courtesy Dr. Carl Drago, La Crosse, Wisc.)

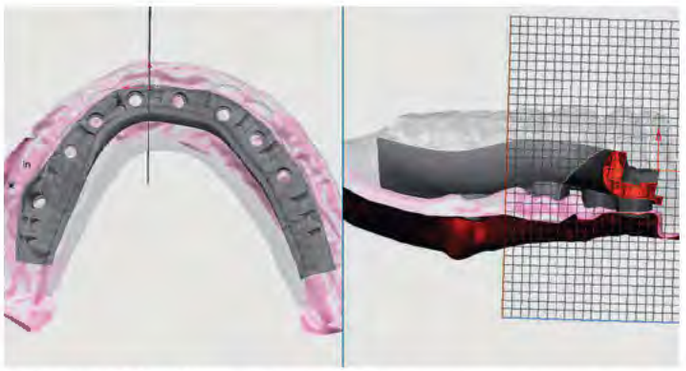


FIGURE 24-12. After verification of the wax try-in, the case is sent to Biomet-3i for bar fabrication. The cast and wax try-in are scanned into the computer. The bar is designed in computer-aided design (CAD) software on the virtual cast according to the specifications of the work order. (Courtesy Dr. Carl Drago, La Crosse, Wisc.)

framework does not seat completely passively, the dentist should determine the location of the stress point. The framework then is sectioned, and GC Pattern resin is used to connect the sections after the abutments have been seated and tightened with finger pressure. A wax or Poly Vinyl Siloxane (PVS) bite registration should be taken in the proper centric and vertical dimension, and the records should be transferred to an adjustable articulator with a facebow. The prosthetic technician then can fabricate the overstructure prescribed by the restorative dentist and return it to the dentist for insertion (Fig. 24-15).

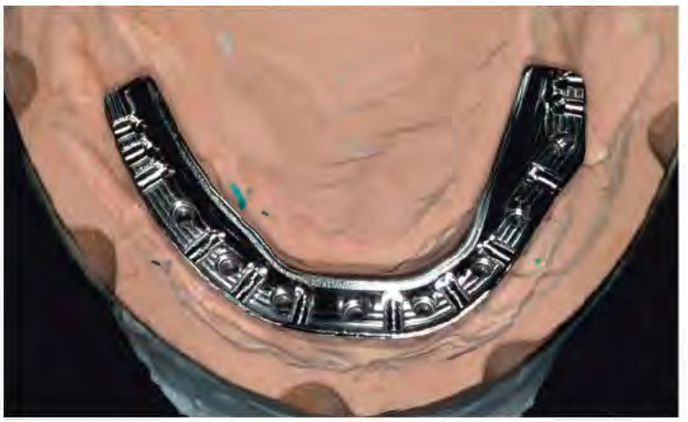


FIGURE 24-13. The design is transferred to the milling machine, and the bar is milled from a solid block of titanium alloy. The computer-aided machined (CAM) StructSURE Bar is milled with a raised lingual area for retention of the denture teeth and acrylic resin. The finished CAM StructSURE fixed hybrid prosthesis is returned to the laboratory. (Courtesy Dr. Carl Drago, La Crosse, Wisc.)

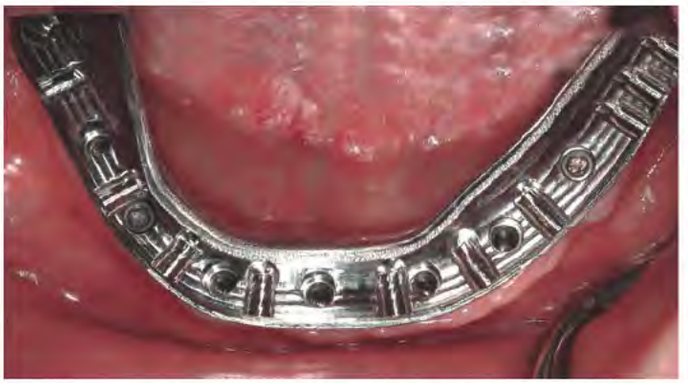


FIGURE 24-14. The CAM StructSURE Precision-Milled Bar is sent to the dental surgeon for the final try-in. After verification, the bar is returned to the laboratory, where it is opaqued, and the teeth are processed onto the bar with acrylic resin. The prosthesis is finished, polished, and returned to the surgeon. (Courtesy Dr. Carl Drago, La Crosse, Wisc.)

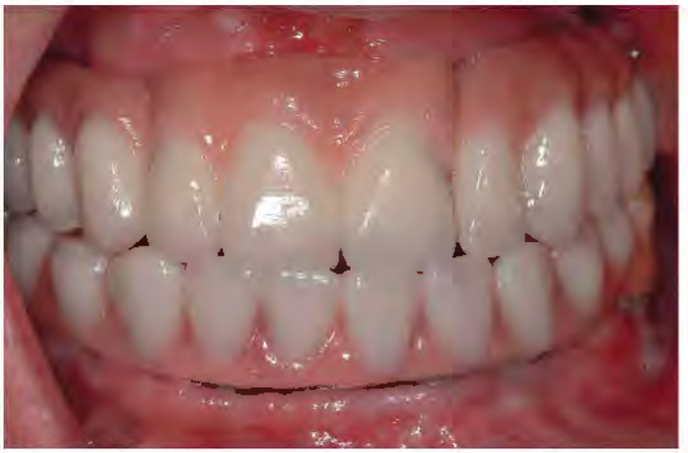


FIGURE 24-15. The healing abutments are removed from the implants. The fixed hybrid prosthesis is placed on the implants and secured with hexed Gold-Tite abutment screws torqued to 20 Ncm. (Courtesy Dr. Carl Drago, La Crosse, Wisc.)

Veneering Materials

Veneering materials include zirconium, porcelain, acrylic, and composite resins. Porcelain is used extensively in restorative procedures, because it is esthetic and reliably maintains its shape and color. However, porcelain and zirconium are hard, brittle, and resistant to repair. The larger an implant prosthesis, the less acceptable porcelain is as a veneering material. Nonetheless, porcelain has never been shown to be more destructive to supporting tissues because of its hardness; therefore it is not contraindicated for this reason.

Acrylic resins should not be used on occlusal surfaces because of their low resistance to abrasion. The singular advantage of the resins is that they are easily and readily repaired, and this can be done with prostheses fixed in position. Repairs on fixed-detachable prostheses are much less of a problem, regardless of the construction material.

Recent improvements in composite resins have made them stronger and quite resistant to abrasion. They are stable in color and readily repaired either in situ or on the bench. Composites such as Isosit are the most versatile and popular of the veneering materials for implant-borne, fixed superstructures.

As the number of splinted teeth increases, so does the likelihood that a restoration will not seat passively. Attention must be paid to the design of the framework. The benefits of clinical splinting should be evaluated and the number of splinted units minimized. At the try-in visit, a porcelain-metal bridge may not seat fully if the prosthesis is designed to fit below the gingival margins. The patient should be asked to bite gently but firmly on a cottonwood bite stick for 5 full minutes. If blanching of the soft tissues is noted, these tissues are preventing full seating of the restoration. If the blanching persists after 5 minutes, mesial and distal crevicular releasing incisions are made on either side of the blanched gingivae to allow them to receive the crown margins passively. If no blanching is seen but the restoration does not seat, the frame-to-abutment relationships should be re-examined. Baking porcelain sometimes causes the substrate to warp or distort. This can be checked by reseating the restoration on the verified analog cast.

The same strategy is followed for cementable and screw-retained restorations. With the latter, after the bite stick is used, continued, gentle, incremental screw tightening is used for 5 minutes until complete seating is accomplished. Surgical release of the tissues also may be required.

Topical or local anesthesia may be required when prostheses are seated. If doubt about complete seating arises, radiographs should be taken. The restoration should be evaluated for shade, shape, overall esthetics, emergence profile, embrasure design, ability to be cleaned, and occlusion (see Fig. 24-9, *F* to *I*). Light centric occlusion with balanced excursive contacts is desirable. If the restoration is going to be actively used for excursive function, canine guidance is desirable in lateral movements, and anterior guidance is required in protrusive movements. The closure of screw access holes is discussed in Chapter 23.

A measurable torque driver is recommended for applying torque to all screws. All screws should be a hex or other internal engaging design for ease of use with a screw hex, Allen wrench, or nut drivers.

A fixed bridge design is made to simulate natural teeth as they emerge from the soft tissue. The development of emergence through the soft tissues starts with selection of the abutment and the style of restoration. If implants are positioned very far lingually, such situations may not be possible. If implants are not placed below the level of the cementoenamel junction (CEJ) of adjacent teeth, esthetic restorations cannot be done without ridge lap acrylic additives. This requires frequent hygiene visits and more meticulous home care. Large embrasure areas are desirable and are more easily cleaned, but patients tend to accumulate food in these areas and object to them. These embrasures can be closed and completely obliterated, but they may not compress the soft tissues. They must allow the patient to pass floss and a Proxybrush beneath the ridge laps and adjacent to the abutments; in short, they are a poor but often necessary choice. As an adjunct that allows the embrasures to remain open, a Preat Gingivamoll soft prosthesis can be given to the patient for cosmetic use. The patient must remove this frequently at home for oral hygiene (Fig. 24-16).

Cantilevering

When at least five evenly distributed, root form implants 15 mm long are used in the anterior mandible, the maximum allowable extension is 15 mm cantilevered from the distal implant on either side. Cantilevering is discouraged in the maxilla, and it is absolutely contraindicated for blade implants.

Fixed-Detachable Superstructures

A fixed-detachable prosthesis can be designed in two basic forms. One is the traditional high-water hybrid design introduced by the Brånemark group. The other is the unit type or anatomic fixed bridge prosthesis, which can be used only if the implants are placed accurately in natural tooth positions at the time of surgery. The latter technique is successful only if the prosthetic workup was impeccable, and placement of the implants was determined carefully through the use of a surgical template (see Chapter 4).

High-Water Hybrid Design

The high-water hybrid design allows more flexibility when implants have been placed at irregular intervals or at nonconforming angles. The techniques for design fabrication are described in Chapter 25.

Insertion of the Prosthesis

After the finished prosthesis has been completed and inserted, all occlusal contacts are checked and necessary corrections are made. Oral hygiene procedures are reviewed with the patient, and the practitioner makes sure that the patient is able to maintain a high level of cleanliness (see Chapter 29).

Covering Screw Holes in a Fixed-Detachable Bridge

When the bridge is first inserted, the screw openings are not covered with a polymeric composite or cement. If the bridge must be removed for adjustments, the masking material adds a considerable amount of chair time.

Once the surgeon and patient are satisfied with the prosthesis and the patient has demonstrated the ability to maintain a satisfactory level of oral hygiene, the crowns are affixed with screws, which are tightened to the manufacturer's recommended level with a torque wrench, and the screw access openings are covered with self-curing or light-cured composite resin. The resin is placed in the opening only after the screw slots have been blocked out with temporary stopping, cotton, Cavit, gutta percha, or Fermit (Fig. 24-17).

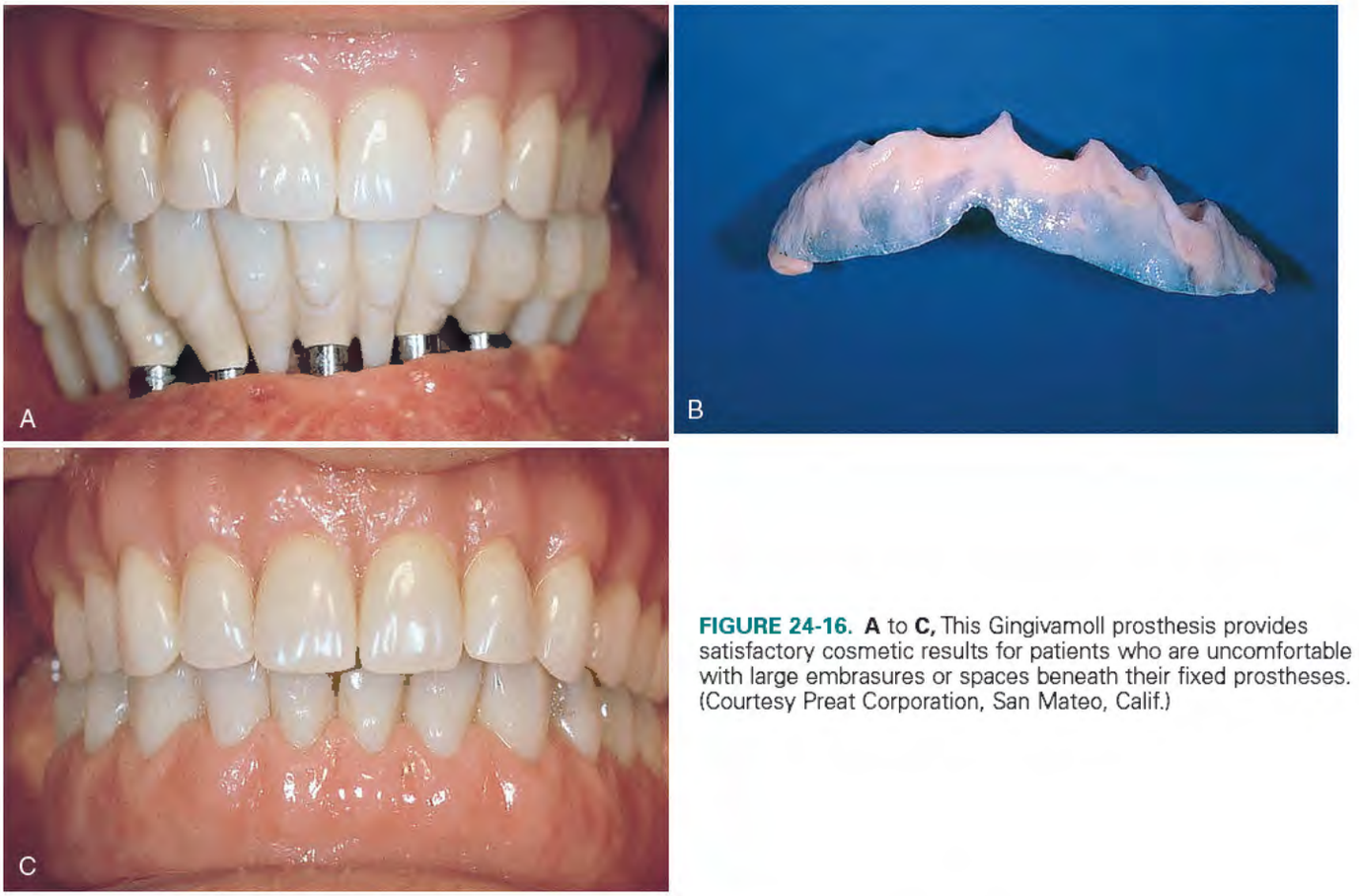


FIGURE 24-16. **A** to **C,** This Gingivamoll prosthesis provides satisfactory cosmetic results for patients who are uncomfortable with large embrasures or spaces beneath their fixed prostheses. (Courtesy Preat Corporation, San Mateo, Calif.)

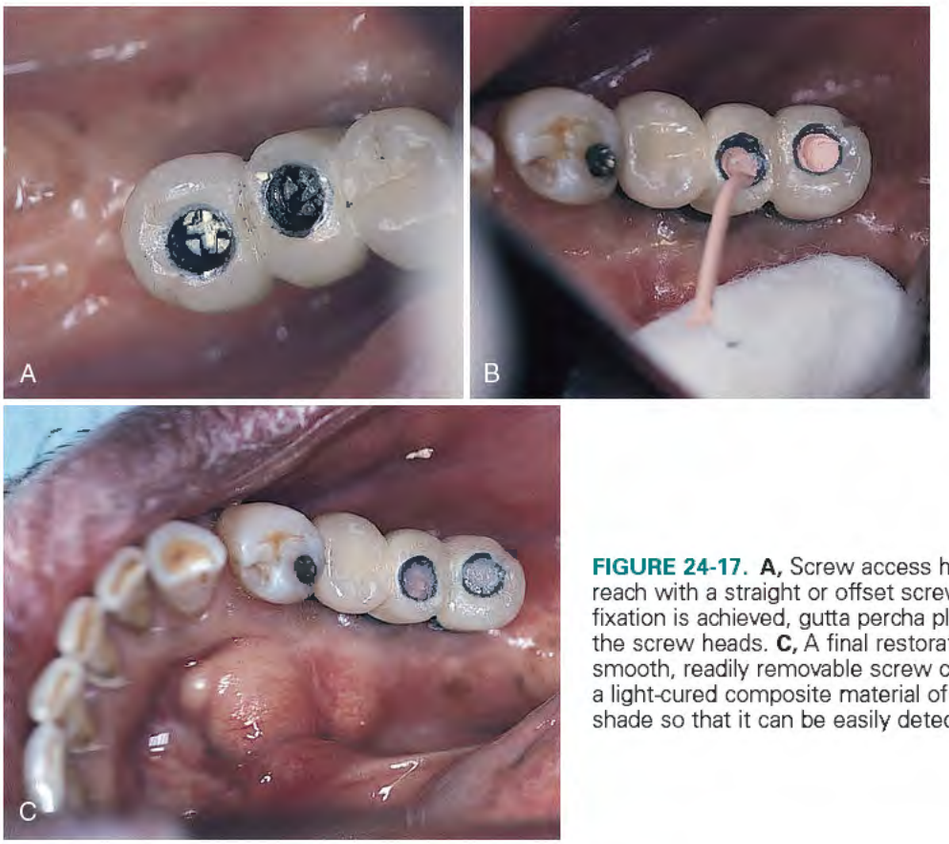


FIGURE 24-17. **A,** Screw access holes must be easy to reach with a straight or offset screwdriver. **B,** After screw fixation is achieved, gutta percha plugs are used to cover the screw heads. **C,** A final restoration with esthetic, smooth, readily removable screw covers are achieved with a light-cured composite material of a slightly different shade so that it can be easily detected.

This prevents damage to the screw slot when the composite is drilled out in the future because retrieval is required.

Implaseal, a nonhardening grout, serves as a hygienic sealant when placed beneath crowns before screw fixation. In some cases, screws loosen repeatedly. This annoying development can be forestalled by the use of Loctite, Implaseal, or Cekabond. These sealing materials are nonirritating, and they discourage the screws from backing out spontaneously, without creating difficulties at times of removal. The sealant, which pulls away easily from the screw threads, must be renewed whenever it is removed.

Cementation

The final cementable fixed prosthesis can be inserted with a soft, temporary cement initially and maintained in this fashion indefinitely if the surgeon and patient so choose. Temporarily cemented prostheses must be removed regularly, particularly when natural teeth are involved, to check for cement washout. Whenever possible, all natural teeth should be protected with individual telescopic gold copings, which are placed with a permanent cement. After a trial of 2 to 4 weeks, the prosthesis is cemented permanently in the conventional manner.

Implant Prosthodontics: Design and Fabrication of a Hybrid Bridge Fixed-Detachable Prosthesis

25 CHAPTER

FULLY EDENTULOUS ARCH

The hybrid bridge is a fixed bridge made of denture teeth processed to a cast metal barlike framework. The prosthesis must be screw retained, and it usually is used in completely edentulous arches. The prognosis is best when the opposing arch is a complete denture or another hybrid bridge.

Mandibular prostheses require a minimum of five implants; maxillary hybrid bridges require six, or preferably more. The more maxillary root form implants placed (even up to 12), the better the prognosis. The hybrid bridge is a less costly bridge to make, and it is less demanding to fabricate than fixed or fixed-detachable prostheses. It is useful for patients with significant loss of alveolar dimension, whose teeth would appear unrealistically long if a conventional construction technique were used. The most valuable benefit of the hybrid bridge is that it serves well both functionally and cosmetically when implant emergence angles prohibit classic construction techniques.

Provisional Restoration

The completely edentulous jaw can be restored with one of two types of provisional prostheses before and during implant treatment. The provisional restorations may be complete removable dentures or provisional fixed bridges made subsequent to the second stage of surgery. Chapter 21 describes in detail the manner in which any of the designs selected for patient comfort can be fabricated.

Surgical Template

A surgical template is necessary to place and position implants accurately and predictably. The surgical template for a hybrid bridge should show what the final prosthesis will look like, including buccal position, incisal edge position, overall height, and cingulum and occlusal areas of the teeth. If the patient is wearing a denture in which tooth positions are to be replicated, this denture is used as a guide for construction of the surgical template. If a change in tooth positioning is planned, a trial denture is constructed that demonstrates the new dental alignment, and it is used for template duplication. Chapter 20 presents the techniques for fabricating surgical templates.

Abutment Selection

After the implants have been exposed and the healing collars removed, the abutments are chosen. Shouldered, standard, or conical abutments are used for hybrid bridges (see Chapter 22). The abutments act as platforms on which the hybrid bridge framework seats. Abutments of a height that places their interfaces with the hybrid cast framework at the level of the soft tissue should be selected. This allows the prosthesis to be adapted to the soft tissues, blocking out all spaces. It also helps prevent food from becoming lodged beneath the framework, and neither saliva nor air can escape from beneath the ridge lap. The soft tissue beneath the hybrid frame is sufficiently compliant to allow a Proxybrush to perform successful ablutions.

Abutments can be fitted directly in the patient's mouth or from the master cast after impressions are completed. After the abutments have been firmly placed with a recommended torque wrench, impressions are made using the square or tapered coping techniques described in Chapter 24 (Fig. 25-1, *A* to *K*).

Prosthetic Technique

Chapter 24 presents the technique for computer-aided design/computer-aided manufacture (CAD/CAM) fabrication of the abutment-supported bar.

The final casts are completed by using analogs on which the final hybrid bar is fabricated. The guidelines presented in Chapter 21 are followed to convert temporization from a relined overdenture to an interim fixed prosthesis.

Screw-retained provisionals may use temporary cylinders that seat directly on the implant head or on top of a final abutment. A hole is made completely through the provisional restoration to allow the chimney of the abutment cylinder to pass through it or at least to be seen through it; this provides access to the retaining screw. The cylinder is processed to the provisional restoration with self-curing acrylic directly in the patient's mouth. Care must be taken when luting the cylinders. Using small paintbrush acrylic slurry increments prevents filling of the screw access holes. Also, a cotton pellet is placed in each screw access hole to protect the screw heads from becoming covered. Wax is an unsuitable blocking agent, because it dissolves when the monomer comes in contact with it.

After the cylinders have been tacked into position, the acrylic is allowed to set for 10 minutes. Removing the temporary before chemical stabilization causes shrinkage, which hampers accuracy.

Once the master cast has been trimmed, a verification jig is made. The verification tip is made by luting together cylinders or transfer copings placed in the master cast. GC Pattern may be used to lute them together. The luted assembly then is tried-in on top of the implant abutments. Only one screw is inserted and tightened. All the abutment coping interfaces are then examined for complete passive seating. If any joint is open, the assembly is cut with a thin disc, the coping with its retaining screws is seated, and the assembly is luted together again. The master cast is modified by repositioning the analog, or a series of analogs is attached to the assembly and placed in die stone to create a solder index. When the assembly fits passively, the final hybrid bar is fabricated on the master cast (Fig. 25-1, *L* to *O*).

The maxillary cast is mounted to a semiadjustable articulator with the facebow record, and the mandibular cast is mounted to the maxillary cast using the centric-oriented record base. The appropriate

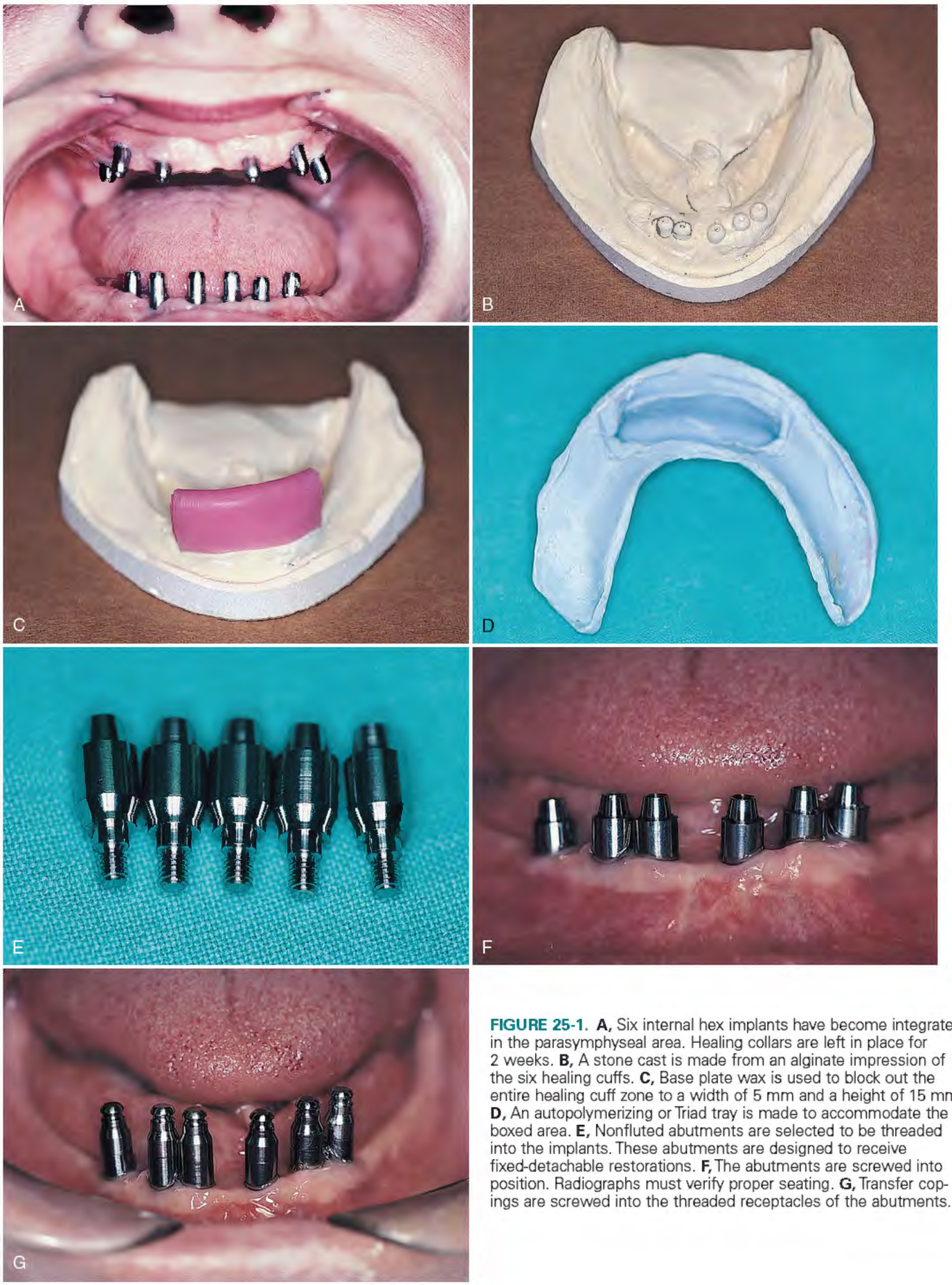
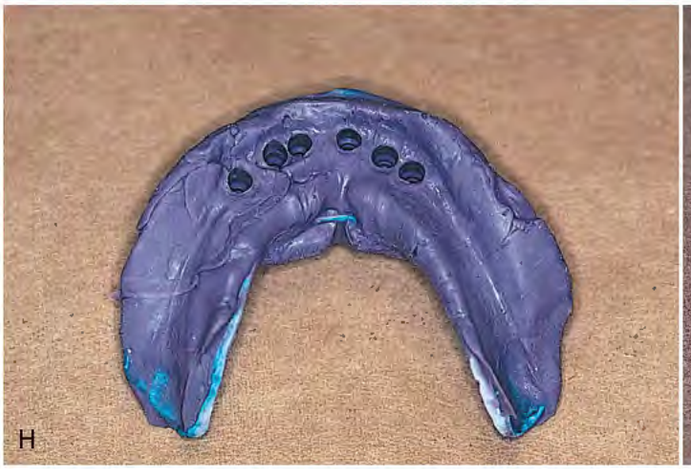
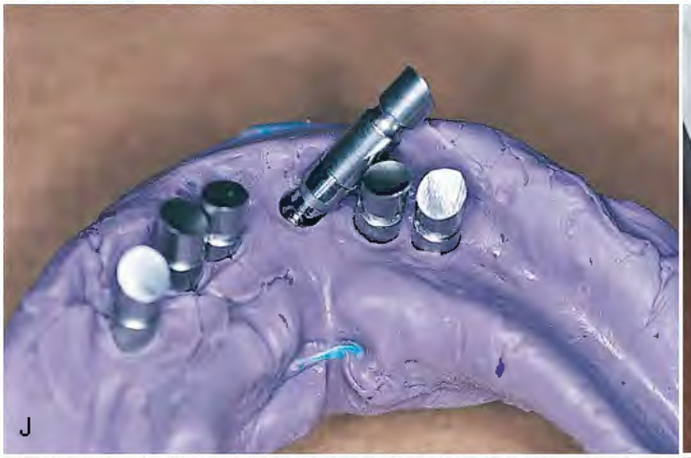
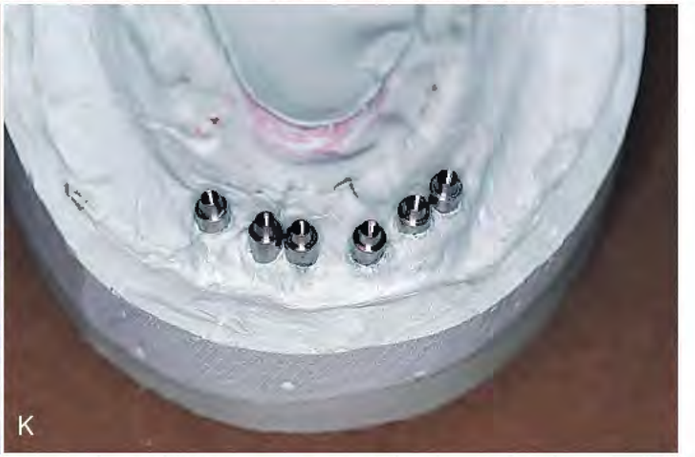


FIGURE 25-1. **A,** Six internal hex implants have become integrated in the parasymphyseal area. Healing collars are left in place for 2 weeks. **B,** A stone cast is made from an alginate impression of the six healing cuffs. **C,** Base plate wax is used to block out the entire healing cuff zone to a width of 5 mm and a height of 15 mm. **D,** An autopolymerizing or Triad tray is made to accommodate the boxed area. **E,** Nonfluted abutments are selected to be threaded into the implants. These abutments are designed to receive fixed-detachable restorations. **F,** The abutments are screwed into position. Radiographs must verify proper seating. **G,** Transfer copings are screwed into the threaded receptacles of the abutments.







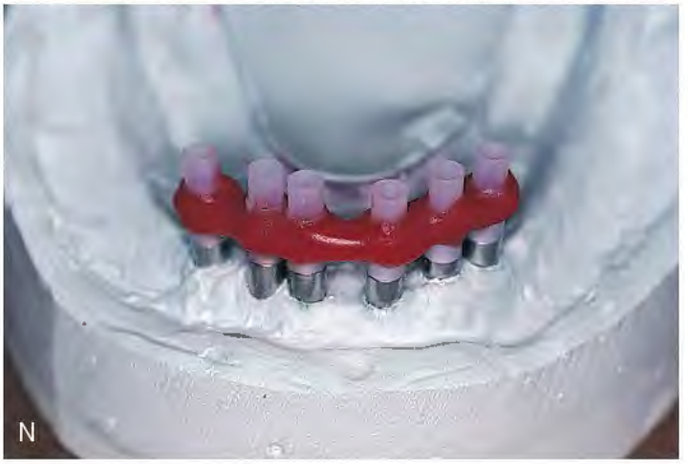


FIGURE 25-1, cont'd. H, An Impregum impression is made to register the position of the transfer copings. **I,** Each transfer coping is supplied with a prosthetic abutment analog *(left)*. The coping and the abutment are connected by a threaded feature *(right)*. **J,** Each transfer coping–abutment analog complex is fitted into the Impregum impression, as can be seen by the positioning of the right central incisor. **K,** A master cast is poured in stone. The prosthetic abutment analogs are replicated in their true anatomic positions. **L,** Each abutment has a plastic waxing sleeve available, which is affixed to the analog with a coping screw. **M,** After the surfaces of the waxing sleeves have been abraded, each sleeve is screwed into position on the cast. **N,** A verification jig is fabricated using GC Pattern or Duralay resin, which bonds mechanically to the abraded sleeve surfaces. This is used to stabilize the sleeves during the refitting maneuver over the actual implants in the patient's mouth.

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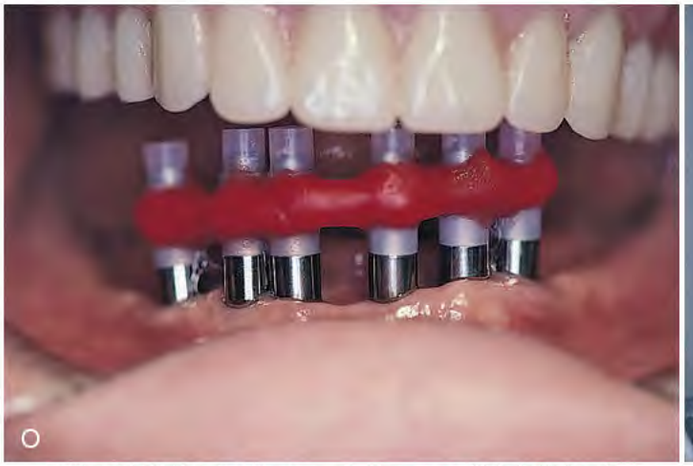

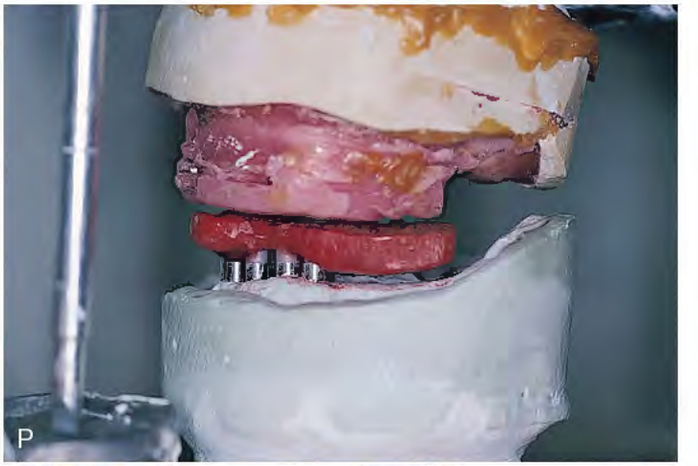

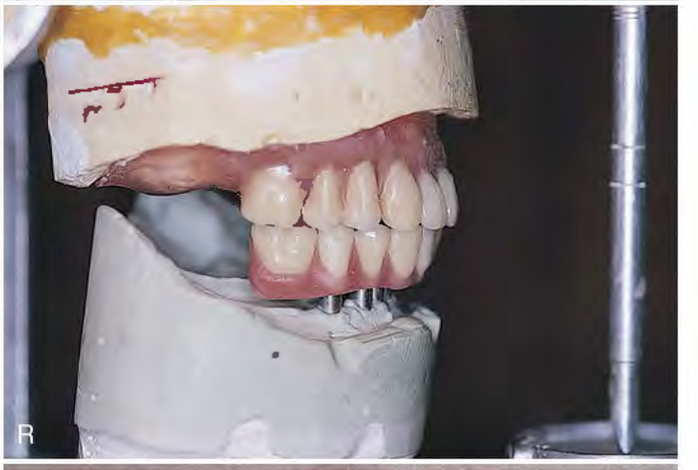

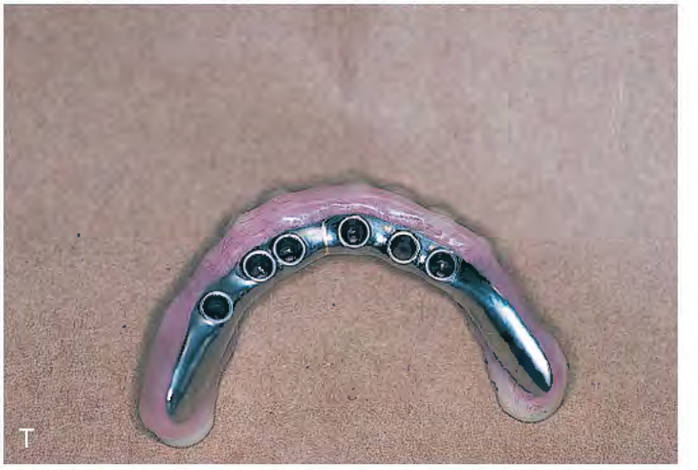

FIGURE 25-1, cont'd. O, Placement of a single distal fixation screw should allow the entire complex to fit intimately and accurately into place without torquing or lifting. **P,** The verification jig and abutment assembly is replaced on the master cast, and a wax rim is made to fit over the GC Pattern resin. **Q,** Vertical and centric recordings are registered using the rim. **R,** The casts are affixed to a semiadjustable articulator, and teeth are set in wax with respect to incisal length, midline, labial position, and inclination. **S,** A silicone impression of the trial bridge is made on the master cast. Each tooth is removed from the wax-up and seated in the silicone index. This guides the location of the waxed superstructure in relation to the teeth borne by it. **T,** The surface of the completed prosthesis is designed for access and easy cleaning. **U,** The location of the fixation screws creates an esthetic and functional result.

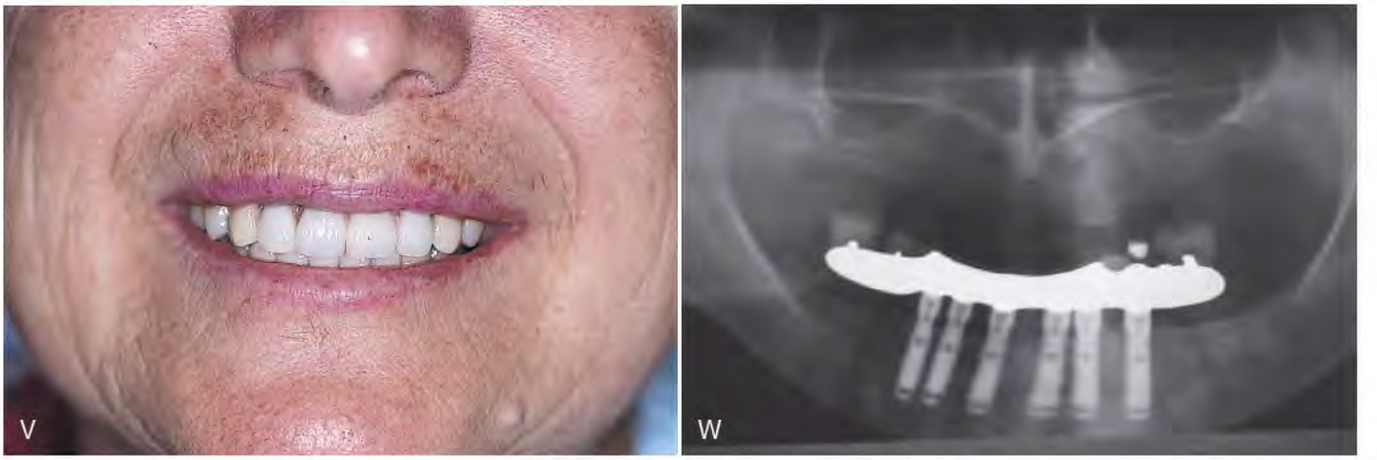

FIGURE 25-1, cont'd. V and **W,** The hybrid superstructure, both clinically and radiographically, reveals an esthetic prosthesis that has become an integral component of the patient's masticatory apparatus.

teeth are set on the record base, and a try-in follows. The centric relation, vertical dimension, and overall esthetic appearance must be verified (Fig. 25-1, *P* to *R*).

Once the tooth try-in is complete, the metal framework to support the restoration is fabricated. The laboratory makes a silicone index of the tooth position and its relationship to the master cast (Fig. 25-1, *S*). The frame is waxed in relationship to the tooth position. The framework is designed to support denture teeth that are processed to it and to include female receptacles through which fixation screws are placed and activated. To fabricate this, gold copings are fitted to each flat or tapered abutment analog and incorporated into a waxed outline of the bar. A precious metal casting (platinum, palladium, or gold) is made with retention loops for acrylic attachment.

After the casting has been given a high polish, the following requirements are confirmed: The metal frame should come down to touch the alveolar ridge adjacent to the implants and may extend posteriorly in the mandible 15 mm distal from the most posterior implant abutment. In the maxillae, cantilevers must be avoided.

Metal Framework Try-in

The metal framework is seated in position over the abutments, and one screw of the most distal abutment on one side is inserted and tightened with a torque driver. All abutment-framework interfacial relationships are evaluated clinically; if they are not easily visible, they are evaluated radiographically. The framework should be seated on all abutments. The screw is then loosened, and a second screw on the other end of the frame is tightened. The same criteria must be satisfied. Now all the screws are inserted and tightened to finalize the assessment of accurate fit. The framework is removed, and the protective caps are replaced on the abutments. If the framework does not seat passively (i.e., one or more interfaces show gaps), it is sectioned and reconnected until it is satisfactory.

When the metal framework is acceptable, it is returned to the laboratory so that the denture teeth can be set and the final wax-up done. The hybrid bar is tried-in with teeth in the patient's mouth, and the centric relation, vertical dimension, and esthetics are confirmed. The final laboratory task is the processing of the denture teeth to the metal frame with acrylic (Fig. 25-1, *T* to *W*).

Insertion

At the last clinical visit, the abutments are torqued down to the manufacturer's recommended levels, and the completed prosthesis is inserted over the abutments. All the screws are inserted and tightened, and the tissue contact is evaluated. It is considered satisfactory if no space is visible between the prosthesis and the alveolar ridge, but floss can be passed beneath the prosthesis (Figs. 25-2 and 25-3).

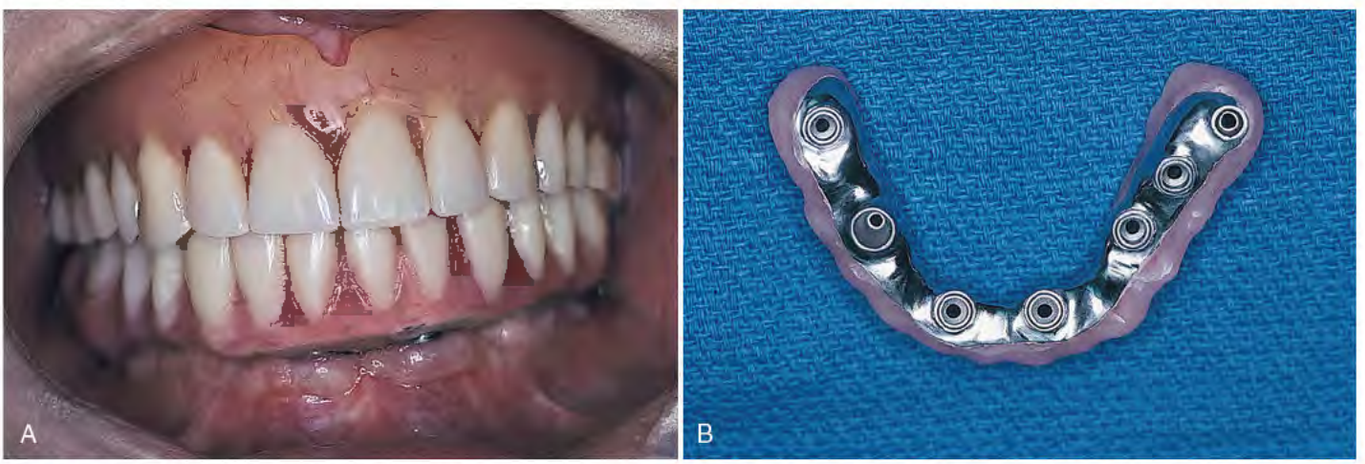

FIGURE 25-2. A and **B,** The cast metal hybrid framework can be designed to touch the gingival tissues as long as it can be hygienically cleaned.

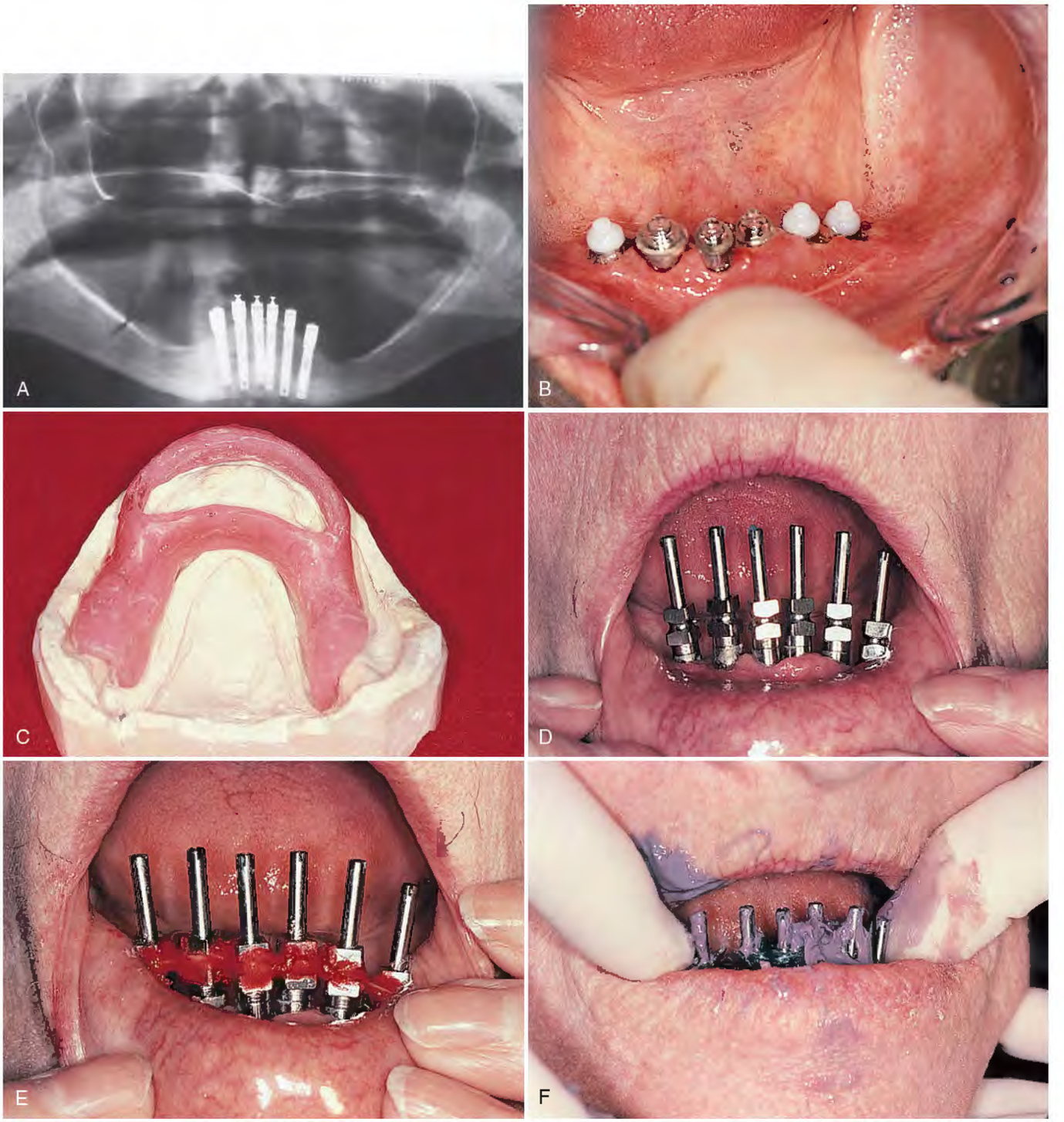

FIGURE 25-3. **A,** A radiograph of six parasymphyseal, well-integrated, Brånemark implants. The transepithelial abutment (TEA) is screwed into place in each implant. **B,** Clinical view of Brånemark implants with attached TEAs. Three are covered by healing caps. These caps offer a smooth, plaque-free surface during construction of the prosthesis. **C,** Impression making begins with the fabrication of a well-extended autopolymerized tray. The fenestration permits access to the implant sites. **D,** The healing caps are removed, and square transfer copings are screwed to the TEAs using long, threaded guide pins. **E,** A figure-8 continuous floss lattice is covered with GC Pattern or red Duralay, assembling the six-abutment complex. **F,** When the tray is seated, the guide pins protrude through the chimney fenestration. Next, a piece of softened base plate wax is pressed over the pins, sealing the tray and creating a means of compressing the impression material around the implants. When these steps have been completed, the tray is removed, and polyether (Impregum) is used to record the final impression. Some of the material escapes from around the guide pin access holes.

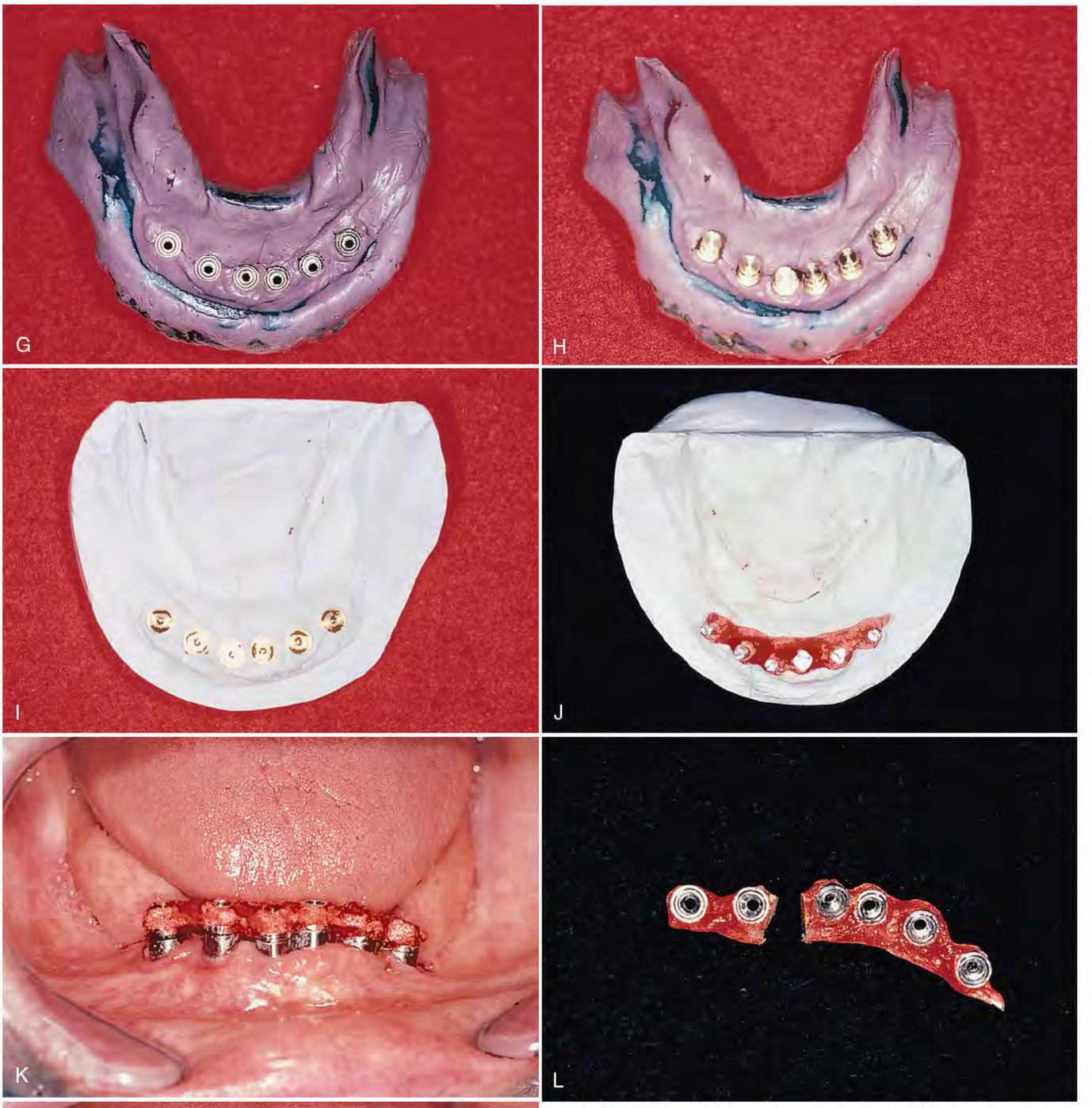

FIGURE 25-3, cont'd. G, After the polyether has set, the protruding pins are unscrewed, allowing removal of the impression tray; the transfer copings, bound with acrylic and floss, are retained in the impression material. **H,** A brass abutment analog is attached to each transfer coping. The master cast is then poured, accurately relating the abutment analogs to one another and to the other anatomic structures. **I,** The master cast is poured, thus relating the abutment analogs to one another and to the other anatomic structures with accuracy. **J,** The final gold copings, supplied by Nobel Biocare, are placed on the analogs. They are luted with GC Pattern resin and, on their removal in a single unit, they are tried into the mouth for verification of cast accuracy. They are removed in a single unit and tried in the patient's mouth to verify the accuracy of the cast. **K,** In some cases, accuracy is not achieved. In this case, for example, the gold copings on the patient's right side obviously have not gone into position. **L,** The assemblage is removed, and a disc is used to section it at the point of suspected error. **M,** The two parts are seated successfully, as can be seen from the precise marginal relationships of all the gold copings. Strategically placed guide pins hold the segments securely in position while new GC Pattern material is used to relute the parts.

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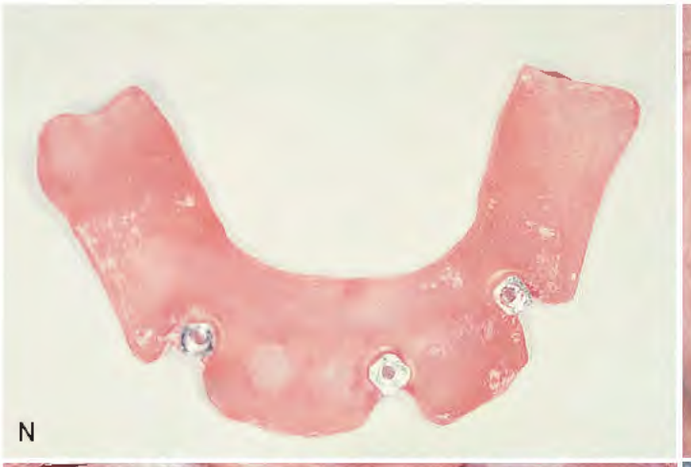
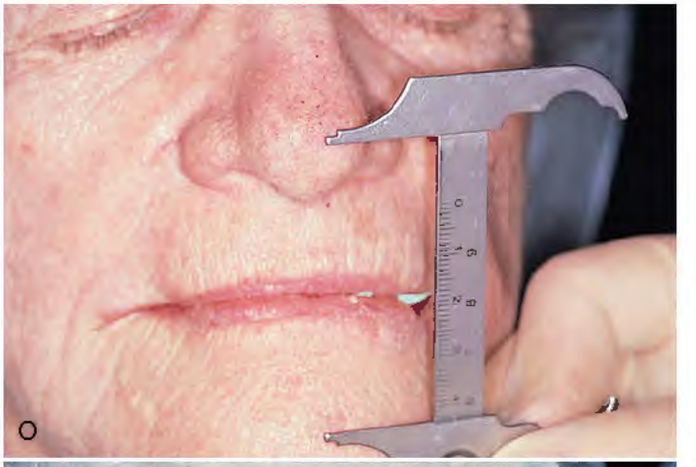
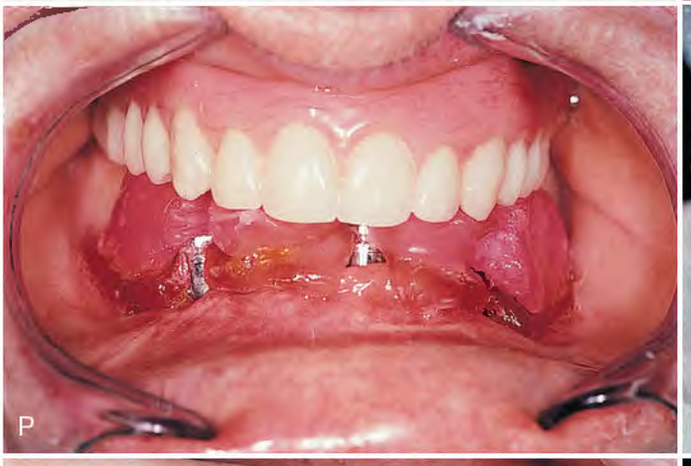
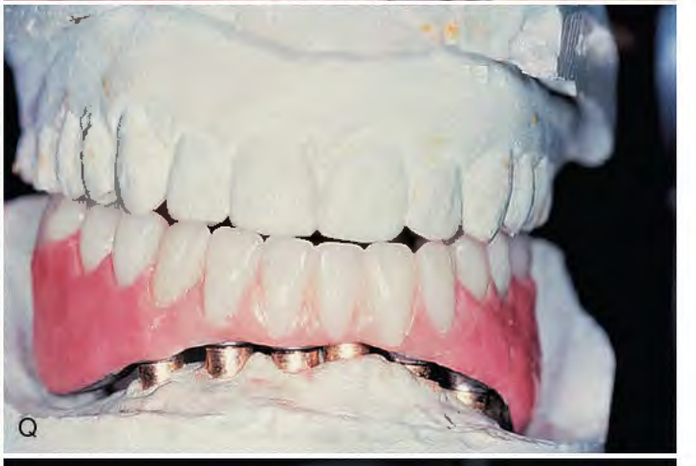
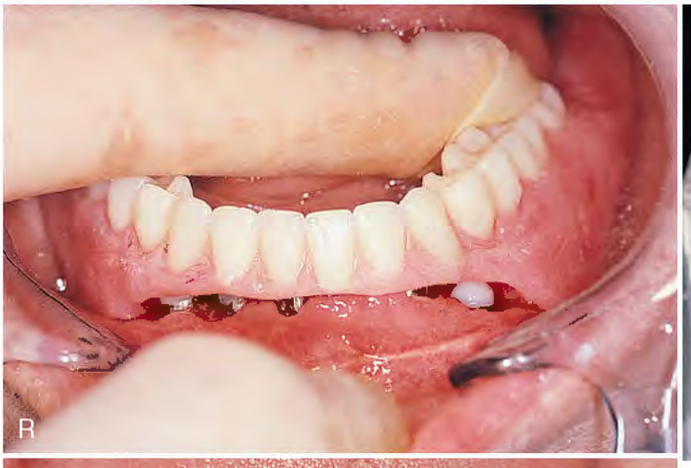
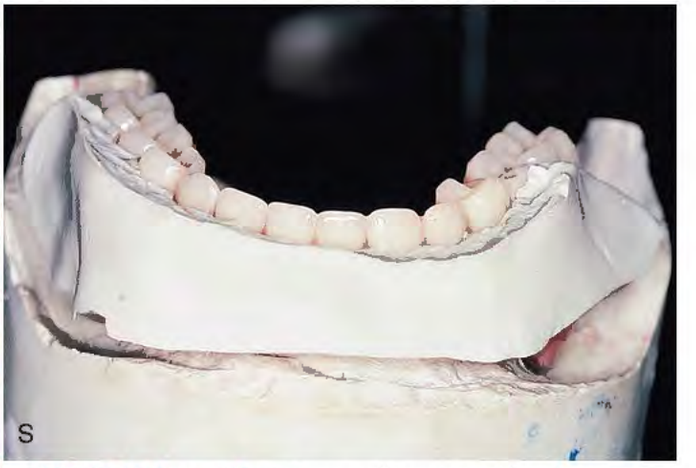












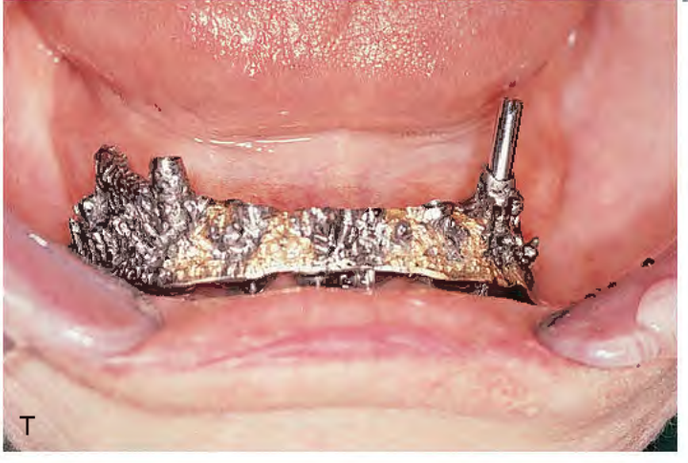


FIGURE 25-3, cont'd. N, Three well-located gold copings are processed into a final record base. This allows the base plate to be affixed firmly in place, ensuring accurate vertical and centric relationships. **O,** Classic prosthodontic techniques are used, including assessment of anatomic distances and relationships. **P,** Centric and vertical dimension recordings are made. **Q,** The teeth are selected and set into wax using a semiadjustable articulator. **R,** The patient is given the opportunity to evaluate the esthetic aspects of the prosthesis during the same visit at which the practitioner assesses function. **S,** Polyvinylsiloxane putty is used to make an impression of the labial surfaces of the teeth and denture base. After it has been removed, the denture base is unscrewed, the teeth are set into the putty, and the gold copings are placed in position on the abutment analogs. A bar incorporating the copings and the putty impression, with teeth in place, is waxed and used to determine the shape and size of the bar. **T,** After the bar has been cast, it is placed over the implants and retained with a single screw. This allows testing for total passivity during seating.

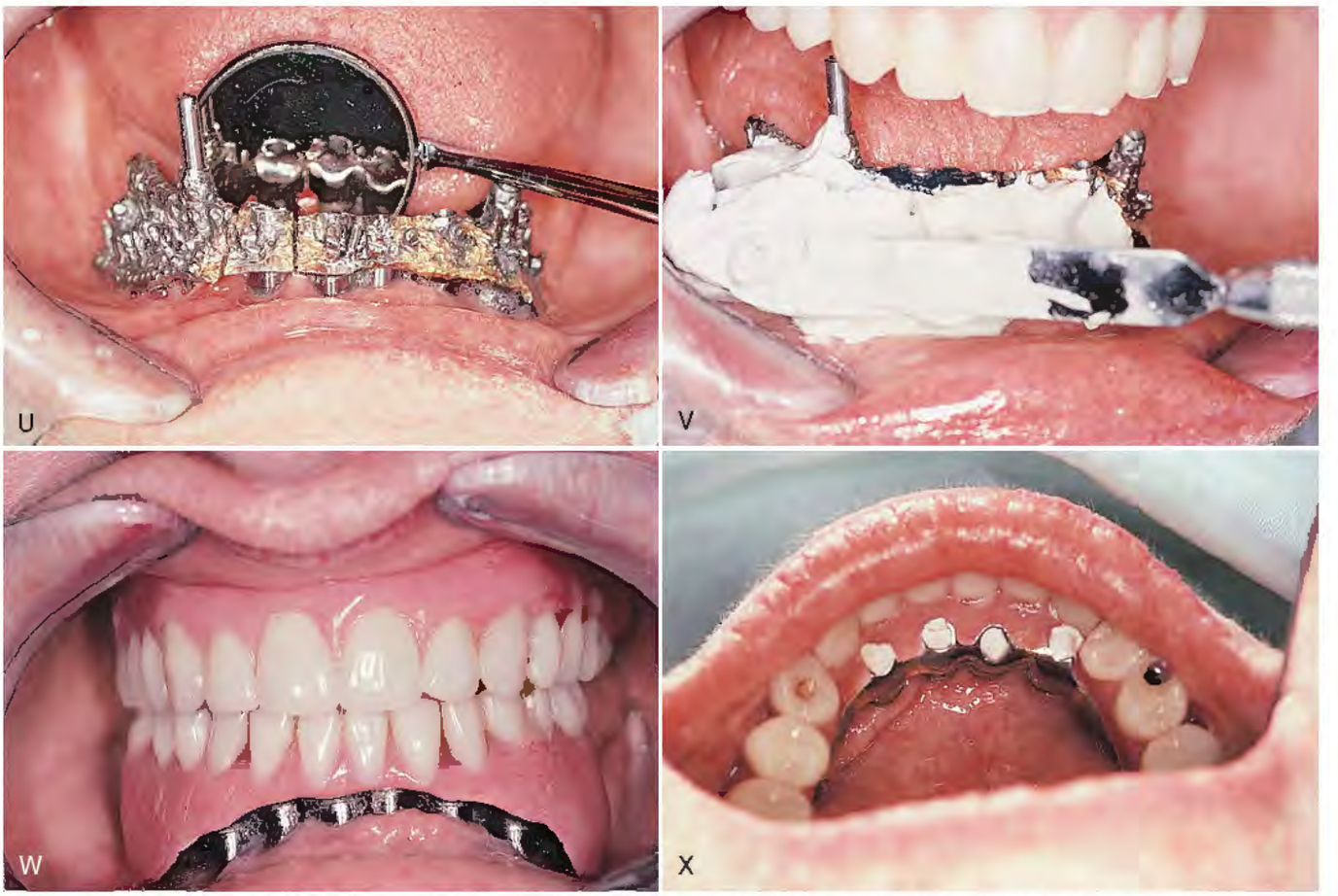


FIGURE 25-3, cont'd. U, If seating is inaccurate, the bar is cut, and a plastic index is used for reassembly. **V,** A plaster index is an effective means of making a solder index. **W,** The labial flange is trimmed away aggressively to facilitate hygiene and observation. **X,** From the occlusolingual view, the fixation screws are well concealed, easy to clean, and accessible for removal and replacement. Temporary filling may be used to cover the screws during the early trial visits.

Occlusion

Occlusion is evaluated after fixation of the hybrid. Even contact should be seen on all the teeth in centric relation. A mutually guided occlusion is developed in lateral excursive movements, placing the canine and incisors on the working side into function. Anterior guidance should be present in protrusive movements.

The prosthesis is removed and polished. It then is reinserted with all screws placed to their manufacturer's suggested levels with a torque controller. The screw access holes may be covered with a cotton pellet and temporary sealing material (e.g., Fermit-N). Final radiographs, panoramic and periapical, are taken at the time of completion to document the condition of the implants and adjacent bone, as well as the seating of all components. These radiographs also serve as a baseline for future comparisons.

An appointment is made with the patient for examination in 1 month. At that time, the prosthesis is re-evaluated with regard to esthetics, occlusion, and the patient's ability to maintain good oral hygiene. If all these aspects are satisfactory, the screw access holes are closed definitively with composite material. A cotton pellet is placed over the screw, and Fermit-N is light-processed to it to protect it. About 4 mm of the coronal access chamber is left clear. The metal is etched, and a primer and bonding agent are placed, followed by a light-cured composite, which can be blended with the occlusal restorative material. The occlusion is rechecked, and the composite is polished.

PARTIALLY EDENTULOUS ARCH

A fixed-detachable hybrid can be beneficial for restoration of partially edentulous sites as well as for a fully edentulous jaw. Hybrids and adaptations can solve problems of implant placement, location, angulation, and emergence profile, problems that might render the implants useless if conventional fixed or fixed-detachable techniques were used. The hybrid design can be used to replace any number of missing teeth beyond one.

The principles governing presurgical planning, fabrication of temporary prostheses, and surgical templates are described clearly in Chapters 5 and 20. Implant placement must be optimal, using as many implants as practicable. The decision to use the hybrid often can be made by careful analysis at the treatment planning stage (Fig. 25-4).

The technique for bar fabrication follows the methods described for the fully edentulous arch in every detail. With a partially edentulous arch, the presence of natural teeth facilitates record making, which offers guidance as to centric relationship, vertical dimension, free-way space, and tooth alignment.

After the implants have been exposed, and the gingival contours have been allowed to mature, the final flat or tapered abutments are screwed into place with a wrench set to the recommended torque. Square or tapered abutment transfer copings are affixed with secondary screws, again with appropriately applied force, and an elastomeric impression is made. The accuracy of the copings' positions

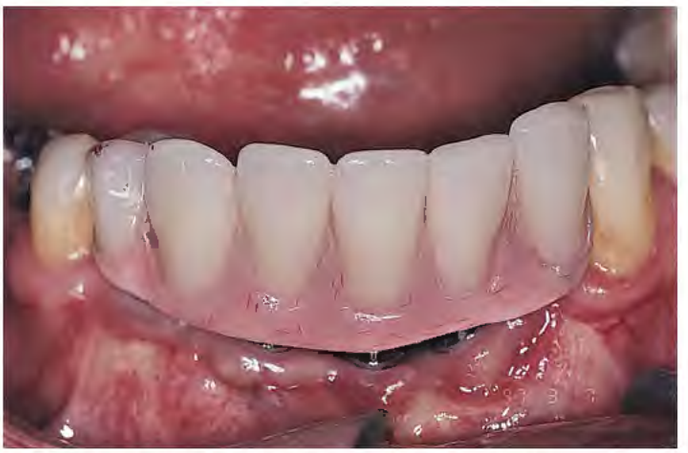


FIGURE 25-4. The hybrid bridge can be a functional, low-cost, fixed prosthesis for a partially edentulous arch.

in the impression is confirmed by inspection; then, the abutment analogs are attached, and the cast is poured in stone.

A semianatomic articulator facebow mounting is made. The accuracy of the articulator relationship is verified by analyzing dental wear facets or by using tooth-mounted wax rims on base plates. The prosthesis is waxed and then cast in a precious alloy as described earlier.

The accuracy of ridge lap relationships and implant interfaces is validated by inspection and by alternating individual placement of fixation screws. Sectioning is performed if an inaccuracy, such as rocking, is detected. The segments are luted with GC Pattern and solder for reconnection.

When the bar fits properly, the teeth are waxed to it, gingival contours are corrected, and the prosthesis is placed and then screwed into position. The design of partial hybrid dentures allows successful daily hygiene by the patient and periodic removal by the implantologist for maintenance and repair.

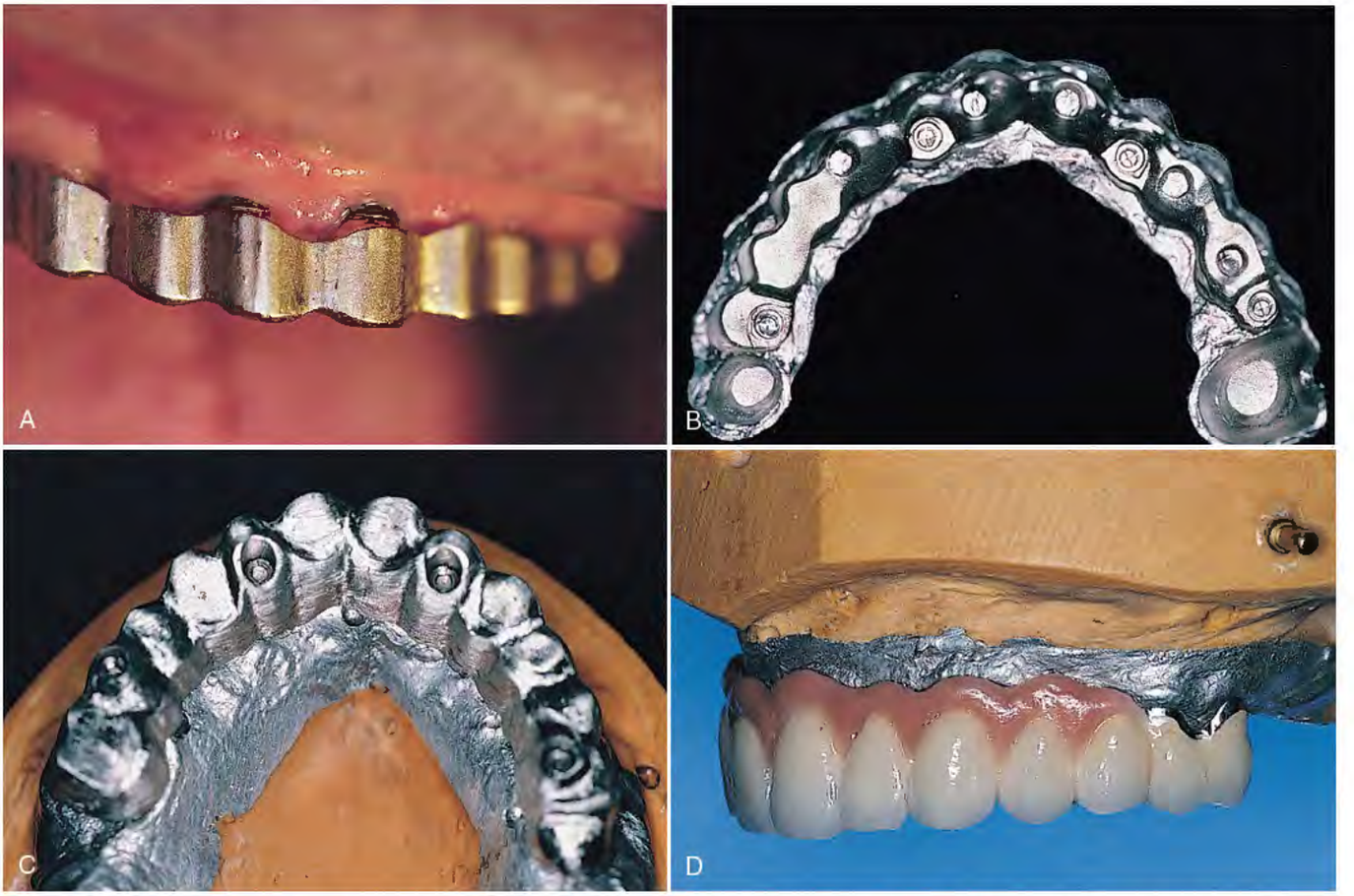


FIGURE 25-5. **A,** Electron discharge machining or spark erosion techniques were used to mill this mesostructure bar, shown attached to implants with fixation screws. **B,** The armature (i.e., the skeleton to which the porcelain is baked and the denture teeth are processed) is milled intimately to fit by a precise frictional relationship to the mesostructure bar. **C,** The external surface of this structure is prepared to receive the processed prosthesis. **D,** The completed spark erosion–fabricated mesostructure bar, with a totally porcelain-baked superstructure, can be maintained by a frictional relationship. If additional retention is desired, strategically related latches, such as Ceka-like attachments, can be used. (Courtesy Dr. Aram Sirakian).

Electronic Discharge Machining (Spark Erosion)

Electronic discharge machining (EDM), or spark erosion, uses milling and electrical technology to create hybrid-type overdentures that seat with precision on mesostructure bars attached by screw retention to implants. These prostheses are designed for pure implant support and may serve as replacements for all or several missing teeth. They offer excellent mechanical retention and a flange-free construction, facilitating oral hygiene measures. The accuracy of the machined fit between the 2-degree tapered bar and its matching female component is within 10 μm. Despite its initial cost and the demands of prosthetic skill, the spark erosion hybrid prosthesis offers the benefits of simple placement and removal; stable, firm retention; and elimination of screws for fixation.

Fabrication of this system requires completion of a primary cast mesostructure bar, machined facially and lingually, the sides of which converge with a 2-degree taper (Fig. 25-5, *A*). Bars made by the spark erosion technique are shaped and machined without heat and are designed to be attached to a number of well-placed implants by screw fixation. Because of the special demands placed on this retention system, the number of implants should be the same as are ordinarily placed for fixed prosthesis support.

Impressions are made for bar fabrication according to the steps presented earlier for hybrid bar construction. When the impression is boxed, sufficient labial room must be allowed for placement of a facial index, which should be made from the interim denture. Its position determines the height and location of the machined bar.

The bar must satisfy the requirements for a flawless fit; if it does not, the classic corrective measures of verification are required (see Chapter 24). Once fitted, the bar is screwed firmly atop the supporting implant abutments.

The denture/hybrid superstructure is designed with the assistance of the index and is cast in a precious metal with a high platinum content. Its transfer to the master cast with the primary bar positioned on the implant/coping analogs confirms the accuracy of casting. Then, using a reverse polarity ionization technique, the electronic erosion of the secondary bar is completed (Fig. 25-5, *B* and *C*). Secondary retention is achieved with two or more Ceka-like attachments or simple swivel latches to obtain primary retention from the precise relationship of the bar and a number of strategically placed vertical fins.

After final precision milling, the denture teeth are set and processed, hybrid fashion, to the secondary bar. As an alternative, the prosthesis can be made of teeth and gingiva from fused porcelain (Fig. 25-5, *D*). The prosthesis is adjusted intraorally, and the patient is trained in removal and insertion techniques, as well as oral hygiene measures. This is an extremely satisfactory alternative method for affixing hybrid prostheses to their supporting implants.

Implant Prosthodontics: Overdentures and Their Mesostructure Bars

26 CHAPTER

Overdentures are the recommended prostheses for many types of implant systems and are relatively economical and easy to use. Proper positioning of a mesostructure bar is essential to a successful result with overdentures, both esthetically and functionally, and for complete subperiosteal, ramus frame, transosteal, or root form implants. If the bar is in an inappropriate location (e.g., impinging on the tongue space or placed too far labially, creating an unesthetic or dysfunctional condition), a surgically acceptable implant may not be restorable. In addition, if inadequate vertical dimension has been left for construction of the overdenture, successful use of the implant may be impossible.

The preoperative procedure of making a surgical template (see Chapters 4 and 20) should serve as a guide for the placement of a bar or implants designed to hold a bar in the optimum position. The template can be used at the time of surgery to guide the placement of transosteal, blade, and root form or ramus frame implants, at least within the limits of the available bone. It also can be used after implant integration to guide placement of the bar. Furthermore, after making a template, the dental surgeon may realize that the procedure must be abandoned entirely because prosthetic restoration is not possible.

If a complete subperiosteal casting is planned, the clear surgical template should be placed over the bone model (although its fit is only approximate) to guide bar placement by the laboratory. If the computer-aided design/computer-aided manufacture (CAD/CAM) or stereolithographic method was not chosen, then at the time of first-stage surgery, an impression is made of the opposing arch and a wax or Optosil putty interocclusal recording with the bone exposed at the correct vertical dimension and centric relationship (Fig. 26-1). This allows accurate mounting of the bone model and proper placement of the abutments (Fig. 26-2). CAD/CAM technology creates a more significant problem, because even the most splendidly executed cast is returned without its relationship to the opposing jaw (although the CAD/CAM section in Chapter 14 provides a solution to this problem). The tube and stylus technique ensures accurate placement of the bar or abutment.

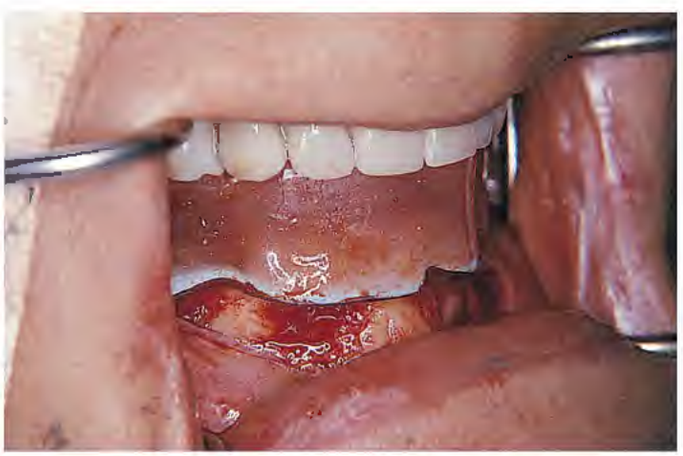


FIGURE 26-1. A centric and vertical dimension recording may be taken with a wax rim to establish a relationship between the bony mandible and the fixed anatomic structures of the maxillae.

Chapter 5 explains bar attachment designs. If the bar is to be made separately from the implants, it should be the fixed-detachable or cemented type and should be fabricated in accordance with the techniques outlined in Chapters 24 and 25. Of course, a bar may also be a part of the implant infrastructure casting, as with ramus frame and subperiosteal designs.

FULL SUBPERIOSTEAL IMPLANTS

The prosthetic technique of choice for the complete subperiosteal implant is an overdenture. Full arch fixed splints have been used, but they are not the recommended treatment primarily because of hygiene considerations.

If centric relationship and vertical dimension records were taken at the first stage of bone surgery, the laboratory can articulate the bone impression model reliably. Once the impression model has been articulated, the information needed to fabricate the implant is available, and an interim or temporary denture can be made for the patient (Fig. 26-3). The surgeon may insert this at the time of surgery and use it during the healing period (Fig. 26-4).

The temporary denture usually consists of anterior teeth and posterior bite blocks. The laboratory also can make a temporary denture with a CAD/CAM model if the soft tissue duplication or tube and stylus method is followed. However, if a 1-day, two-stage procedure is being followed, the laboratory will not have time to fabricate a temporary overdenture. In such cases, the patient's existing denture can be modified to fit over the implant. After aggressive reaming, a soft lining material (e.g., Coe-Comfort, Viscogel, or Softone) is used. It is important that there be no soft tissue contact anywhere beneath the denture base; the denture should be completely implant borne. This is also true for the final superstructure restoration. Tissue contact or pressure could lead to dehiscence of the implant infrastructure.

After the denture has been adapted to the activated Locator abutments or Brookdale bar, the patient is dismissed, and healing is allowed for 6 weeks before the final prosthesis is fabricated.

During the impression procedure, care must be taken not to lock material under the bar or force material beneath the tissues surrounding the implant cervices. The area under the bar should be blocked out with a soft wax (e.g., periphery wax) or block-out material and the impression is then made with an alginate material in a stock tray (Figs. 26-5 and 26-6). The impression is poured with die stone, and the cast is used to fabricate a custom tray (Fig. 26-7). This tray is used to record the final impression, which is done with an elastomer (e.g., Impregum), and for which the

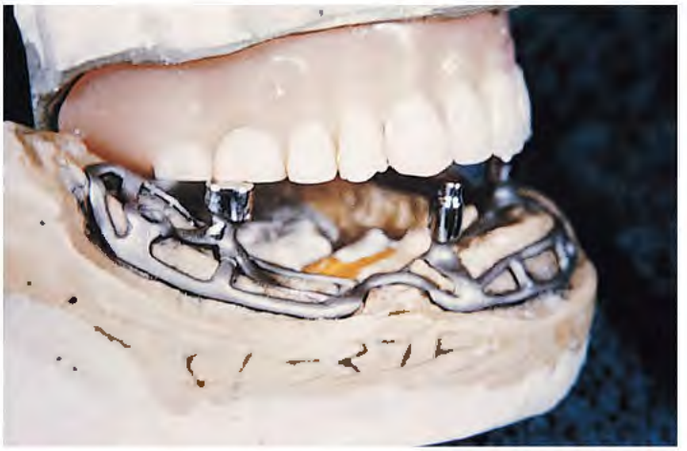


FIGURE 26-2. Mounted casts using the acquired relationship allow accurate placement of abutments or a Brookdale bar.

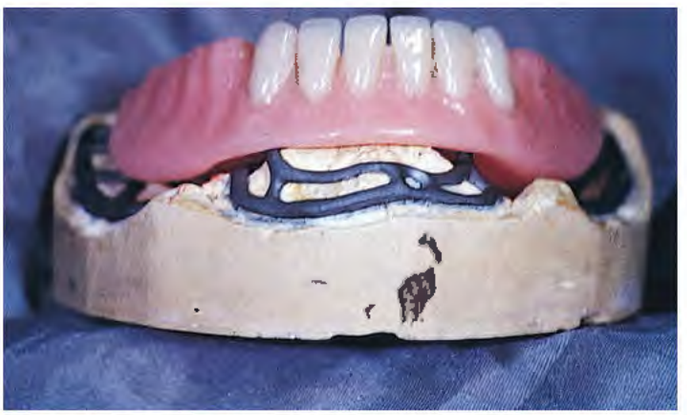


FIGURE 26-3. Accurate mounting allows the fabrication of a temporary overdenture (six anterior teeth and a posterior bite block), which may be inserted immediately after implant placement.

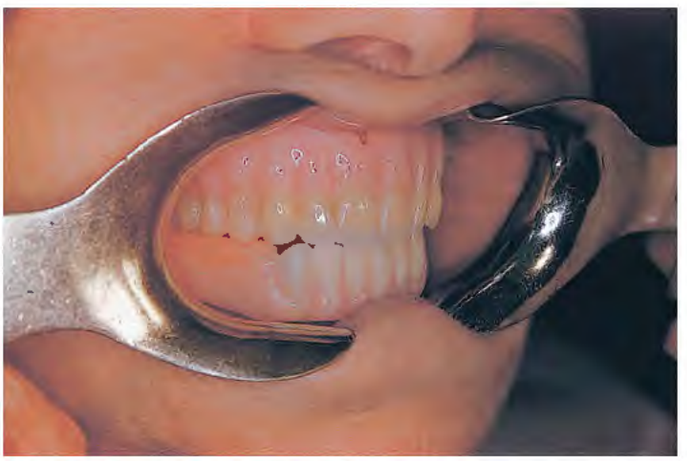


FIGURE 26-4. A temporary overdenture may be worn over a newly placed subperiosteal implant throughout the postoperative period and until the patient is supplied with the final prosthesis. It must be totally implant borne.

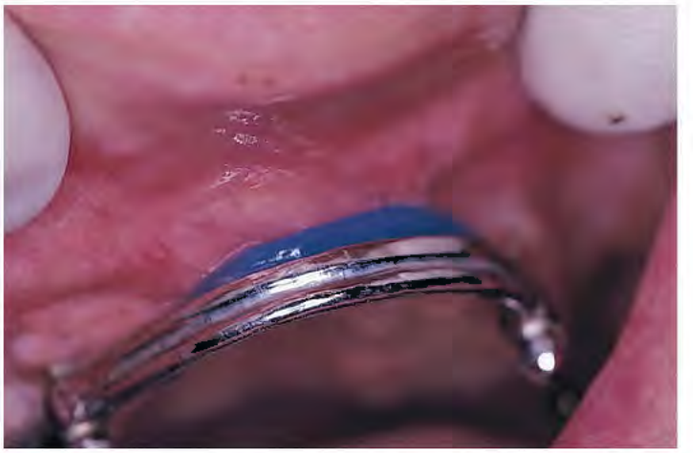


FIGURE 26-5. Blocking out undercuts beneath the bar with periphery wax facilitates impression making.

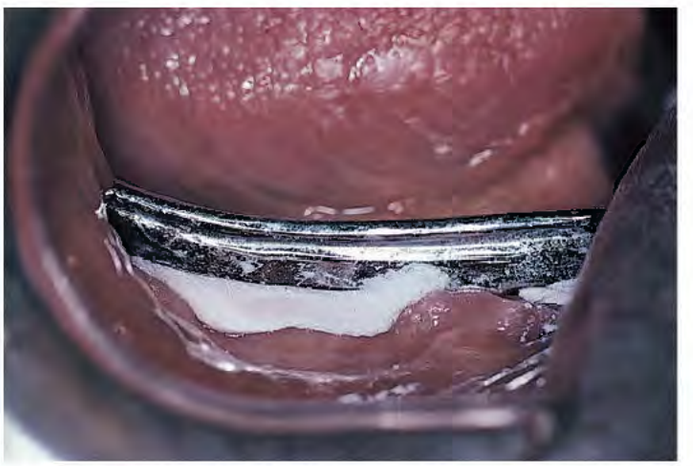


FIGURE 26-6. Ultradent block-out material is effective and lends itself to this application with ease before a final impression is made.

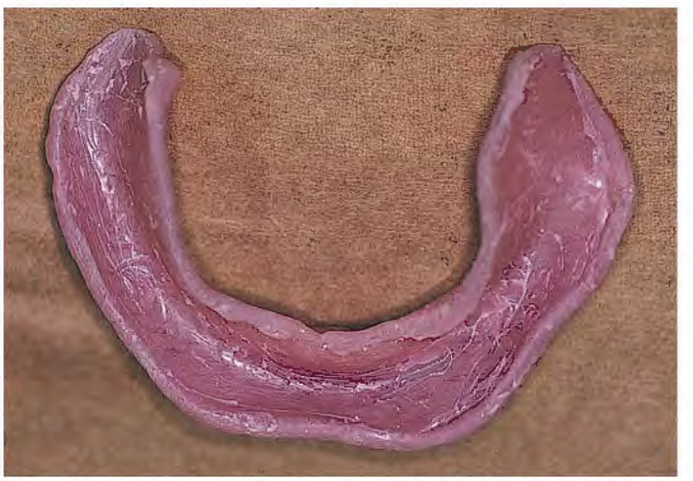


FIGURE 26-7. Custom trays may be made of acrylic, Triad, or shellac.

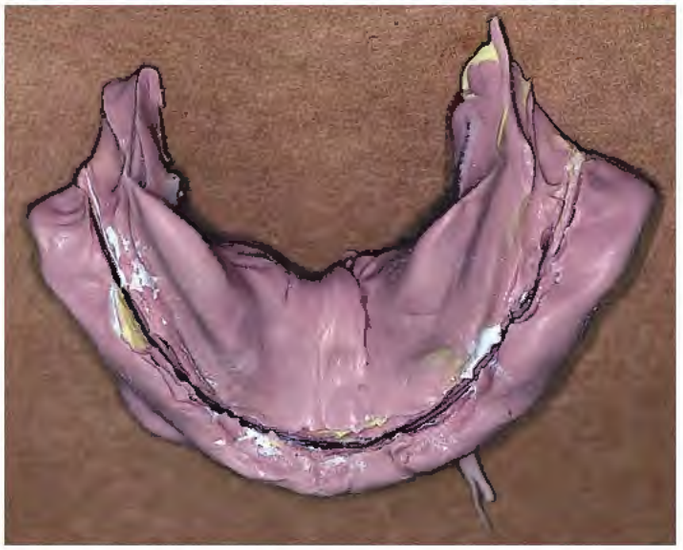


FIGURE 26-8. Impressions can be taken only after bar and other structural undercuts are blocked out. Polyethers or polyvinylsiloxanes may be used for these impressions.

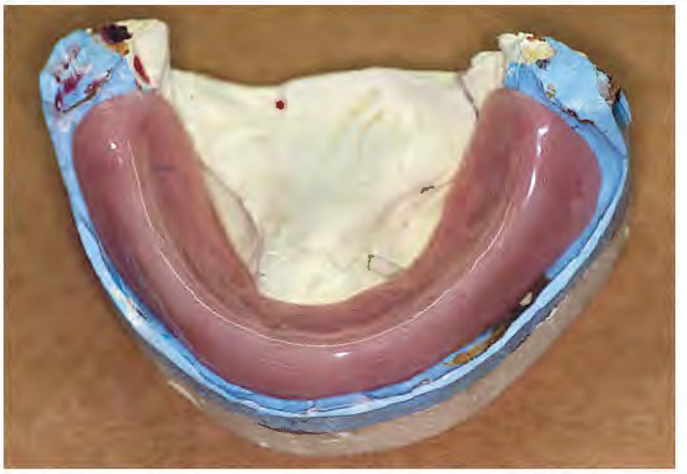


FIGURE 26-10. A heat-cured polymethylmethacrylate final denture base is the most accurate means of acquiring records.

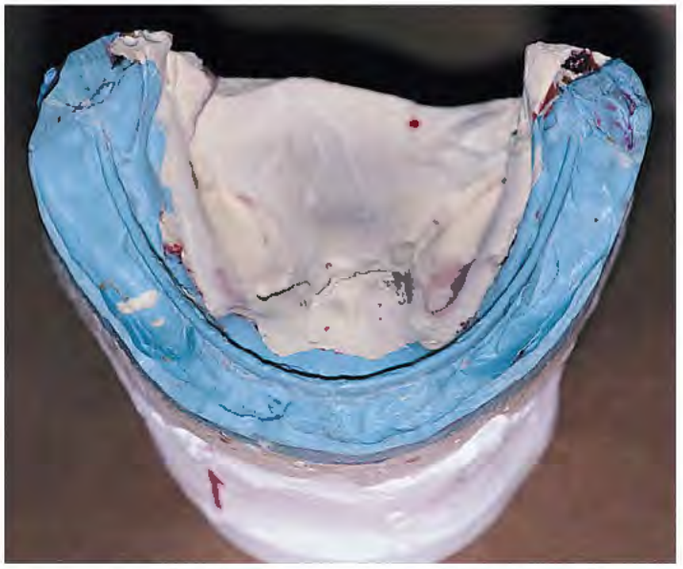


FIGURE 26-9. The laboratory should be instructed to make casts of epoxy material. This withstands the machinations to which the laboratory subjects it.

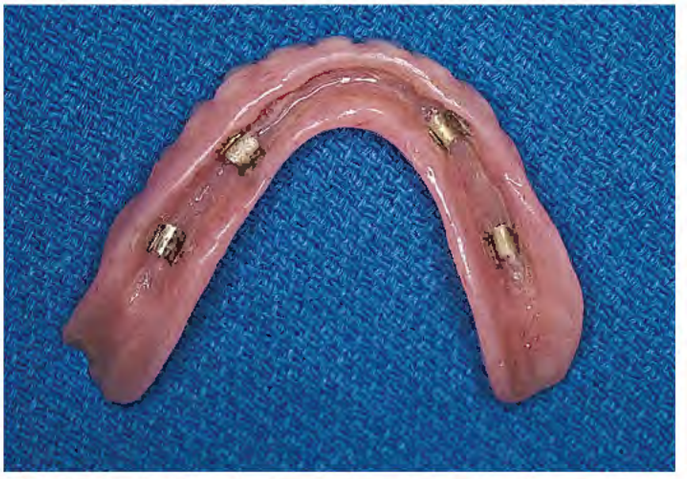


FIGURE 26-11. The retentive devices planned for the superstructure are placed in the base before prosthetic registrations are recorded. This ensures the stability required for recording accurate relationships.

areas under the bar again are blocked out (Fig. 26-8). The final cast is made of an epoxy material using the centrifuge technique to ensure accuracy, density, and strength (Fig. 26-9). This method ensures a detailed duplication of the bar and its retention devices, such as Locator attachments, O-rings, trailer hitches, or Zest anchors.

Next, an acrylic, heat-cured, final denture base is made to establish the maxillomandibular records (Fig. 26-10). If retentive devices are to be used as the means of attachment, the laboratory should incorporate them into the base so that its final position allows accurate records to be made (Figs. 26-11 and 26-12). If the trial setup is satisfactory, this base is used as the final one onto which the teeth are processed (Figs. 26-13 to 26-15).

Zero-degree acrylic denture teeth are used to minimize oblique and lateral forces that are transmitted to the implant (Figs. 26-16 and 26-17).

UNIVERSAL SUBPERIOSTEAL IMPLANTS

The universal (or bilateral) subperiosteal implant is a full arch casting that is placed with natural teeth, which the prosthesis' peripheral struts circumvent. The usual reconstructive technique is an overdenture with cast gold copings placed on the natural teeth (Figs. 26-18 to 26-20).

Telescopic copings are made on the natural teeth after the tissues have healed. If these copings are placed before healing is complete, gingival recession occurs at their margins. If a single-cast gold coping splint is cemented for the natural teeth, standard impression techniques are used to fabricate the overdenture. The bases for anchorage of natural teeth and subperiosteal implant abutments are dissimilar; therefore a one-piece coping bar splint is not advisable. Individual gold copings protect the natural teeth from caries and facilitate hygiene procedures.

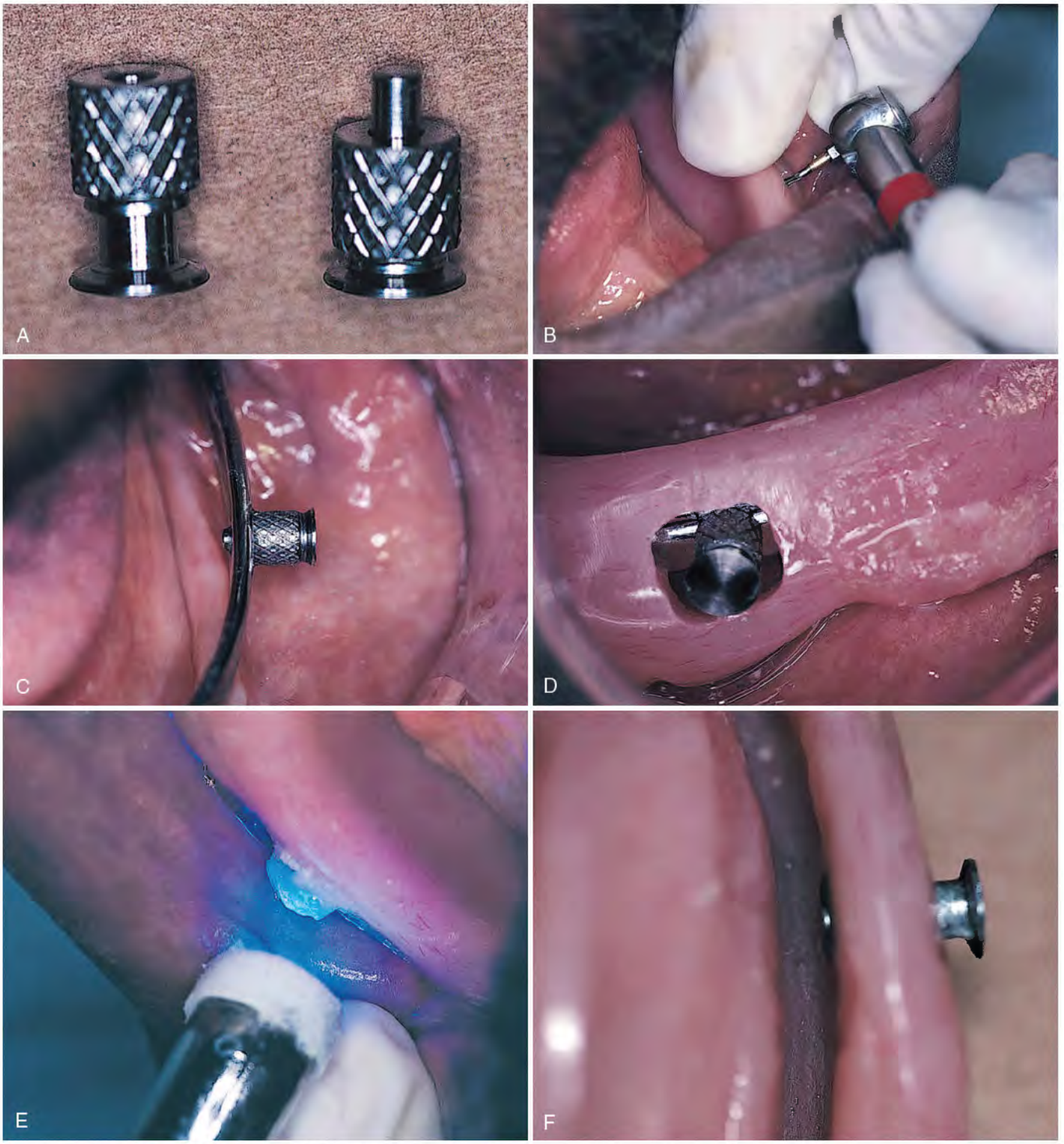


FIGURE 26-12. **A,** The Lew attachment (Park Dental Research) is a successful retentive device. A pair of them are shown here in opened (released) and closed (fixed) positions. The protruding pin fits into a groove in the mesostructure bar, providing retention. **B,** If the mesostructure bar has not been designed with a retentive groove or notch, one can be cut into it with a diamond or fissure bur. **C,** The relationship of the Lew attachment to the fenestration cut for it in the Brookdale bar. **D,** The overdenture buccal flange is opened to reveal the attachment site. The Lew attachment is processed into this site. **E,** Light-cured composite is used to tack the attachment to the denture. **F,** A profile view of the flange, with the attachment in open position fully processed into it. When the patient presses the button after complete seating of the denture, the pin locks it in place, and the head becomes flush with the flange.

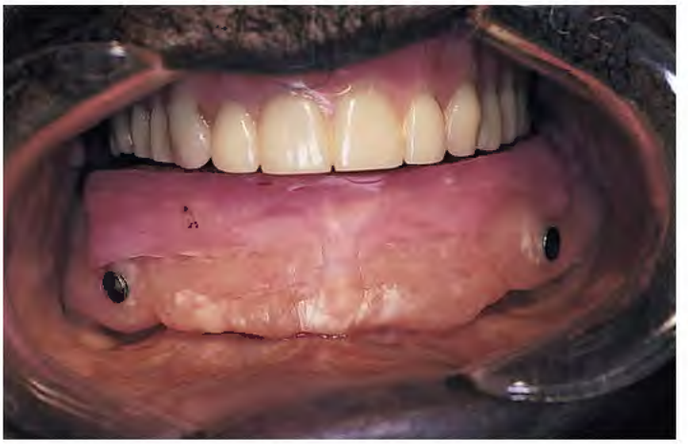


FIGURE 26-13. The final denture construction technique is started by record making with a wax rim that has been mounted on the stabilized base. The base is retained by Lew attachments.

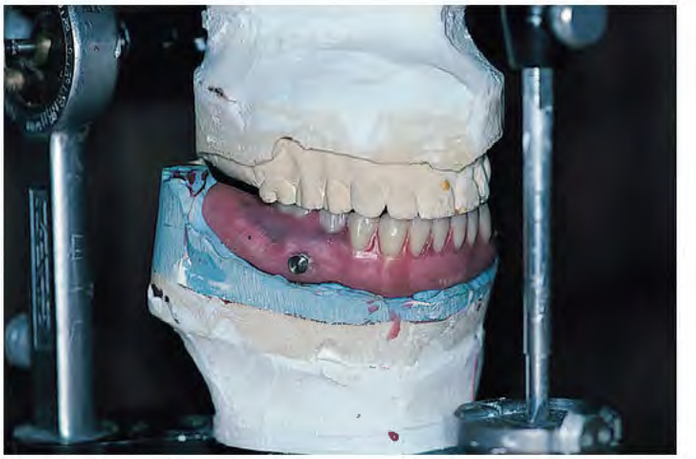


FIGURE 26-16. The initial try-in has the teeth set into wax on the final, attachment-supplied denture base.

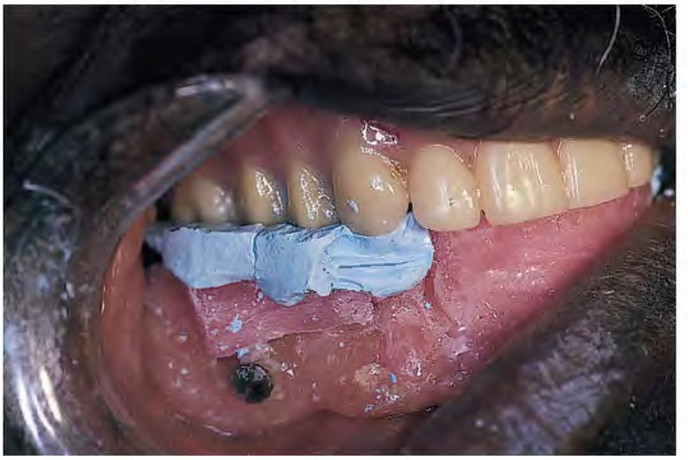


FIGURE 26-14. After the rim has been adjusted, centric and vertical relationships are registered with a rapid-setting bite registration material (e.g., Blue Mousse or SuperBite).

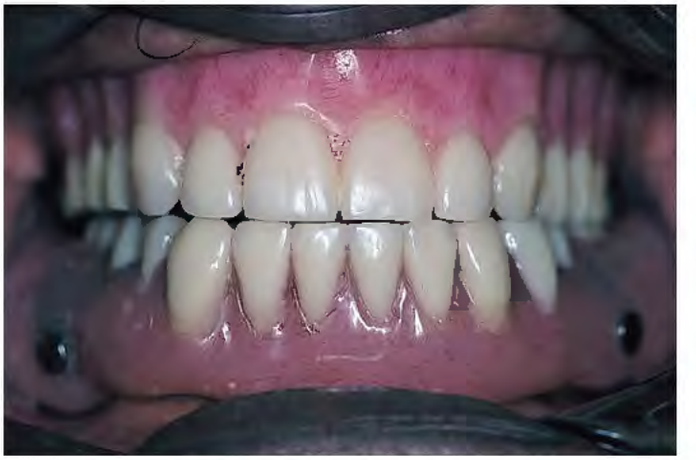


FIGURE 26-17. The completed overdenture is in position, and final occlusal adjustments are made.

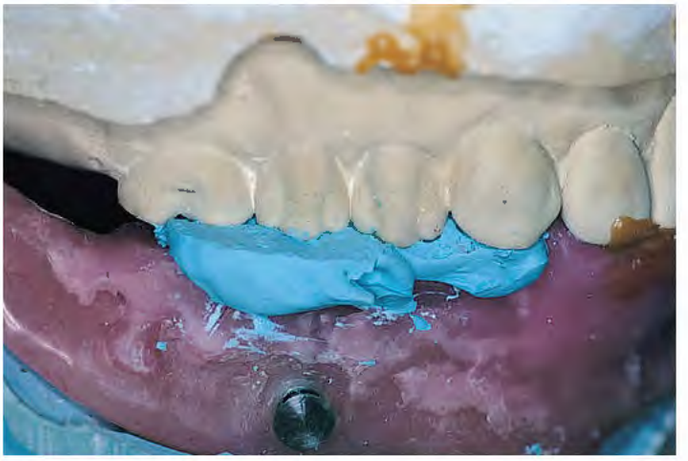


FIGURE 26-15. The base plates are transferred to a semiadjustable articulator. Facebow mounting contributes to accuracy.

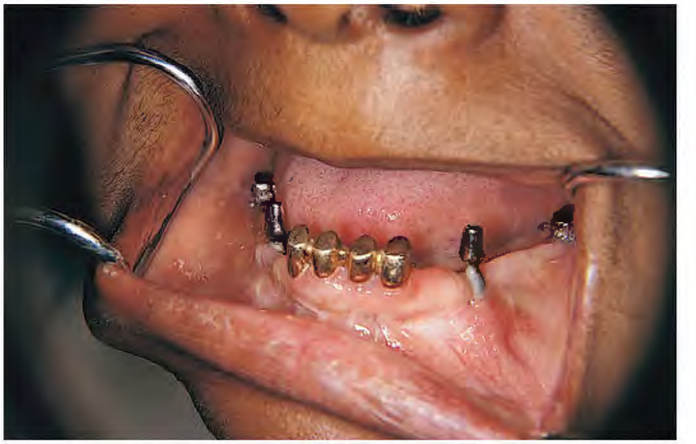


FIGURE 26-18. A universal subperiosteal implant is managed by splinting the patient's remaining four mandibular incisors with gold copings.

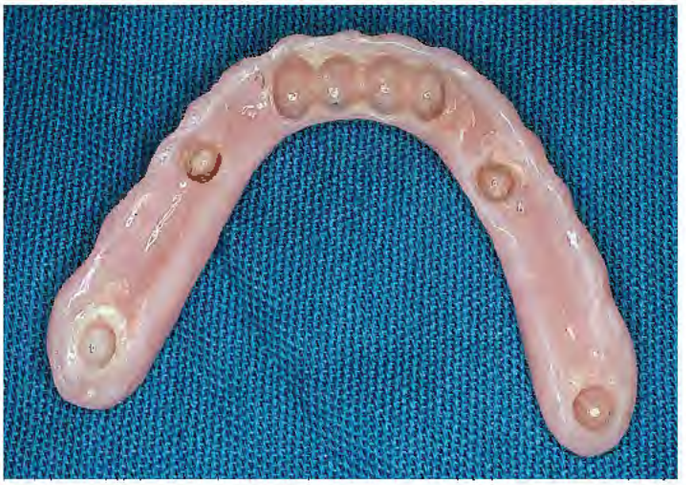


FIGURE 26-19. The overdenture is relined. When necessary, it may be used with or without a bar, depending on retention requirements.

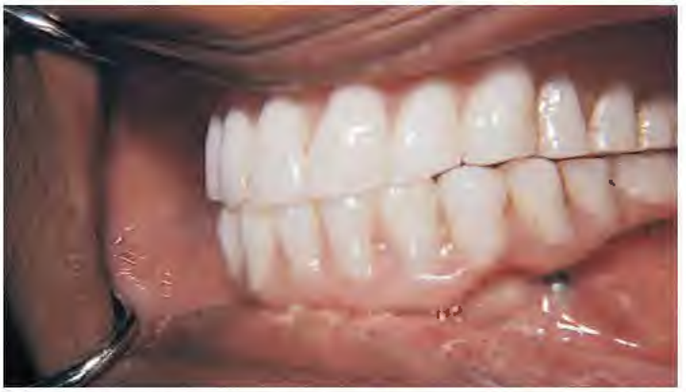


FIGURE 26-20. The completed overdenture satisfies the needs of function and esthetics.

Fabrication of the overdenture follows the techniques described previously. When the overdenture is complete, two options are available if clips are to be used:

- The laboratory can process the clips into the denture base on an epoxy model. Because the use of stabilized bases is the most accurate method of record making, laboratory-made custom clips processed into such bases provide more accurate results.
- The clips can be cold cured into position directly in the mouth at the time of denture insertion in the following manner (Fig. 26-21, *A* and *B*):

1. A window is cut through the lingual or palatal flange of the denture over the sites of the planned clips (Fig. 26-21, *C*). These windows must allow the denture to seat passively without interferences and allow visualization of the bar resting beneath it (Fig. 26-21, *D*).
2. The denture is removed. The attachments (clips with retention wings) are placed on the implant bar, all undercuts beneath the bar are blocked out so that the denture cannot become locked to it, and a small amount of pink cold-cure denture base acrylic is painted onto the retention wings (Fig. 26-21, *E* and *F*).
3. The denture is reseated immediately over the attachments on the bar and the acrylic is allowed to polymerize.
4. When the luting becomes firm, the denture with its clips is removed, and the remaining spaces between the attachments and the denture are filled in with additional acrylic (Fig. 26-21, *G*).
5. The operative fenestrations in the lingual or palatal flanges are filled in with pink polymer, the denture is replaced, and the patient is asked to close into centric relationship. The entire assembly is held in place until the acrylic sets (Fig. 26-21, *H*). If the denture becomes locked under the bar, the lingual windows are reopened and the acrylic that has fastened it in place is removed with a bur. The denture is then removed, the undercuts are reblocked with wax, and these procedures are repeated, with as much as possible done with the denture out of the mouth.

An overdenture with a "sloppy" or imprecise fit also can be completed clinically (Fig. 26-22). The denture must seat passively, without contacting the underlying bar. However, the undercuts beneath the bar or elsewhere are not blocked out. Pink, cold-cure denture relining acrylic (e.g., Durabase) is placed in the dried denture. The bar is lubricated with a thin layer of petroleum jelly (e.g., Vaseline). The denture is seated over the bar, and the patient is asked to close into centric position. After the initial set (approximately 1 minute), the denture is lifted, placed under cold running water briefly to dissipate the heat, and then reseated. This process of removing and replacing the denture is repeated every 15 seconds until the acrylic comes to a final set. At this point, it has developed considerable retention but still allows removal with some effort. The procedure is completed by trimming excess acrylic and polishing the peripheral areas.

RAMUS FRAME IMPLANTS

An integral part of the ramus frame implant is a rectangular bar that retains an overdenture. Attachments cannot be incorporated into this bar. The denture is retained by custom-made clips or by "sloppy fit." Zero-degree teeth are recommended with ramus frame implants, and the occlusion should be adjusted as described for the subperiosteal implant.

TRANSOSTEAL IMPLANTS

As with all types of implants, a careful preprosthetic workup must be done before transosteal implants are placed to establish the implants' planned labiolingual positions. The staple implant, a special type of transosteal implant, may be limited somewhat in the positioning of its abutments. Single transosteal implants, however, can be inserted in positions at which they have the most prosthetic value, particularly if a proper surgical template (see Chapter 13) was used during insertion.

The preferred means of restoration for transosteal implants is overdentures. The abutments are connected with a bar (Figs. 26-23 and 26-24). The dental surgeon can choose from many types of attachments (e.g., O-rings, clips, magnets, ball attachments, Zest anchors, or "sloppy" fit).

When a soft tissue–borne denture that is to be bar retained is fabricated, an accurate impression of the soft tissues, as well as the bar, must be made (Fig. 26-25). A custom tray is fabricated that allows sufficient internal height for the implant and transfer copings. Manufacturers supply transfer copings for the fabrication of the master or working cast.

After the copings have been placed over the implant abutments, a wax relief is made. This allows the tray to be seated passively. The tray is border molded to record all landmarks, as for a conventional denture. The impression is made, using a standard technique, with a stiff

polyether material (e.g., Polygel or Reprosil, a polyvinylsiloxane). When the impression is removed, a die stone model is poured. The mesostructure bar then is fabricated, as is the final overdenture on the master model. (If the final restoration is to approximate the soft tissues, a soft tissue model is fabricated with Vestogum [see Chapter 20].)

Construction of the denture should follow acceptable prosthetic techniques and guidelines.

ROOT FORM IMPLANTS

The overdenture is a good prosthetic option for patients who want prosthesis stability and retention and do not mind that the prosthesis is removable. An overdenture is required for patients who do not have sufficient bone and soft tissue and require the benefits of bulk offered by such designs. In addition, the economics affected by placement of minimal numbers

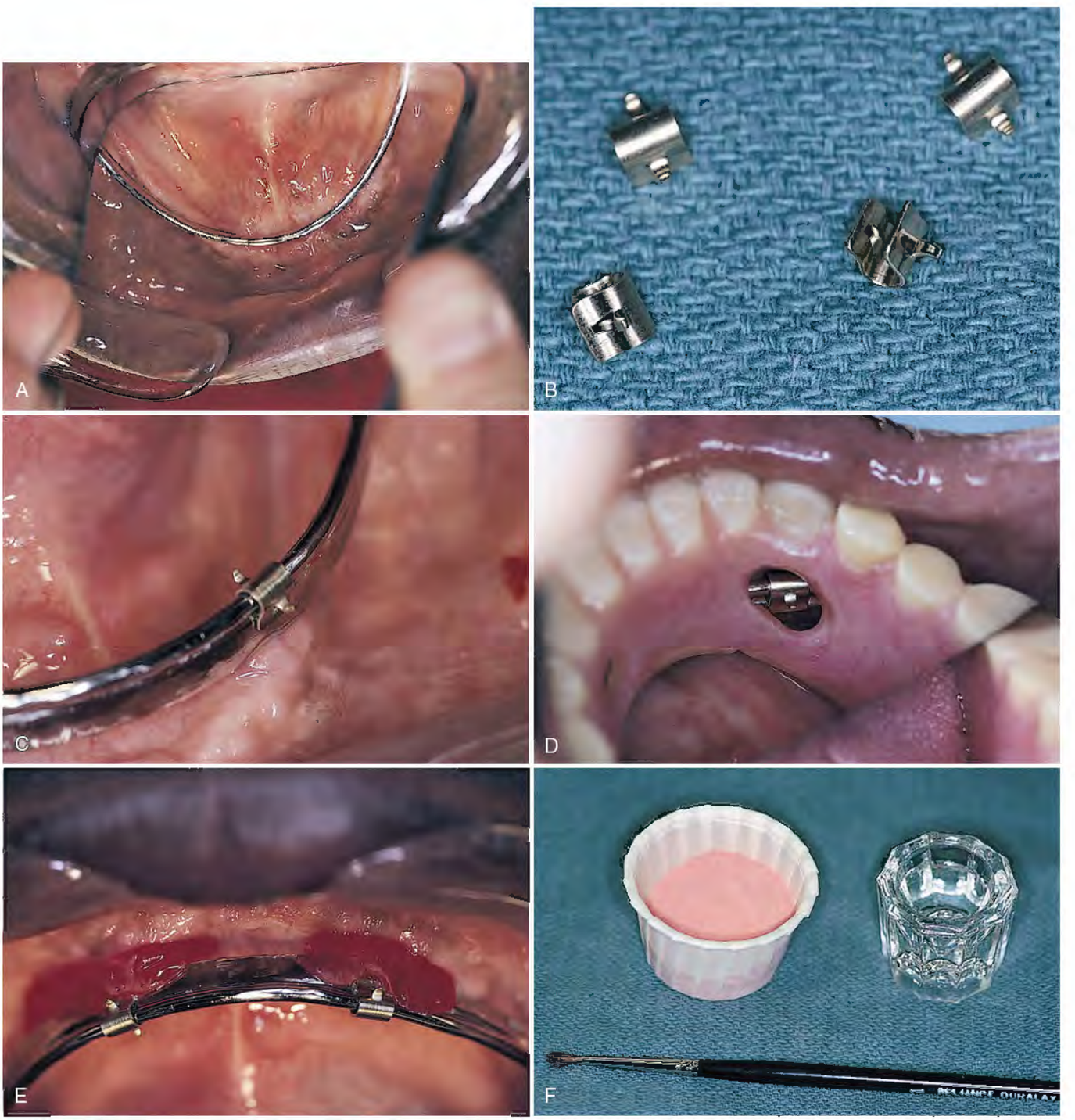
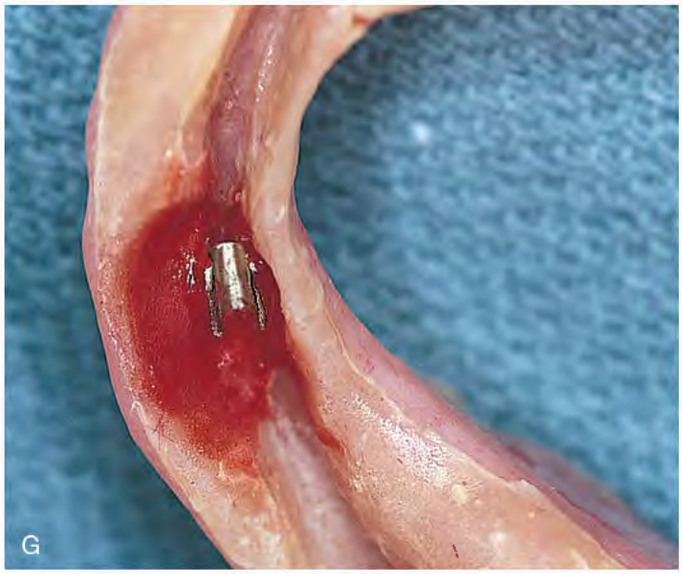


FIGURE 26-21. **A,** A mesostructure planned for reception of Hader clips. **B,** Precious metal Hader clips, each of which is supplied with retention wings. **C,** Clips are placed in selected strategic numbers and locations on the bar. Retention wings should be readily accessible. **D,** Windows are cut through the lingual flange of the overdenture at each clip site. The denture is seated, offering clear access to each device. **E,** The area beneath each clip is blocked with wax. **F,** A strong, quick-setting, autopolymerizing resin (e.g., GC Pattern) is used to process the clips to the denture.



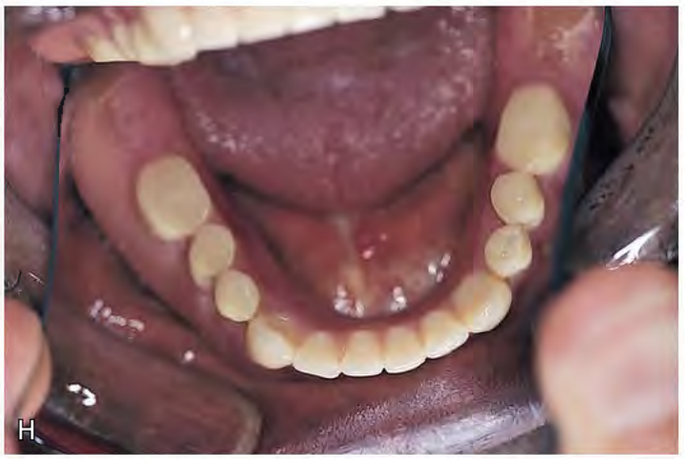


FIGURE 26-21, cont'd. **G,** After processing, the stark contrast between the repair material and the denture acrylic makes correction, retrieval, and clip changes a simple task. **H,** Final finishing should include masking the bright red with pink denture material in areas where esthetics dictate such a change.

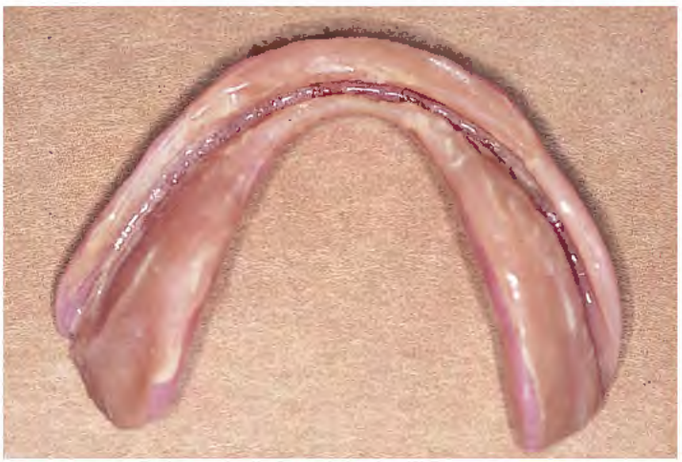


FIGURE 26-22. The "sloppy" fit overdenture is managed by chair side relining procedures. Care must be taken to prevent the denture from becoming locked beneath the bar during the application of hard, self-curing resin.

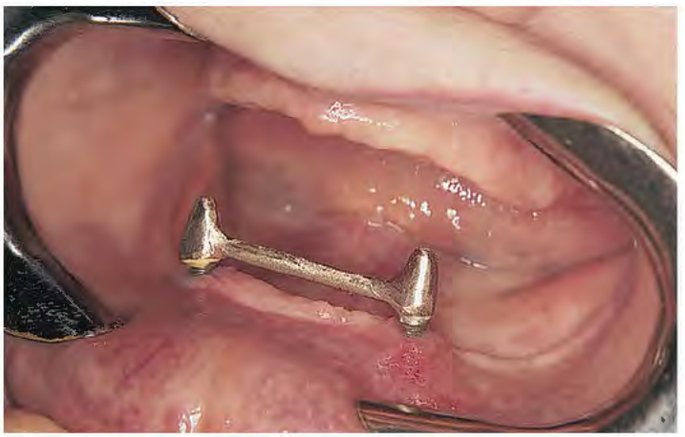


FIGURE 26-24. Routine prosthodontic techniques supply the patient with a precious metal coping bar splint.

FIGURE 26-23. Internally threaded, chrome alloy abutments are available for transosteal implants.

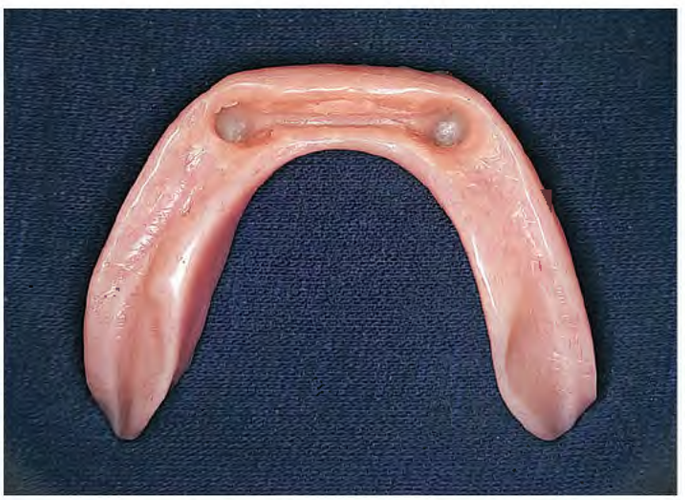


FIGURE 26-25. The overdenture, which is both bar and tissue supported, must demonstrate good peripheral extension and accurate fit.

of implants demands the trauma-sparing behavior delivered by overdentures.

Essentially, the overdenture is the fundamental prosthesis, the linchpin, of implant-borne reconstruction. Several types of overdentures are available, and each has its purpose and requirements. If individual attachments are affixed to these implants, the attachments offer retention for the denture, but the hard and soft tissues supply all the support. Although the overdenture is retentive, it does move slightly on the soft tissues. When a bar is used to splint implants, the overdenture derives retention from attachments adapted to the bar and support from the bar and implants, as well as from the soft and hard tissues. As greater numbers of implants are added and bar length increases, an increasing amount of support comes from the bar and implants. The result is greater stability of the prosthesis.

Unlike the mandible, which may have as few as two implants for overdenture support, maxillary overdentures require a minimum of four implants splinted with a bar to serve as support mechanisms.

The projected designs of the final prostheses determine the number of root forms placed. In general, solid, secure overdenture prostheses require at least four implants in the mandible and six in the maxilla. However, if the aim is to obtain moderate retention with the use of a tissue-borne overdenture that offers the benefits of stress breaking or if economics is a factor, a fair result can be achieved with two implants. The bar connecting them should be made as a straight segment so that the internal clips or attachments fitted to it allow the saddles to rotate against the resilient bearing tissues covering the posterior ridges. If the bar is curved or the attachments are poorly aligned, the saddles are not stress broken, and excessive stresses are transferred to the implants.

The abutments for overdentures may contain housings for fixation screws; in such cases, the bar can be screwed into them just as if it were a fixed-detachable prosthesis. As an alternative, these coping bars can be cemented.

The choices for abutments and their retentive devices are the same as for all fixed-detachable devices, and the options for the use and correction of misaligned or angled implants are also the same as those described in Chapters 22 and 28.

PROVISIONAL RESTORATIONS

The provisional restoration used during implant treatment often is a complete denture, although laboratory-processed temporary prostheses are an option (see Chapter 21).

SURGICAL TEMPLATES

Surgical templates are designed to guide implant location, angulation, and placement. They must conform to all functional esthetic requirements (see Chapters 4 and 20 for design and fabrication instructions).

FINAL PROSTHESIS FABRICATION

After the implants have been uncovered and the soft tissues have healed, fabrication of the final prosthesis is begun.

For a stable and retentive overdenture, a mesostructure bar may incorporate any of the attachments described in Table 5-1. When five or six implants have been used, the bar is cantilevered past the last implant on either side. The length of the extensions depends on the number and length of the implants. If six implants 13 mm long or longer are used, the cantilevered bars may extend 15 mm in the mandible; however, this should not be done in the maxillae. Fewer or shorter implants allow the use of commensurately shorter extensions. If the record base used was screw retained, the reliability of this technique allows the laboratory to incorporate the attachments directly into the denture at the time of processing. If the base was not stabilized with screws, the attachments usually must be processed into the denture while it is stabilized intraorally. Cold-cured acrylic is used through lingual operative fenestrations (see Fig. 26-21 and the accompanying text). If rotating or other stress-broken prostheses are made, the bar is made shorter, because the overdenture will be retained by only two or three implants.

Zero-degree denture teeth are recommended for use in overdentures. If a patient has any remaining natural teeth that are periodontally sound, they should be included in the bar configuration. If the bar is to be screw retained, there is a prosthetic complexity using natural teeth. If it is to be cemented, removal becomes difficult or impossible. Also, the cement may wash out from under castings, which may lead to decay of the natural teeth. To prevent this, individual gold copings should be placed on natural teeth to protect them from caries. The bar is then fitted over the copings and implants, safely incorporating the natural teeth into the reconstruction.

If a fixed-detachable prosthesis is the desirable approach and the patient has a combination of implants and natural teeth, impressions of those teeth are made after their preparation, and copings are fabricated and then picked up in a master impression. The laboratory can solder internally threaded sleeves (Attachments International's TSFH) to the occlusal surfaces of the copings. This allows the natural teeth to join the implants in a classic fixed-detachable system, either for bar or other, more realistic types of prostheses (Fig. 26-26).

When reconstruction is limited to the use of two implants and, as a result of anatomic considerations in the structure of the patient's arch, they are too far apart to be connected, they can be used as freestanding abutments with attachments for overdentures. The attachments most frequently used in these situations are Locator abutments (Fig. 26-27), ERA attachments, or O-rings (Fig. 26-28). Either can be screwed into the threaded housing of the implant, and the retentive component is cold-cured into the patient's denture through lingual fenestrations. In these cases, the attachments should be kept as low to the tissue as possible to prevent unfavorable crown-root ratios.

ABUTMENT SELECTION

Abutments are selected after the impressions have been made so that implant positions can be studied. The healing collars are removed with a counterclockwise motion using a screwdriver compatible with the implant system. The tissue depths are measured with a periodontal probe, and the healing abutments are replaced, one implant at a time. If the healing abutments are left off for extended periods, the tissue may be drawn over the periphery of the implants. The patient then will have pain on reinsertion of the healing abutments. Abutments 1 mm longer than the tissue depth measurements should be selected.

For a bar overdenture, a shouldered abutment that accepts a screw-retained bar should be chosen. For individual attachment-type abutments, the implants must be parallel to one another. If they are not, angled abutments that allow parallelism are required. Divergence of the abutments causes divergent paths of removal, which may be responsible for attachment breakage, premature wear of the attachments, or unnecessary stress on the implants.

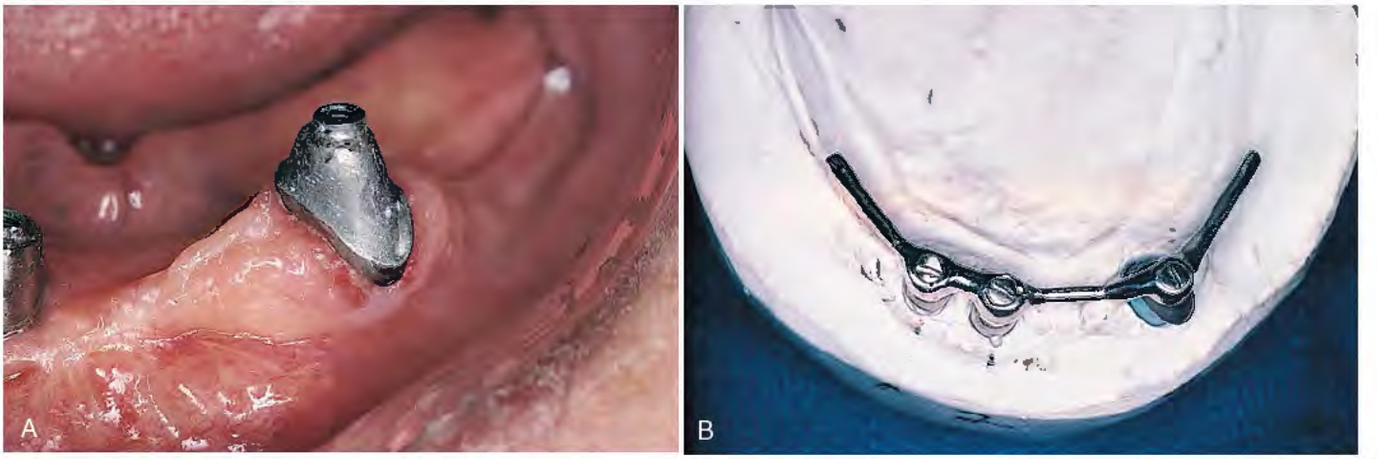


FIGURE 26-26. **A,** When use of a fixed-detachable coping bar splint is preferable with natural teeth, the internally threaded TSFH attachment (Attachment International) can be soldered to the coping. **B,** In such a fashion, the resulting splint can be attached by screws to all supporting abutments, whether natural or implant borne.

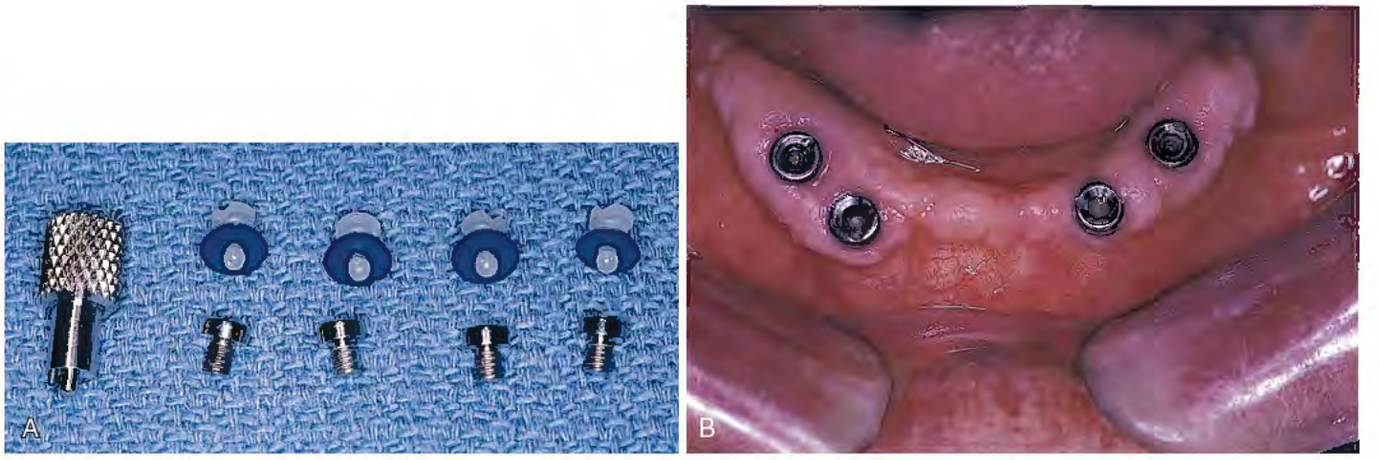


FIGURE 26-27. **A,** Locator abutments offer good sources of overdenture support. The attachments are threaded, and the instrument on the left is used to insert them into the threaded interiors of osseointegrated implants. Above each attachment is a metal housing retentive device with interchangeable tension retention rings; this device will be processed into the overdenture. The washers are used for their stabilizing effects; after the processing procedure, they are discarded. **B,** Four well-integrated implants are shown, each with a Locator male abutment screwed into place.

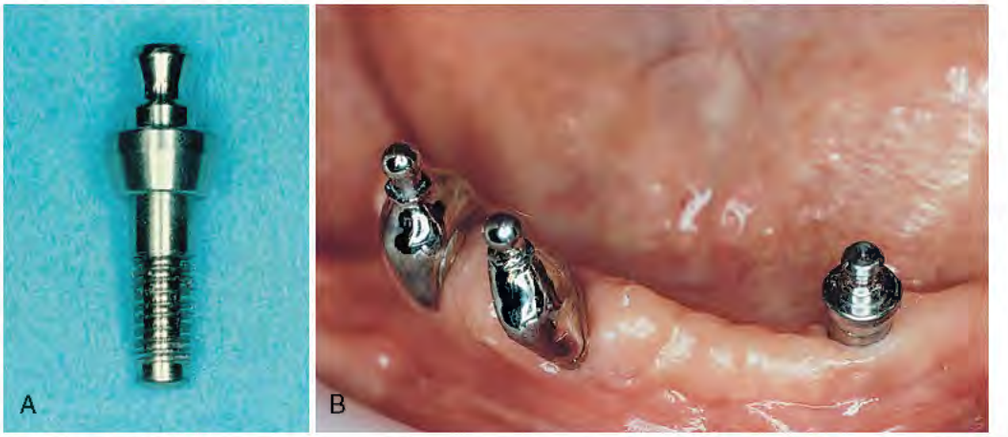


FIGURE 26-28. **A,** An O-ring male attachment is placed as it relates to a root form implant. **B,** When processed into an overdenture, O-rings may seek retention from natural teeth (right mandible) as well as implants *(left)*. There is sufficient resilience in design to allow their use with multiple abutments, regardless of their support mechanisms or imperfect parallelism.

IMPRESSION MAKING FOR OVERDENTURES

A custom tray is fabricated. It should have full-flange extensions, as if it were designed for a conventional denture impression. The tray must be able to accommodate the implant abutments and impression copings (Fig. 26-29). The custom tray is inserted over the abutments and impression copings, and its borders are adjusted. Manipulation of the tray should not be limited by the presence of the copings (Fig. 26-30). The border molding is completed, and final seating of the tray is done (Fig. 26-31) (see Chapter 24 and Fig. 26-32).

On completion of the impression, protective caps are placed on the abutments using either square or tapered abutment transfer copings (Fig. 26-33). The provisional denture is relieved and relined with a soft tissue liner; it is then reseated and checked for proper occlusion.

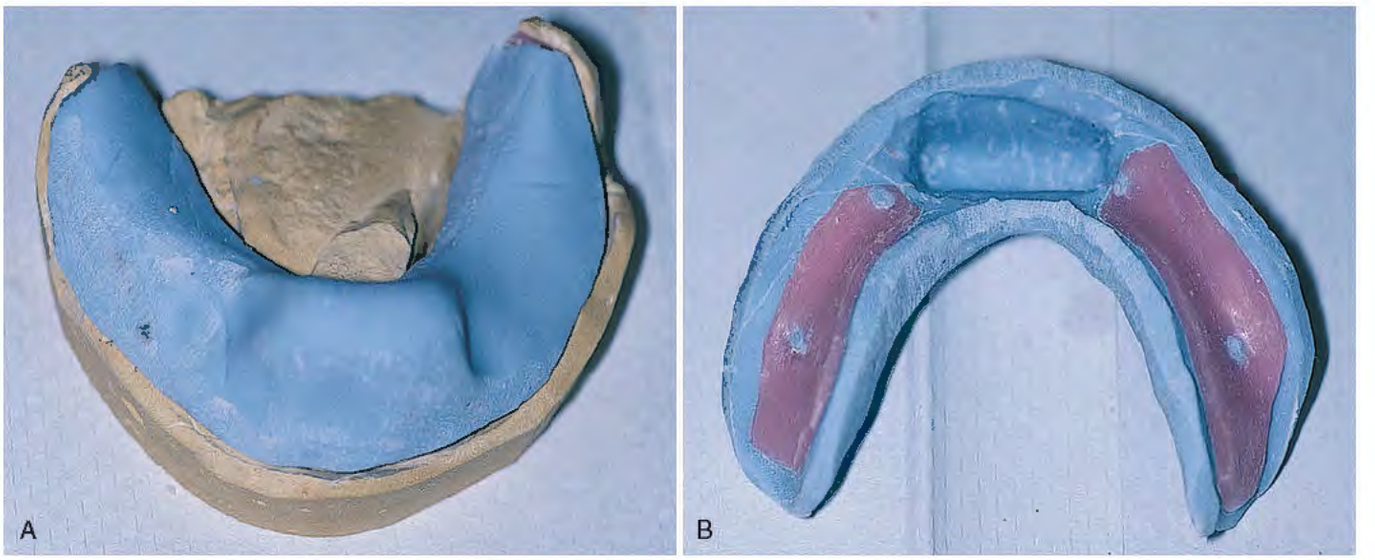


FIGURE 26-29. **A,** Fabrication of a coping bar must begin with the construction of a polymeric custom tray, which has a housing large enough to accommodate abutments and transfer copings. **B,** The tissue-borne side of the tray demonstrates the pink wax relief areas for the ridges, as well as the adequacy of the housing.

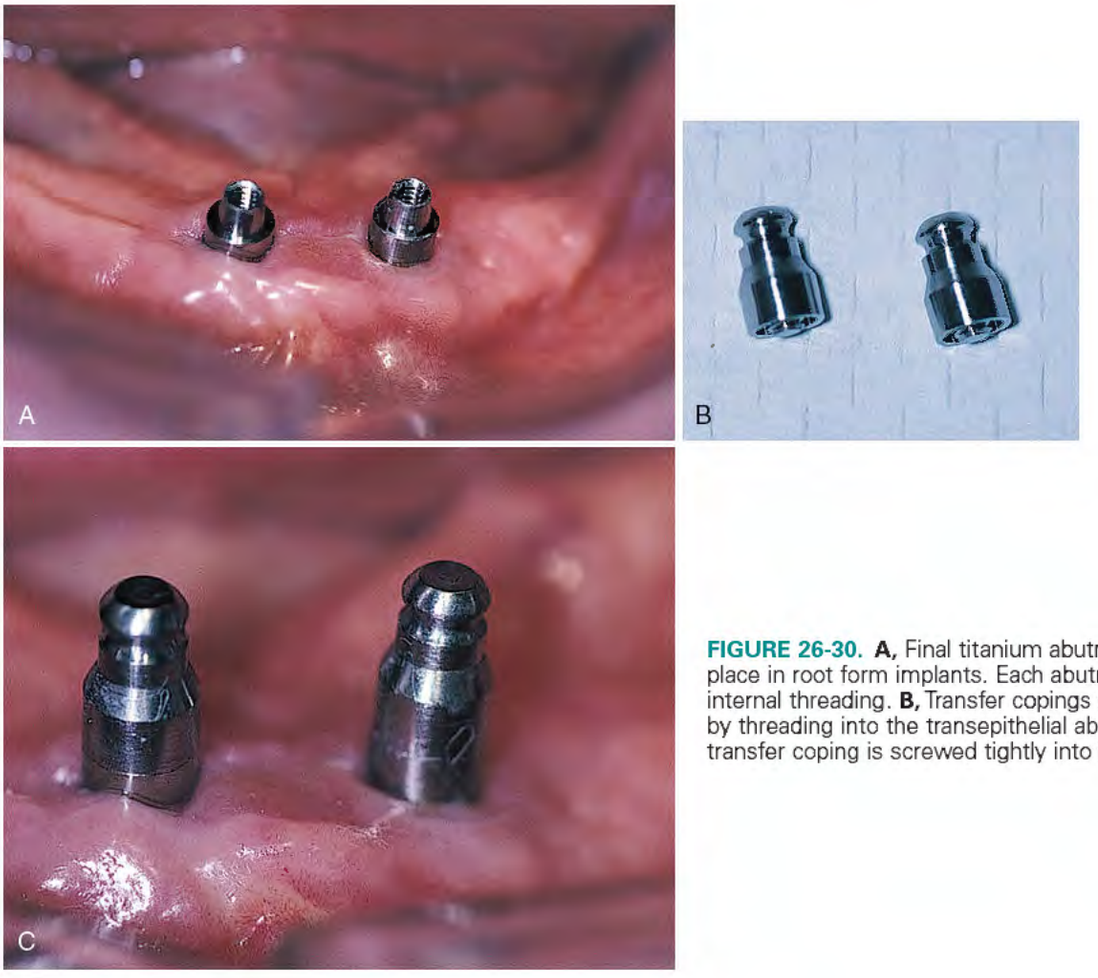


FIGURE 26-30. **A,** Final titanium abutments are screwed into place in root form implants. Each abutment is supplied with internal threading. **B,** Transfer copings are made to be seated by threading into the transepithelial abutments (TEAs). **C,** Each transfer coping is screwed tightly into its matching abutment.

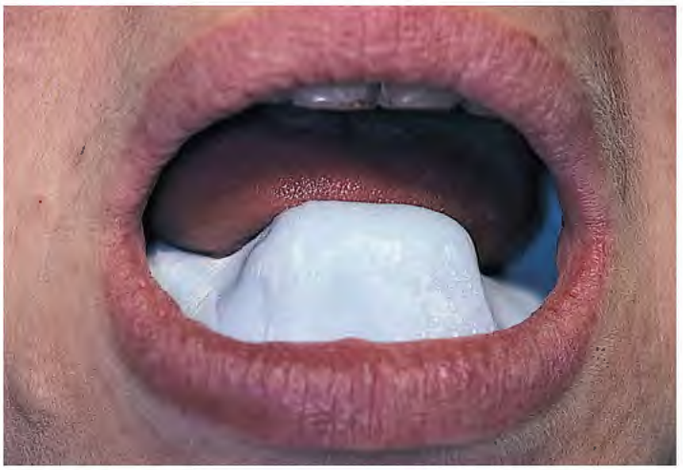


FIGURE 26-31. After the tray is seated freely and comfortably over the TEA–transfer coping complex, it is border molded in an acceptable manner.

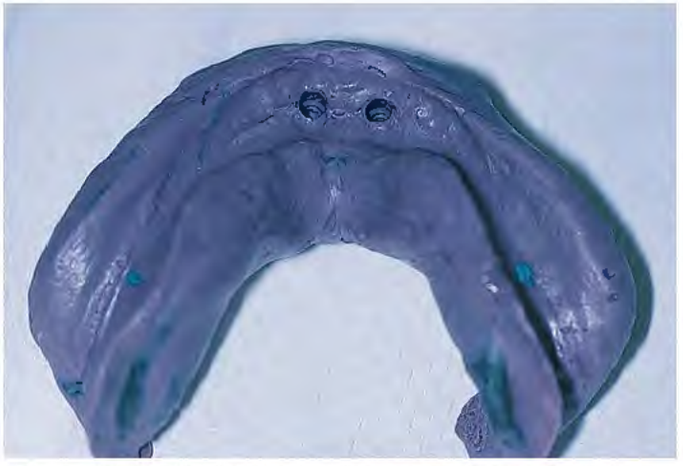


FIGURE 26-32. The final impression accurately records all tissues and transfer copings.

FIGURE 26-33. A, Important detail is recorded most successfully by use of an impression syringe. **B,** Each transfer coping is removed from its abutment and screwed into a prosthetic implant analog. These mated components are seated into the impression. The cast is poured in yellow stone.

If individual attachment abutments are planned, the impression copings are used as the portions of the attachments that are affixed to the denture base. If this technique is adapted, the attachments are coated with adhesive and placed on the abutments. They are picked up with the impression, into which the individual attachment abutment analogs are then placed.

A master cast is now made. The final impression is beaded, boxed, and poured in dental stone. A soft tissue model is required if the soft tissues touch the impression copings when impressions of the implants are made (see Chapter 23).

VERIFICATION JIG, VERTICAL DIMENSION, AND CENTRIC RELATION

After the master cast has been trimmed, a verification jig is made by placing square/locking impression copings on top of the abutments or implant analogs on the cast. A stable acrylic resin (e.g., GC Pattern) is used to lute them into a unit.

A traditional base plate, made sufficiently large to accommodate the capped abutments (Fig. 26-34, *A* and *B*), is used to record centric relation, vertical dimension, and esthetic contours. It is mounted on the articulator using a facebow transfer (Fig. 26-34, *C*). The caps are removed from the abutments, and teeth of an appropriate shade and mold are selected (Fig. 26-34, *D* and *E*). The verification jig is placed on the abutments, and a screw is tightened at one end (see Chapter 25).

These steps are required only when multiple splinted units will be used. When the copings have been seated satisfactorily, they are transferred to a working cast, appropriate teeth are set on the record base, and a try-in is scheduled. After verification of the vertical dimension, tooth shade, tooth shape, and overall esthetic appearance of the overdenture, a cast metal frame is placed into it. The space accommodation for the abutment and bar creates weak points in the denture that may cause wear or fractures. The cast metal frame should be made of a nonprecious metal; it serves most successfully if it accommodates the implant abutments, attachments, and bar (Fig. 26-35). The metal frame is made when the

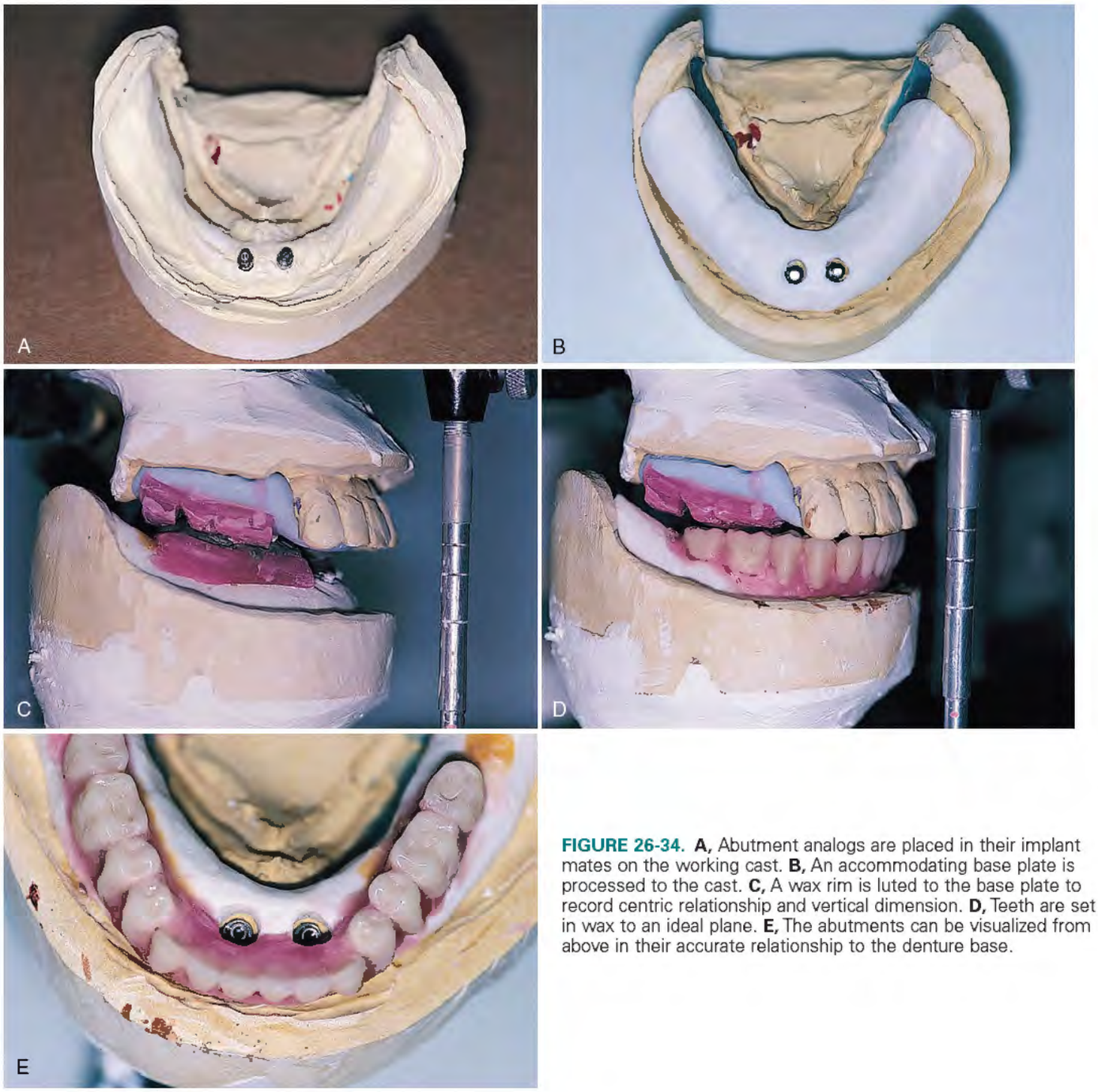


FIGURE 26-34. **A,** Abutment analogs are placed in their implant mates on the working cast. **B,** An accommodating base plate is processed to the cast. **C,** A wax rim is luted to the base plate to record centric relationship and vertical dimension. **D,** Teeth are set in wax to an ideal plane. **E,** The abutments can be visualized from above in their accurate relationship to the denture base.

record base is prepared. If the dental surgeon elects to construct the metal frame after the try-in phase, the teeth are reset on the casting and the denture is tried-in before processing.

The laboratory now may also fabricate the bar with attachments. These bars are cast from precious metal, and machined gold copings are used for the bar-abutment interface. The machined copings, along with their appropriate retaining screws, are available from the manufacturer of the abutments. The bar is positioned on the abutments with an index of the waxed-up denture in place. This allows the bar and attachments to be positioned relative to the tooth and flange positions. Ideally, the bar is placed just lingual to the cingulum areas of the anterior teeth, which allows the maximum vertical space.

The positioning of the attachments depends on their design, how they function, and how the denture uses them. If two implants are used with a Hader bar for attachment, the bar must be perpendicular to the posterior alveolar ridges. A single clip is used as the attachment to the bar. This allows the clip to rotate around the bar at 90 degrees to the posterior alveolar ridges. Cantilever bar extensions must not be used. If ERA attachments are used, they are placed distal to the most posterior abutment on either side of the bar.

The bar and denture wax-up are tried-in, along with the casting. The denture's esthetics, centric relation, and vertical dimension are verified. The bar is fitted by removing the protective caps from the abutments and tightening a screw on the side with the most distal abutment. All abutment-bar interface joints are evaluated clinically; if they are not easily visible, they are examined radiographically for reverification. Now, all other screws are inserted and tightened to ensure flawless seating. The bar is then removed, and the protective caps are placed on the abutments. The denture is processed, but not

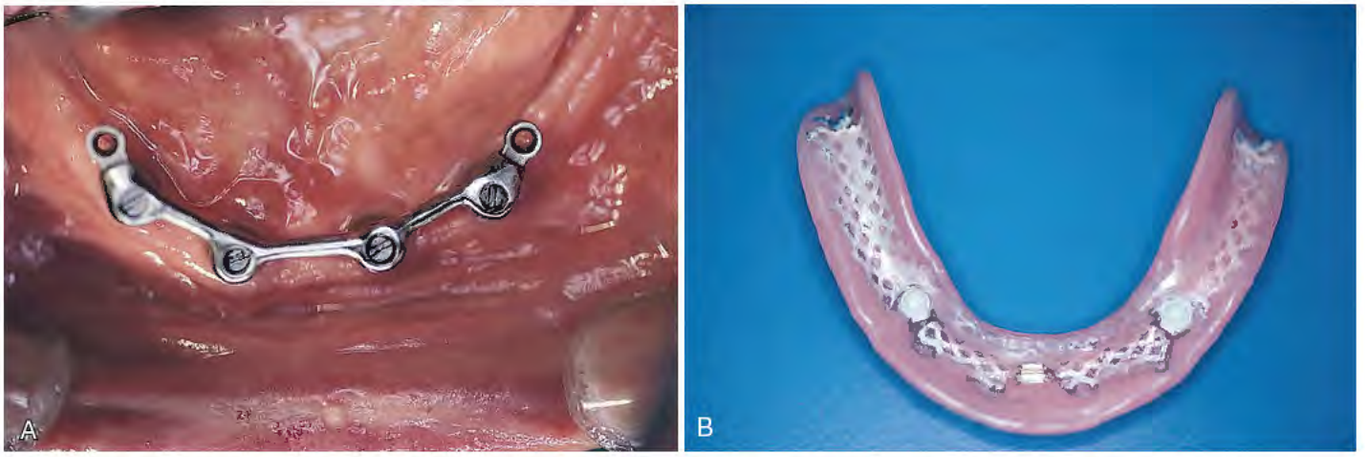


FIGURE 26-35. **A** and **B,** Although the mandible can be restored with two implants, a more reliable fixation is ensured with four implants and a fixed-detachable bar that offers Hader clip and ERA retentive devices to an overdenture that is supported as well in the saddle areas.

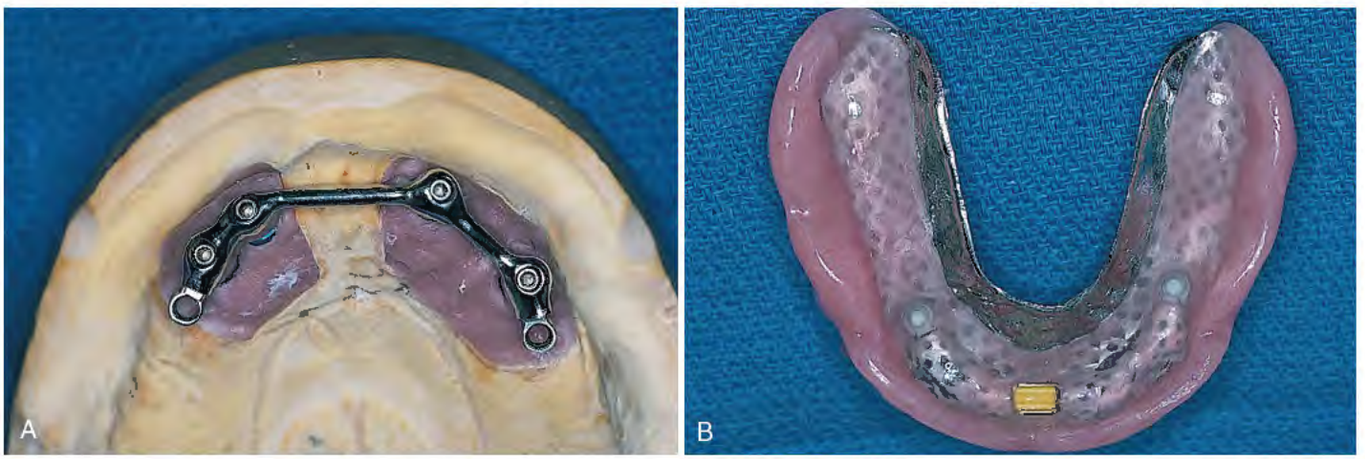


FIGURE 26-36. **A** and **B,** Four maxillary implants with a fixed-detachable bar offer a variety of attachments, ensuring firm retention without the need for full palatal coverage.

the internal attachments. Instead, space accommodation is made for them.

At the insertion visit, the protective caps are removed and the bar is inserted. The gold screws used to retain the bar are inserted with a torque wrench to the manufacturer's advised level.

The denture base flanges and occlusion are adjusted according to the rules for conventional dentures (Fig. 26-36).

ATTACHMENT CONNECTION

Ideally, the attachments are inserted after 1 week of denture wearing to allow the new denture to settle completely into its resting position (Fig. 26-37). When the attachments are inserted, all adjacent undercuts on the abutments and bar are blocked out 180 degrees to prevent acrylic from locking to the bar (Fig. 26-38). The attachments are seated into or onto the bar in their appropriate positions; they cannot interfere with complete seating of the denture (Fig. 26-39). Self-curing denture repair acrylic is painted onto the attachment and into the appropriate position in the denture. The denture is placed, and the acrylic is allowed to set.

After removal of the denture, the relationship and stability of each attachment are evaluated. If too little acrylic had been placed to retain the attachment, it will have remained on the bar, but its

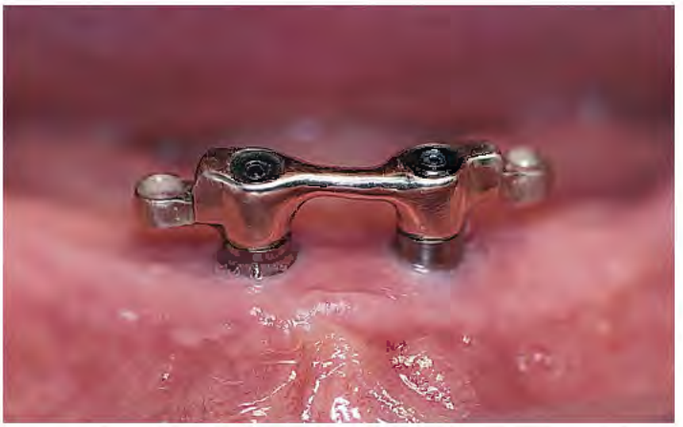


FIGURE 26-37. The copings and bar are waxed on the working cast. When casted and completed, they are screwed into position in the abutments.

indentation is seen in the denture. Additional acrylic is required. It is applied in small increments to prevent the denture from locking onto the bar. After an adequate amount of acrylic has been added and cured, the excess flash is removed, and the occlusion is re-evaluated and adjusted.

The denture then is polished and inserted, and the patient is given instructions on its use and care (Fig. 26-40). Although the

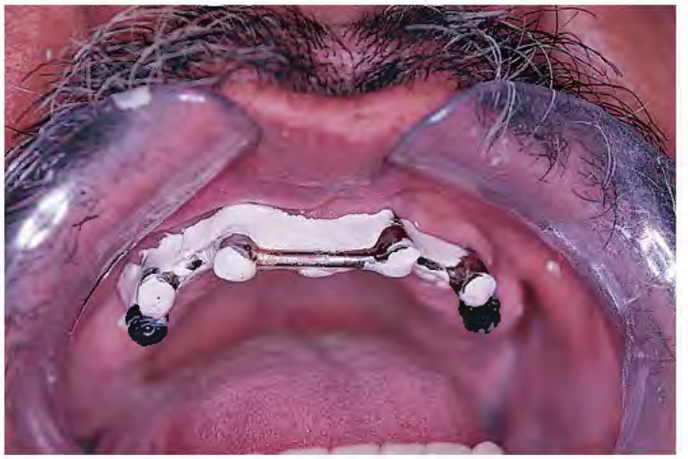


FIGURE 26-38. ERA black attachments are placed directly in the patient's mouth, and undercuts are blocked out in preparation for denture relining and pickup of the attachments.

laboratory can place attachments, the numerous transfers almost always cause inaccuracies. Precision is most readily achieved by direct intraoral assembly.

An appointment is made to see the patient for additional adjustments 2 weeks after insertion of the attachment. The attachment may loosen slightly after the first month of use. Some attachments can be retightened, but others should be replaced when they are no longer retentive. The time interval depends on the type of attachment and the patient. Patients generally are told to have the attachments replaced between 6 months and 2 years.

A final panoramic or periapical radiograph is taken at the time of the initial denture insertion visit to document the condition of the implants and adjacent bone, as well as the seating of all components. This radiograph also serves as a baseline for future comparisons.

Chapters 5 and 26 present specific bar designs and detailed descriptions of bar shapes, their means of anchorage (cemented, fixed detachable), and the wide variety of attachments.

MODIFIED TRANSFER TECHNIQUE

Dr. Marc Kaufman

As an alternative to the classic methods of impression making for overdentures, a modified technique has been used that yields a high degree of accuracy. The standard procedure for transferring implant and abutment positions to a working cast has been hindered by multiple transfers and record reproductions and the errors induced by these many steps, which delays completion of the patient's prosthetic appliances. A transfer technique that uses custom impression trays fabricated from surgical templates allows single-visit transfer of the centric occlusion, vertical dimension, tooth position, and implant or abutment location.

Traditionally, the prosthetic phase begins with fabrication of a cast by making an alginate impression of the healing abutments. The implantologist then uses the cast to fabricate a custom tray. After this, a final impression is made using implant transfer copings secured by guide pins. The implant transfer copings are luted together with a polymer to increase the accuracy of the registration. The second phase involves the use of the master cast to fabricate a record base. The base must register interocclusal relationships, a step that is required for articulation of the casts. This technique for both partially and totally edentulous patients often requires four or more visits.

The modified technique allows registration of the implant location, tooth position, and centric relation to be established in a single visit. This technique can be used for any type of full arch reconstruction, and it has the additional advantage of requiring minimal use of prosthetic components. Although the technique can be used for any type of implant-borne reconstruction, the focus of this method is overdenture construction.

Appropriate abutments for a bar overdenture prosthesis are selected at the time of second-stage surgery. Tissue heights are estimated with a millimeter probe before the implants are uncovered or by tissue depth measurements taken when the healing abutments are placed.

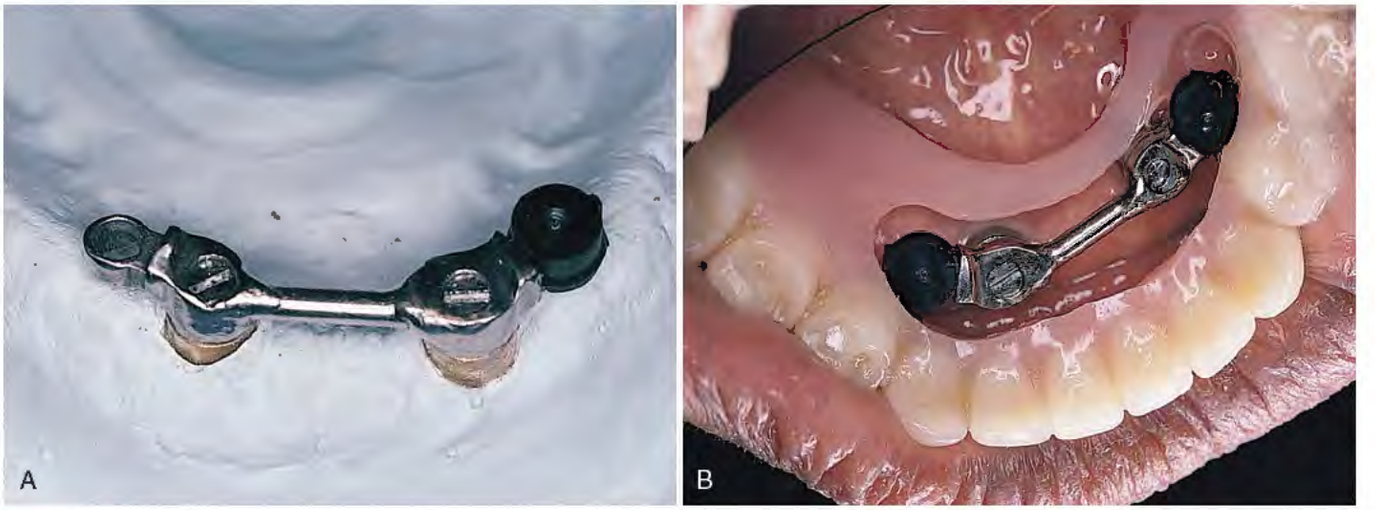


FIGURE 26-39. **A,** The assembly on a working cast for an ERA attachment overdenture includes the actual coping bar splint that was seated on the implant analogs. **B,** To ensure that adequate clearance is allowed, the black attachments are used for the critical step of transferring the male components into the overdenture through a lingually created fenestration.

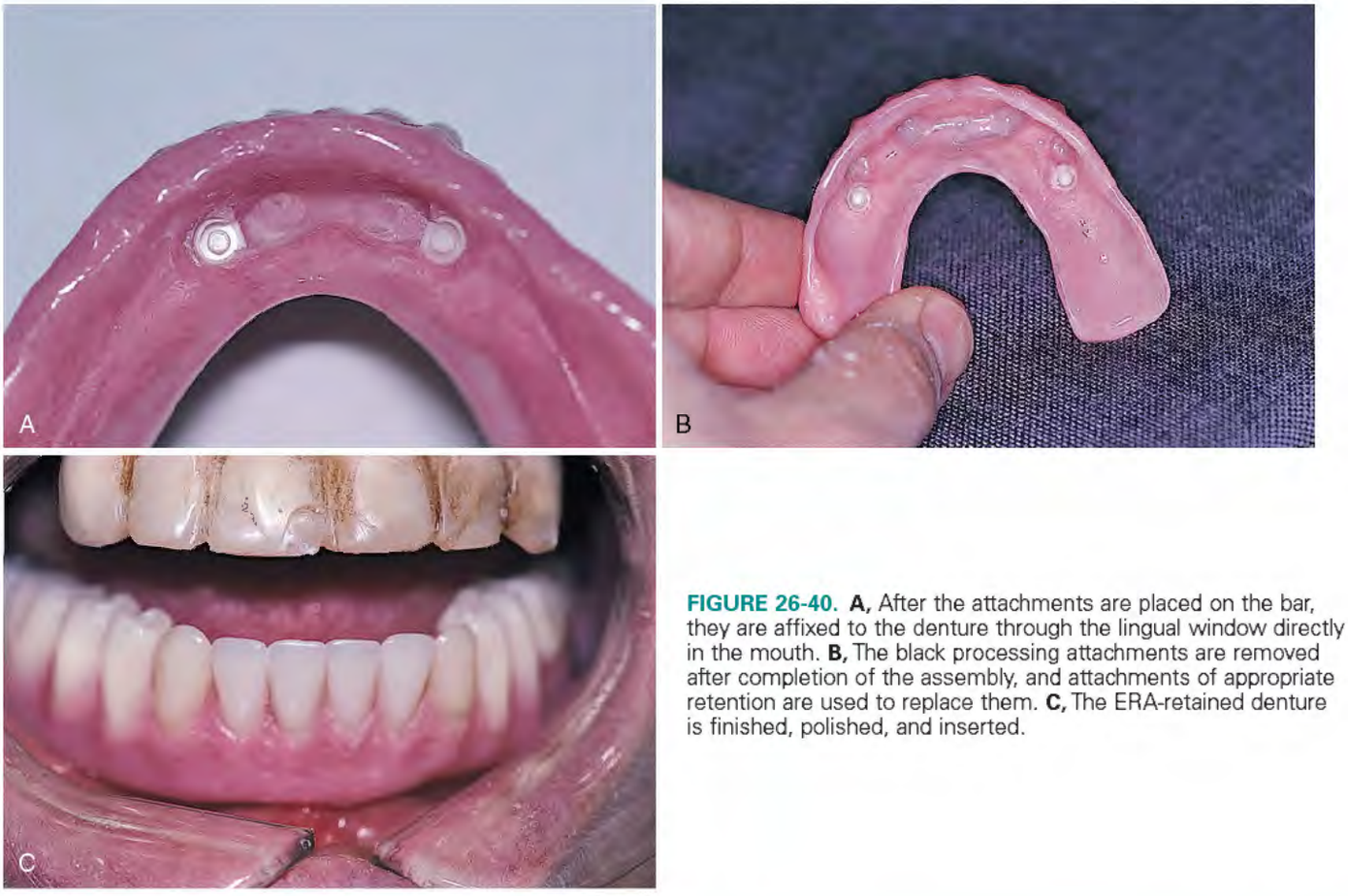


FIGURE 26-40. **A,** After the attachments are placed on the bar, they are affixed to the denture through the lingual window directly in the mouth. **B,** The black processing attachments are removed after completion of the assembly, and attachments of appropriate retention are used to replace them. **C,** The ERA-retained denture is finished, polished, and inserted.

The surgical template used in this technique is a duplicate of the patient's existing provisional denture (Fig. 26-41). The template reproduces the correct tooth position at the established vertical dimension. The surgical template is used to check the angulation, height, and location of each abutment relative to the patient's prosthetic plan. Transfer copings are placed over each abutment (Fig. 26-42), and the surgical template is modified by creating internal clearance so that it can be used as a custom tray. This allows it to be fully seated when the abutments and transfer copings are in place. The transfer copings are shortened, if necessary, to allow the patient to close in centric with the template and transfer copings in place (Fig. 26-43).

After the position of the template is checked for accuracy in the vertical dimension and centric occlusion, the impression is made by placing a polyether impression material into the modified tray, seating it, and guiding the patient's mandible into centric occlusion (Fig. 26-44). After removal of the tray, the occlusal registrations are verified, and the transfer copings are seated into their appropriate positions in the impression.

This procedure relates both arches in centric occlusion and vertical dimension and registers tooth position and abutment location in one step. The counter cast and abutment analogs are sent to the laboratory, where the master model is articulated to it. The laboratory fabricates and returns the custom bar (Fig. 26-45) and waxed overdenture (Fig. 26-46) with the teeth set into position (Fig. 26-47) according to the information obtained from the single impression. If inaccuracies are discovered, the bar is sectioned and then reconnected by applying a stable polymer (see Chapter 24). The joined sections are removed in their proper relationship using a polyether impression material in the wax record base. This is done by removing the attachments from the base before picking up the bar and using an impression wash material with the patient closed in centric position.

FIGURE 26-41. This surgical template is an exact duplicate of the patient's transitional denture.

Discrepancies in tooth position are addressed, as are problems with centric accuracy or lip line contour, by adjusting the wax setup at chair side. After the corrections are complete, the trial base is

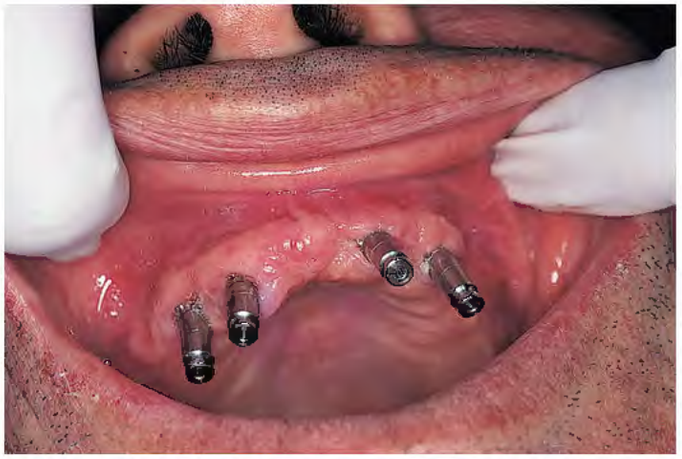


FIGURE 26-42. The abutments and transfer copings are seated in position before the final impression is made.

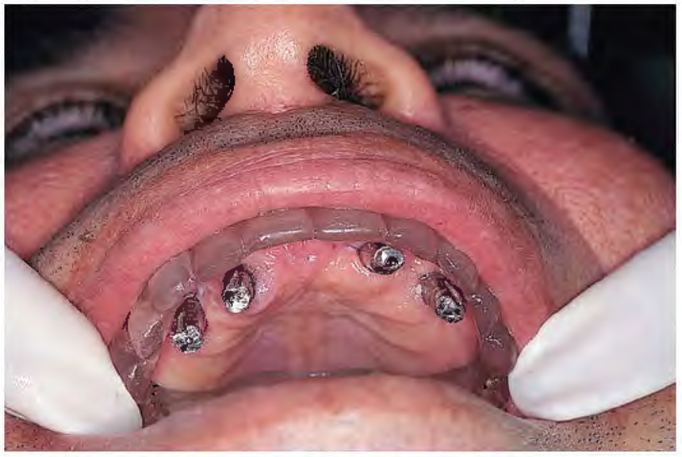


FIGURE 26-43. The modified transfer copings within the surgical template are checked for interferences.

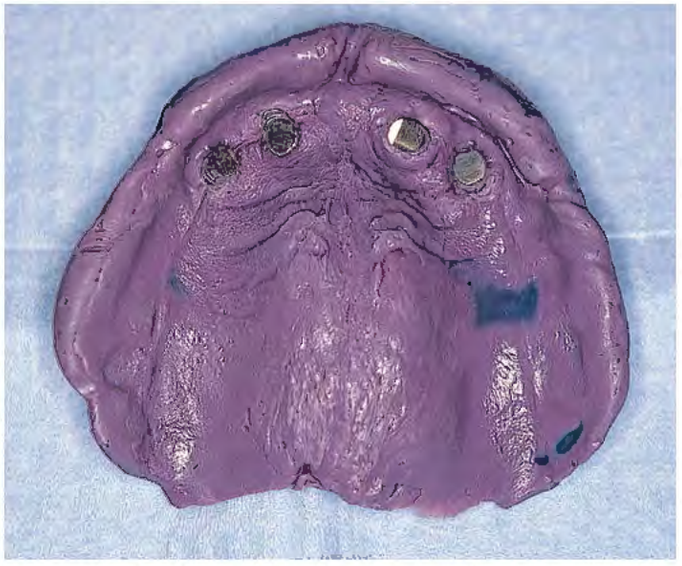


FIGURE 26-44. The final transfer impression is completed with the implant analogs and transfer copings reseated.

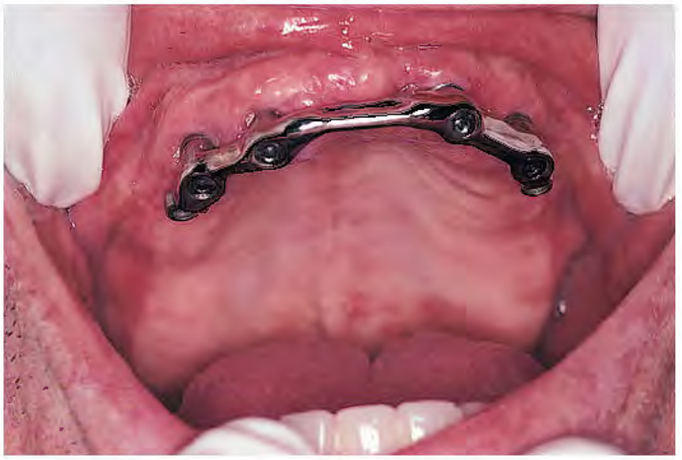


FIGURE 26-45. The cast bar is tried-in and checked for accuracy.

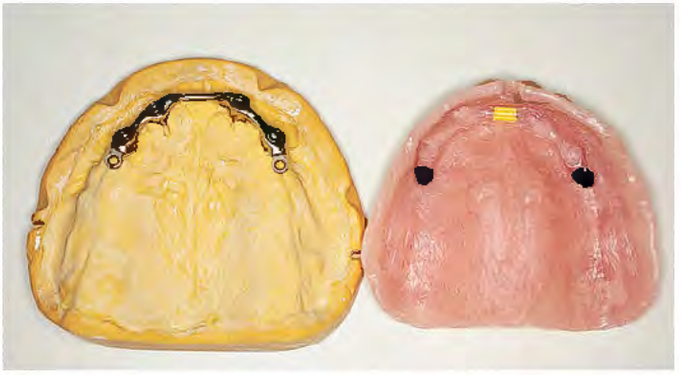


FIGURE 26-46. The fabricated bar and wax-up are tried-in with their attachments in place.

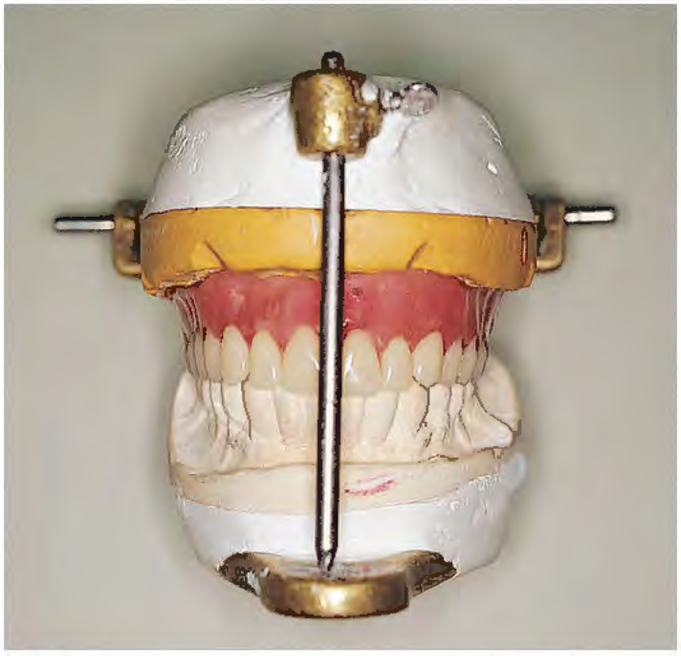


FIGURE 26-47. The wax overdenture is set up before the try-in.

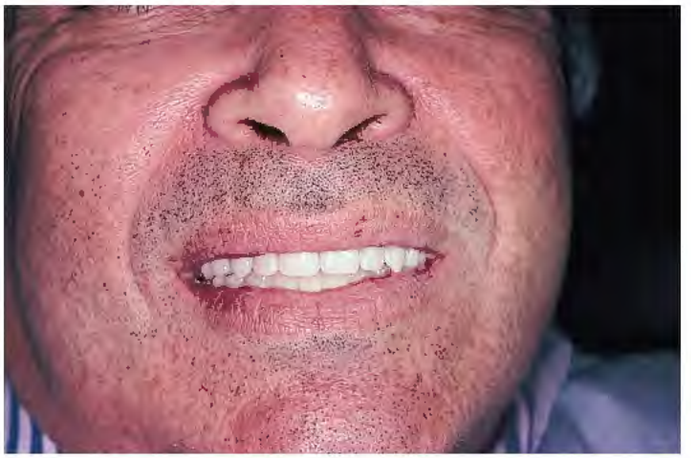


FIGURE 26-48. The completed case is inserted on the third visit.

relined with a polyether impression material and the bar is picked up to compensate for the changes in the soft tissue morphology caused by the surgical uncovering procedure. The laboratory pours a new master cast and completes the processing of the case for delivery on the patient's third visit (Fig. 26-48).

This technique can simplify overdenture construction when the supporting implants are only mildly divergent. When implant angulations are greater, however, the modified technique saves a great deal of time and effort.

The impression and transfer technique described may be used with any dental implant system for the entire spectrum of prosthetic design. Although this technique saves chair time, it requires the development of additional skills. The restorative dentist also must establish a relationship with a dental laboratory that is capable of executing the steps necessary to satisfy these procedures. If this technique is performed correctly, its benefits become apparent because of its efficiency and economics of time.

The patient should be taught the techniques for removing an overdenture. Proper removal reduces the tendency for attachment wear and breakage and minimizes torque on the implants. The patient should be instructed to do the following:

1. Close the teeth together.
2. Place one thumbnail under the overdenture flange in each canine area.
3. Open the jaw in a straight downward direction.

The overdenture is removed as it comes away above the thumbs. This technique is not effective if Lew attachments are used, because they can be opened most easily when the patient's teeth are closed.

Principles of Occlusion in Implantology

27 CHAPTER

The occlusal scheme design for implant-supported prostheses often is discussed only briefly in the implantology literature. Yet, as with all phases of prosthodontics, occlusion is a critical factor in the success or failure of implant-supported restorations. Tremendous efforts have been made to design complex and intricate implant infrastructures for these prostheses. However, it is equally or even more important to design restorations that use occlusal forces constructively, not destructively.

An understanding of implant-supported prosthesis occlusion begins with some basic assumptions drawn from knowledge of natural and prosthetic occlusion.

First, the patient controls the occlusal forces on natural teeth in response to proprioception. Because natural periodontal ligament–mediated proprioception does not occur with implants, its protective influence is lost in determining mandibular velocity and displacement. This means that occlusal forces on implant-supported prostheses must be, if anything, more carefully designed and exactly accomplished than with tooth-supported prostheses.

Second, no single occlusal scheme can be used for every type of restoration. The purpose and mechanism of complete denture occlusion are different from those of a single-crown restoration. For implant-supported prostheses, the occlusal scheme must suit the purpose and location of the restoration.

Third, two arches are involved in every occlusion. Whether the implant-supported prosthesis occludes with natural dentition, tooth-, or tissue-supported prostheses or another implant-supported prosthesis is critical, because each of these prostheses exerts a different range of forces in both functional and resting movements.

Finally, the natural resorption pattern of edentulous alveolar bone is almost never parallel to the ideal occlusal plane of the dentition. In determining abutment height and position, not only adequacy of interarch space but also orientation of the plane of occlusion must be considered, because a disrupted or incorrectly oriented plane of occlusion makes achieving the optimum occlusal scheme impossible (Fig. 27-1).

In all phases of prosthetic rehabilitation, the occlusal scheme is designed to meet the requirements of the oral situation. When an implant-supported prosthesis replaces a single tooth in an otherwise intact dental arch, the occlusion is designed like that of a tooth-supported single restoration. This generally is agreed to include lighter than normal tripodal centric occlusal contacts, to prevent supereruption of the opposing natural tooth. Because teeth have a periodontal ligament, they are microscopically compressible. Centric stops are taken by having the patient close hard in centric. The adjacent periodontal ligaments must be compressed to prevent hyperocclusion of the implant restoration. The implant-supported prosthetic crown should follow the guidance of natural teeth in working relationships, similar to other fixed restorations bounded by intact natural teeth (Fig. 27-2).

Canine disclusion is used in cases in which natural canine teeth are present and periodontally strong. Where canine teeth are replaced with implant-supported prostheses that occlude with natural teeth or other implant-supported prostheses, group function occlusion supported by natural teeth or other implant-supported prostheses is preferable, to avoid loading a single supporting implant during disclusion. Group function occlusion provides occlusal contact in centric position and in working movements but complete disclusion in balancing positions (Fig. 27-3).

By far the most controversial design for implant-supported prosthesis occlusion is in the totally edentulous mandible opposing the edentulous maxilla. Osseointegrated, subperiosteal, staple, and other implant types originally were designed to treat patients who use maxillary dentures with little difficulty but have unfavorable hard and soft tissue configurations for retention and stability in the mandibular arch. This is still probably the oral situation most frequently treated with implant dentistry.

The occlusal scheme requirements are similar between the case of maxillary complete denture or mandibular implant-supported prosthesis and the combination of the maxillary complete denture and mandibular distal extension removable partial denture. Both situations provide a maxillary denture that rests on movable and depressible tissue and a mandibular arch with dentition, either natural or artificial, essentially fixed into place.

At first glance, the principles of complete dentures would seem to apply to implant-supported prosthesis restorations; however, the quality of prosthesis support in the two cases is different. In conventional complete denture cases, both dentures are free to move on the tissues, and balanced occlusion (dynamic occlusal contacts throughout the arch) usually is accomplished, at least in part, by denture base movement on resilient tissue. This is especially true of flat plane cases, which have no cuspal inclines to compensate for Christensen's phenomenon (the disclusion of posterior teeth in protrusive position). In dynamic occlusion with complete dentures, each base moves slightly, and the compressive force delivered to tissue is relatively low. Tissue proprioception is a limiting factor, because the patient patterns the movements to seat, rather than unseat, the mandibular denture.

In the complete denture or implant-supported prosthesis, only the maxillary denture moves in function. Soft tissue resiliency and denture movement cannot be relied upon to help balance dynamic occlusal contacts without excessive compressive and tensile forces under the denture base. Occlusal forces generated against the maxillary denture by the implant-supported prosthesis are similar in magnitude to those for cantilever restorations using natural teeth. These forces are many times greater than would be possible with even a well-supported mandibular complete denture, and tissue proprioception of the mandibular denture base is no longer significant. An occlusal scheme that requires movement of the maxillary restoration could predispose the patient to combination syndrome, as has been documented in patients using maxillary denture restorations that provide only anterior tooth contacts in protrusive position.

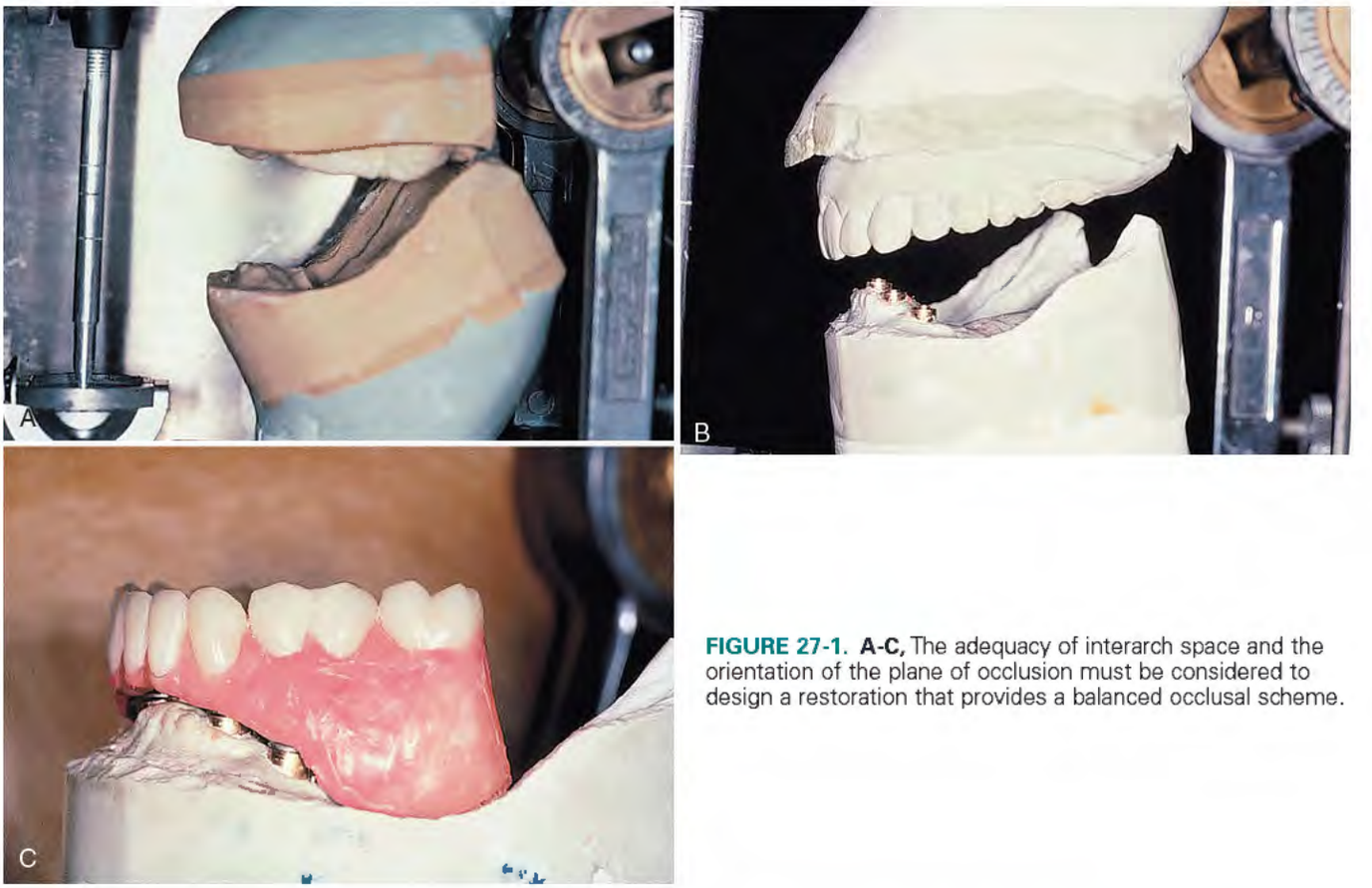


FIGURE 27-1. A-C, The adequacy of interarch space and the orientation of the plane of occlusion must be considered to design a restoration that provides a balanced occlusal scheme.

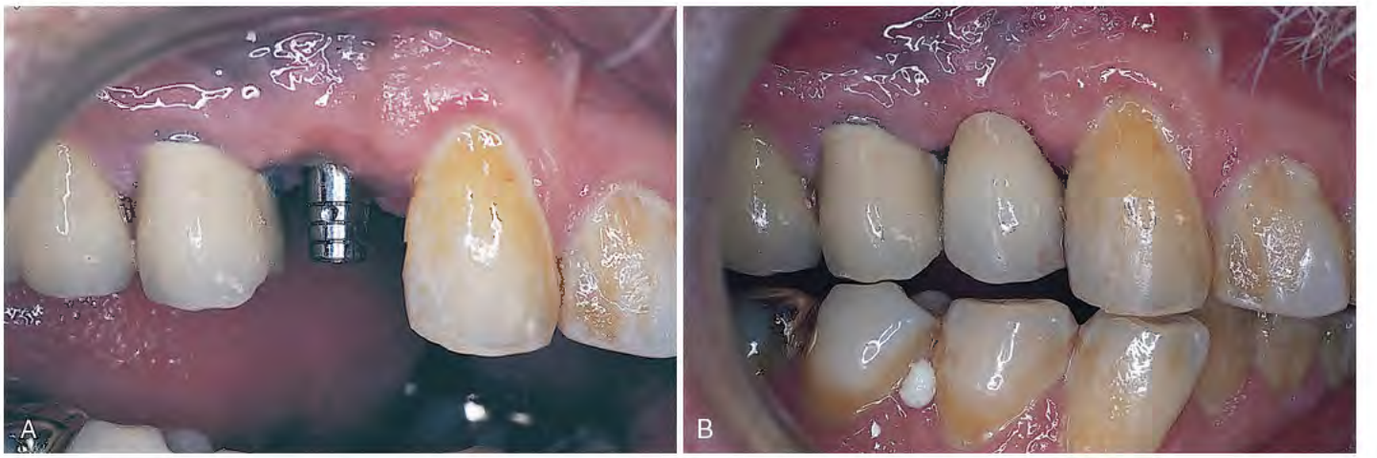


FIGURE 27-2. A, B, Implant-supported prosthetic crowns bounded by natural teeth should follow their guidance in working relationships, similar to other fixed restorations. The canine guidance found in these arches is maintained after restoration of the implants.

Clinical signs of this combination syndrome derive from hyperfunction in the anterior area of the arches resulting from Christensen's phenomenon. They include excessive resorption of maxillary anterior alveolar bone, downgrowth of maxillary tuberosities, and a lowering posteriorly of the occlusal plane of the prostheses. The need for early refining of the maxillary denture signals a rapid degenerative change related to occlusion for this type of restoration.

To avoid initiating this syndrome in patients treated with maxillary complete dentures and mandibular implant-supported prosthesis restorations, the dental surgeon must design an occlusal scheme that is bilaterally balanced during dynamic occlusion. In 1923, Rudolf Hanau formulated the Hanau Quint as an aid to achieving balanced denture occlusion. It is quite useful for the complete denture or implant-supported prosthesis case. It states:

$$< \frac{CG \quad IG \qquad\qquad PO \quad CC \quad CH}{\Delta} >$$

where *CG* is the condylar guidance, *IG* is the incisal guidance, *PO* is the plane of occlusion, *CC* is the compensating curve, and *CH* is the cusp height.

Simply, this means that factors on the left side of the equation must be offset or balanced by factors on the right. Condylar guidance and incisal guidance are factors that are not within the

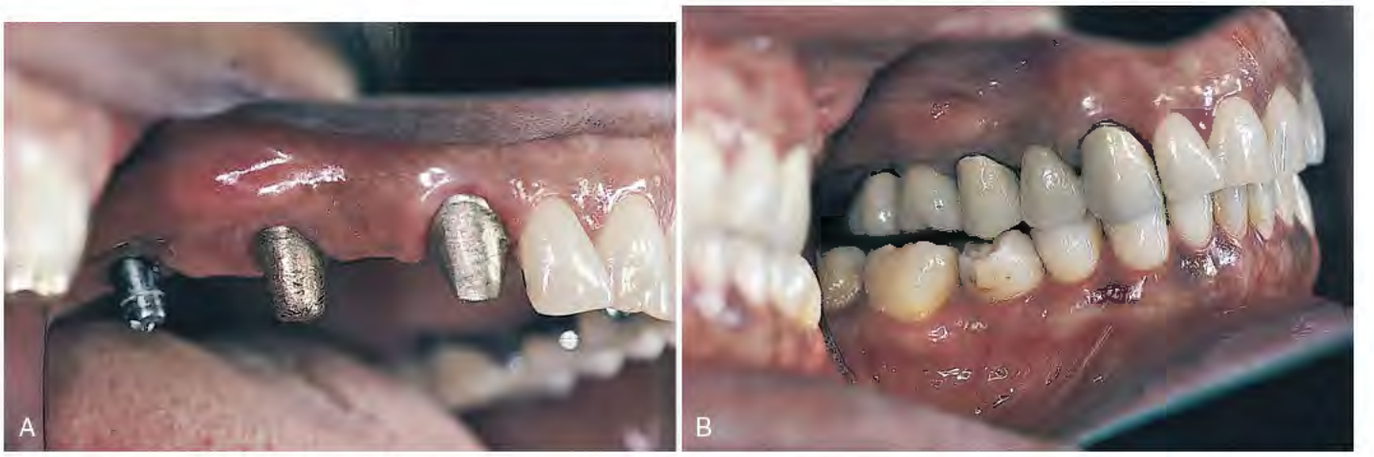


FIGURE 27-3. **A, B,** For canine area implant-supported crowns, group function occlusion supported by natural teeth or implant-supported prostheses is preferable to canine guidance to avoid loading a single supporting implant during disclusion.

dentist's control. Condylar guidance is a function of the anatomy of the temporomandibular articulation. The esthetic position of the anterior teeth, natural or artificial, sets the incisal guide. Factors on the right are within the dentist's control: orientation of the plane of occlusion of the prosthesis, compensating curve of the plane, and cusp height of the artificial teeth. Making the occlusal plane, the compensating curve, or the cusp height steeper promotes balance by providing more posterior tooth contact during protrusive and lateral movements.

Although the orientation of the plane of occlusion and compensating curve are defined as within the dentist's control, the position of the maxillary tuberosity limits them, especially in patients who had retained natural mandibular anterior teeth before implant placement. Also, the bisection of the retromolar pad is a commonly accepted landmark for orientation of the occlusal plane, and this can limit posterior elevation and use of a steep compensating curve.

The factor most easily within the dentist's control is the cusp height of the artificial teeth selected for the prosthesis, and many clinicians, especially those who have considered the potential for combination syndrome, recommend use of cusp or fossa occlusion to provide balance in complete denture or implant-supported prosthesis cases.

Attempts to provide occlusal balance in complete denture or implant-supported prosthesis restorations may cause problems. One problem is the absence of molar occlusal contacts in the shortened arch form usually used for implant-borne cantilever prostheses. The general suggestion is that such cantilevers should be limited to 15 mm posterior to the posterior implant abutment. This scheme provides occlusal contacts only back to the premolars or first molars. Further extension posteriorly directs unfavorable forces to the implants.

Another issue that could argue against the use of cusp or fossa-balanced occlusion is the introduction of horizontal, nonaxial forces on the implants during posterior cusp–guided disclusion. This concern has prompted some clinicians to use either a totally flat plane scheme or to reduce cusp height to the point where the anterior teeth accomplish disclusion. Most complete denture or implant-supported prosthesis cases are made with implant support that extends only to the canine region; therefore, in essence, no posterior tooth contacts are directed along the long axes of the implants even in centric closure. The number and location of implants in fully implant-supported fixed prostheses and saddle and flange extensions to use soft tissue support for implant-supported overdentures compensate for this. In either case, the implant-supported prosthesis in the mandibular arch has a far greater potential for destruction of the edentulous maxilla than the maxillary denture has for the implants, whatever their type or configuration.

When only a limited number of implants can be placed, the restoration of choice often is the implant-supported overdenture. Some authors have advocated a round configuration clip bar extending between two implants only, permitting free rotation of the denture vertically under posterior loading and sparing the implants in occlusion. An unwanted side effect of such a design is the potential for mandibular posterior bone loss and eventual anterior tooth occlusion in centric relationship closure, as well as in eccentric movements. If this design is used, care must be taken in follow-up visits to evaluate occlusion, reline if necessary, and be ready to change occlusal philosophy if rapid mandibular posterior or maxillary anterior bone resorption occurs.

CREATING A BALANCED OCCLUSAL SCHEME

Many dentists and laboratories have grown used to arranging only flat or semianatomic artificial teeth for contact in centric relationship. A brief review of waxing balanced occlusion may be helpful.

1. The master casts are facebow mounted in centric relationship at the determined vertical dimension of occlusion.
2. A semiadjustable articulator is used, and the condylar elements and incisal guide table are set with the use of an interocclusal record made in edge-to-edge protrusive position (Fig. 27-4).
3. The land area of the mandibular cast is marked to show the level of the bisection of the retromolar pads.
4. The maxillary anterior teeth are given a trial insertion to check for esthetic position before the full setup is started. Trial insertion also is done for the mandibular anterior teeth; the position of these teeth is partly determined by the implant abutments. The horizontal and vertical overlap is adjusted to approximately 2 mm in both dimensions. Ideally, this will have been worked out in trial dentures before implant placement and planned with the use of a surgical template to ensure abutment alignment within an acceptable range for esthetic artificial tooth arrangement (Fig. 27-5).

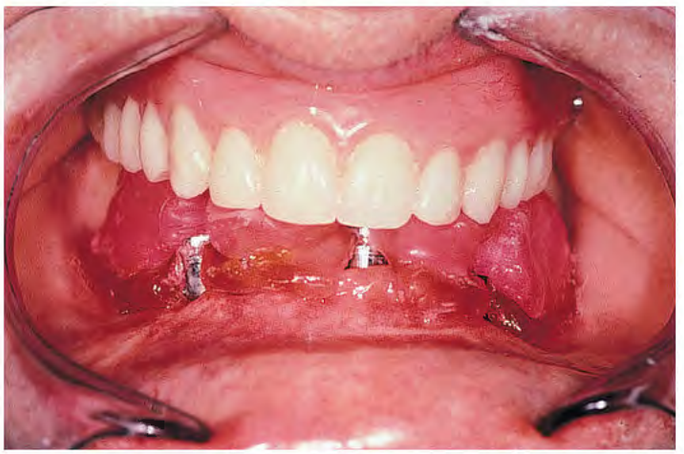


FIGURE 27-4. A protrusive record is used to program the semiadjustable articulator condylar elements and incisal guide table. This record is made with wax rims or after the trial insertion of anterior teeth.

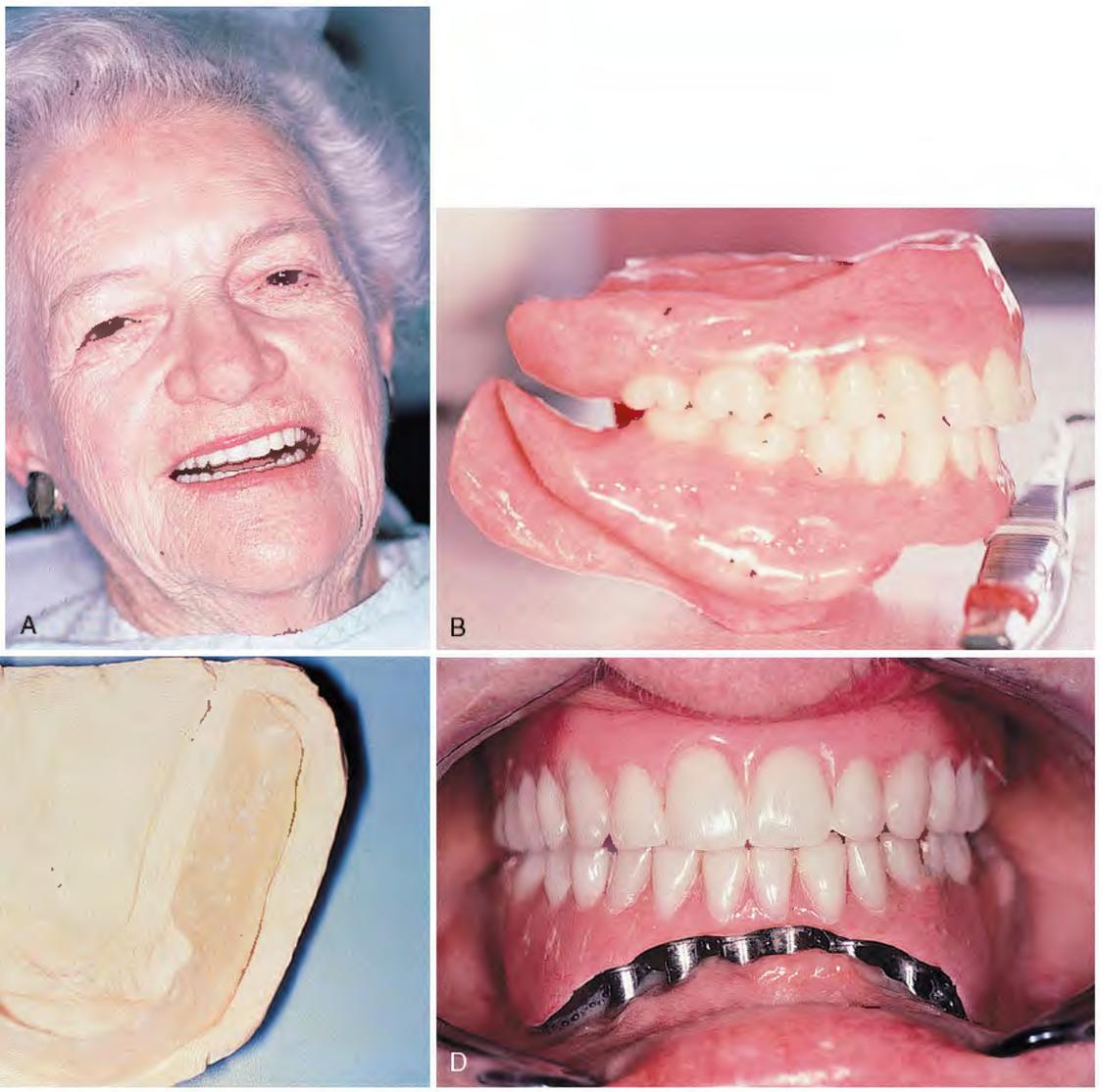


FIGURE 27-5. **A** to **D,** A trial insertion is done to evaluate esthetic tooth position before the full setup is begun. This usually duplicates the tooth position of dentures made before implant placement. A surgical template can aid abutment alignment within an acceptable range for esthetic artificial tooth arrangement.

5. Maxillary 30-degree cusp posterior teeth are arranged with a plane of occlusion so that the first molar mesiolingual cusp bisects the retromolar pad, and a steep compensating curve begins there and rises above the plane 1 to 2 mm (Fig. 27-6).
6. Mandibular 30-degree cusp posterior teeth are arranged to provide tight occlusal contacts when viewed from the lingual and buccal aspects (Fig. 27-7).
7. The condylar elements are unlocked, and the articulator is moved into protrusive position with the incisors at edge-to-edge relationship, so that the dentist can check for cusp tip contacts of all posterior teeth (Fig. 27-8).
8. The articulator is moved into right and left working positions to check for cusp to fossa contacts in working positions and cusp tip contacts in balancing positions, as viewed from the buccal and lingual aspects (Fig. 27-9).
9. The dentist must re-establish that the anterior teeth are just out of contact in protrusive and lateral excursions (Fig. 27-10).

Because the semiadjustable articulator has a straight line condylar path, it cannot duplicate mandibular movements with precision. Before a trial insertion, the teeth are arranged as perfectly as possible, but the dentist must be ready to make another protrusive record, especially when what is seen in the mouth appears different from what is on the articulator. It is better to process the dentures with excessive cuspal contact in lateral and protrusive positions, because this allows for adjustment in a functional grind-in procedure. Excessive cusp height is easily removed, but it cannot be increased if the cusp tips fall short of obtaining balance. In such a case, balance must be obtained by grinding the anterior teeth, with the attendant loss of esthetics.

A successful modification of full cusp balance that may offer advantages is the lingualized occlusion scheme. In this scheme, balance is obtained by continuous contact of the maxillary lingual cusps with the occlusal table of the mandibular teeth during dynamic occlusion.

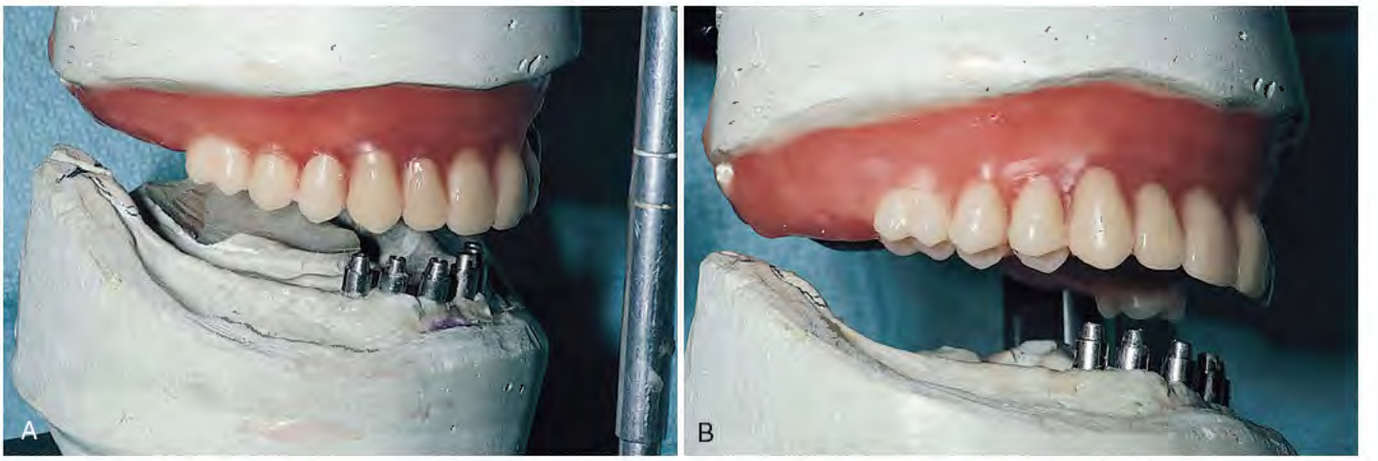


FIGURE 27-6. **A,** Maxillary 30-degree cusp posterior teeth are arranged with a plane of occlusion such that the first molar mesiolingual cusp bisects the retromolar pad, and a steep compensating curve begins there and rises above the plane 1 to 2 mm. **B,** The teeth are arranged so that only lingual cusps touch the plane of occlusion.

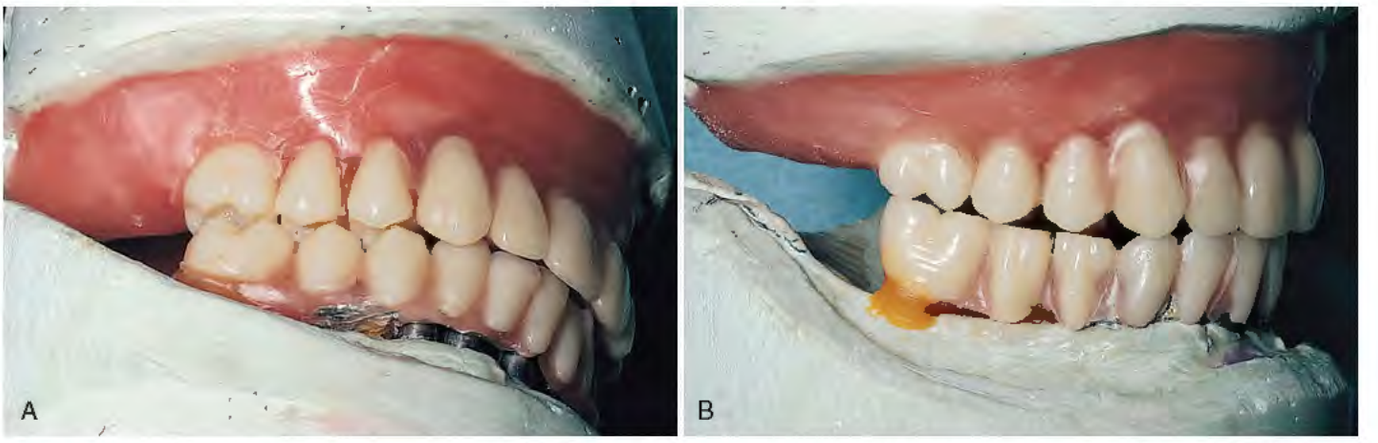


FIGURE 27-7. **A,** Mandibular 30-degree cusp posterior teeth are arranged to provide tight occlusal contacts, as viewed from the lingual and buccal aspects. **B,** These flat or semiautomatic posterior teeth are arranged to provide tight occlusal fossa contacts with the maxillary lingual cusps. Buccal cusps should be out of occlusion in centric and eccentric positions.

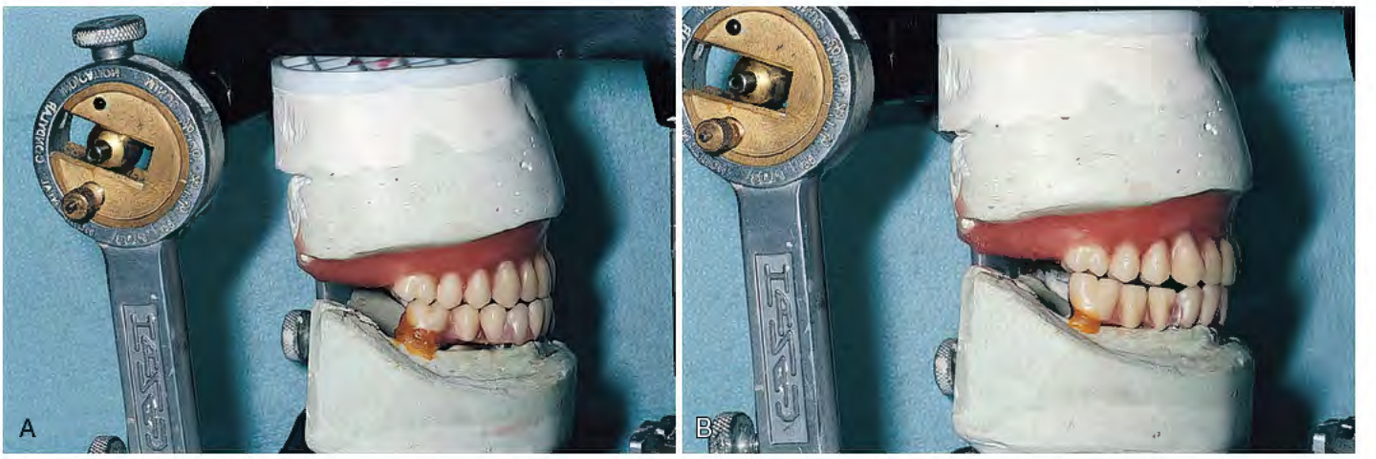


FIGURE 27-8. **A,** Condylar elements may be unlocked and the articulator moved into protrusive position to check for cusp tip contacts on all posterior teeth at the anterior edge-to-edge position. **B,** The maxillary lingual cusp tips of all posterior teeth should contact the mandibular fossae at the edge-to-edge position.

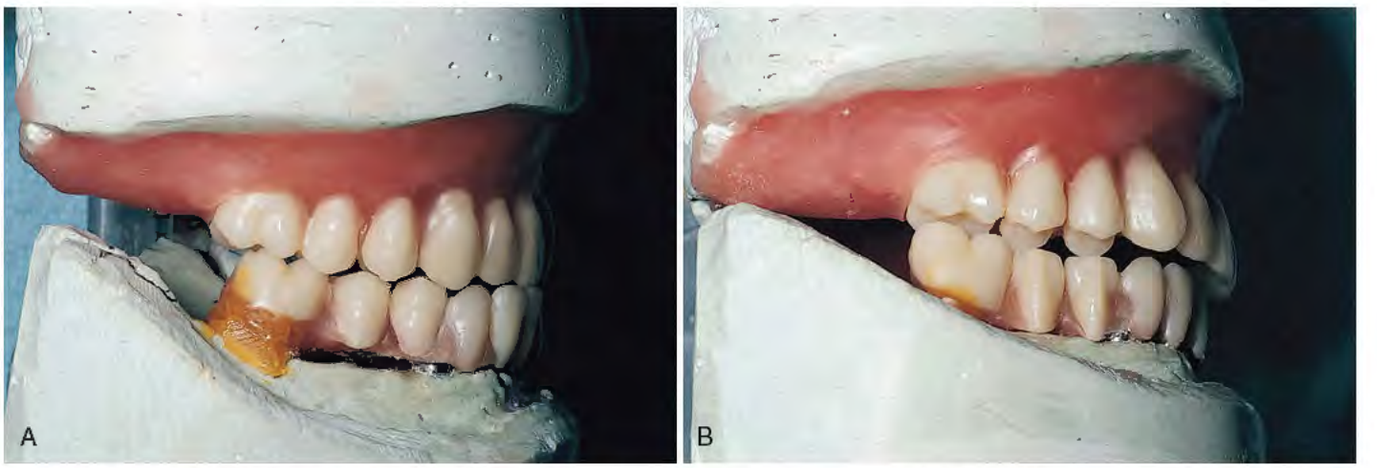


FIGURE 27-9. **A,** The articulator may be moved into right and left working positions to check for cusp-to-fossa contacts in working and cusp tip contacts in balancing positions, as viewed from the buccal and lingual aspects. **B,** The arrangement should provide cusp-to-fossa contacts in a small range of working and balancing positions.

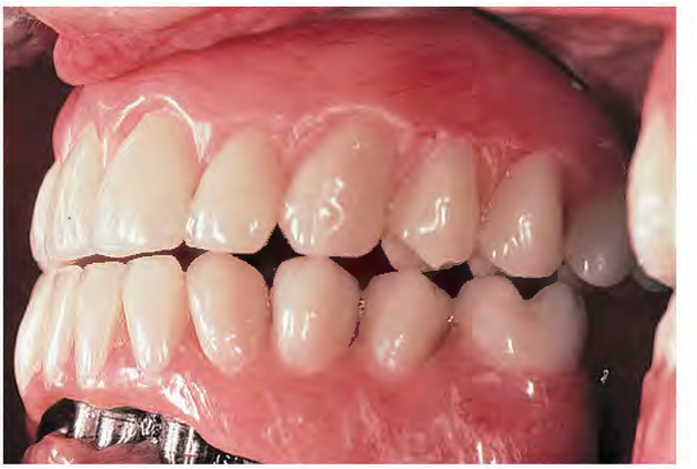


FIGURE 27-10. Anterior teeth should be just out of contact in protrusive and lateral excursions.

FUNCTIONAL ADJUSTMENT FOR BALANCED OCCLUSION

Clinical remount procedures using an articulator can re-establish coincidence between centric relation closure and maximum intercuspation. A stable, unstrained, intercuspal position is the most important aspect of a cusped occlusion. Some authors advocate a laboratory remount of freshly processed dentures before decasting; however, this can cause gross inaccuracies if processing shrinkage has caused the dentures to distort by pulling away from the master casts. The better course is to decast and finish the prostheses and insert them before any occlusal adjustment. Usually, little distortion occurs in implant-supported prostheses with metal infrastructures. They are inserted and tightened into place on their supporting implants before occlusal registration. Tissue-borne opposing "dentures" are disclosed with pressure indicator paste (PIP), and interferences to vertical seating without occlusal contact are removed (Fig. 27-11).

A new centric relation record is made to re-establish centric relation occlusion on the articulator (Fig. 27-12). However, an attempt

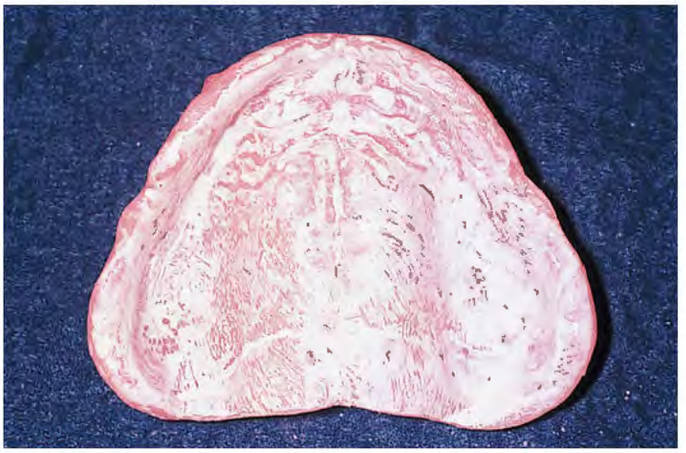


FIGURE 27-11. Tissue-borne opposing dentures are seated under finger pressure using pressure indicator paste, and interferences to vertical seating are eliminated.

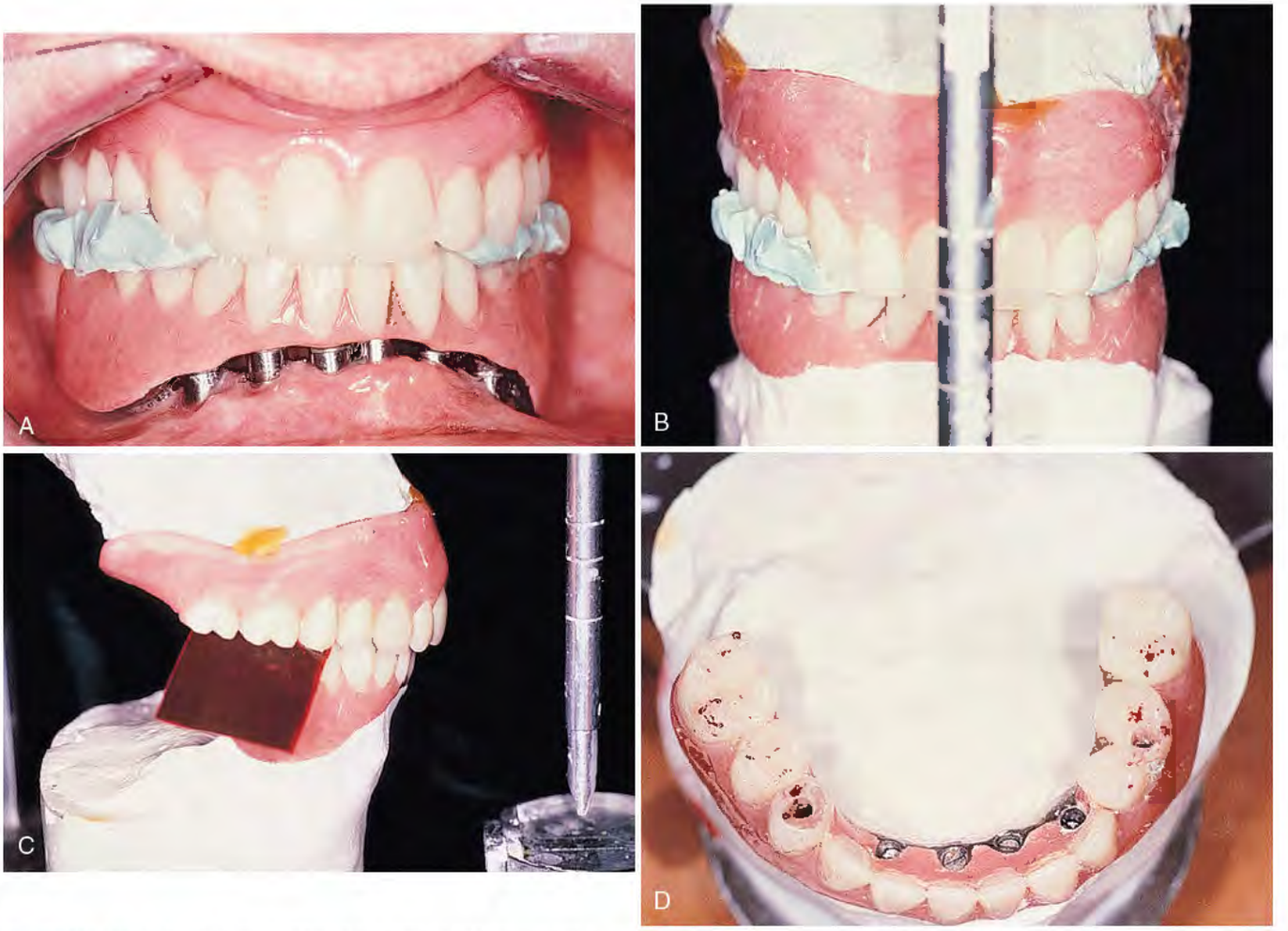


FIGURE 27-12. **A** to **D,** A new intraoral centric relation record is made, and dentures are remounted on the articulator. Articulating paper markings are adjusted until uniform contact in centric relation has been established.

should be made to duplicate dynamic occlusion mechanically; therefore functional methods (e.g., chew-in techniques, centric-bearing devices, and occlusal indicator waxes) should be used instead (Fig. 27-13). To prevent the loss of balanced contacts, adjustments are made by sharpening cusps and deepening or widening fossae. The maxillary denture should be adjusted, rather than the mandibular implant-supported prosthesis, to avoid flattening the orientation of the occlusal plane or compensating curve.

Correct occlusion for implant-supported restorations is a major determinant of long-term success, not only for the prostheses, but also for the remaining oral supporting structures they approximate.

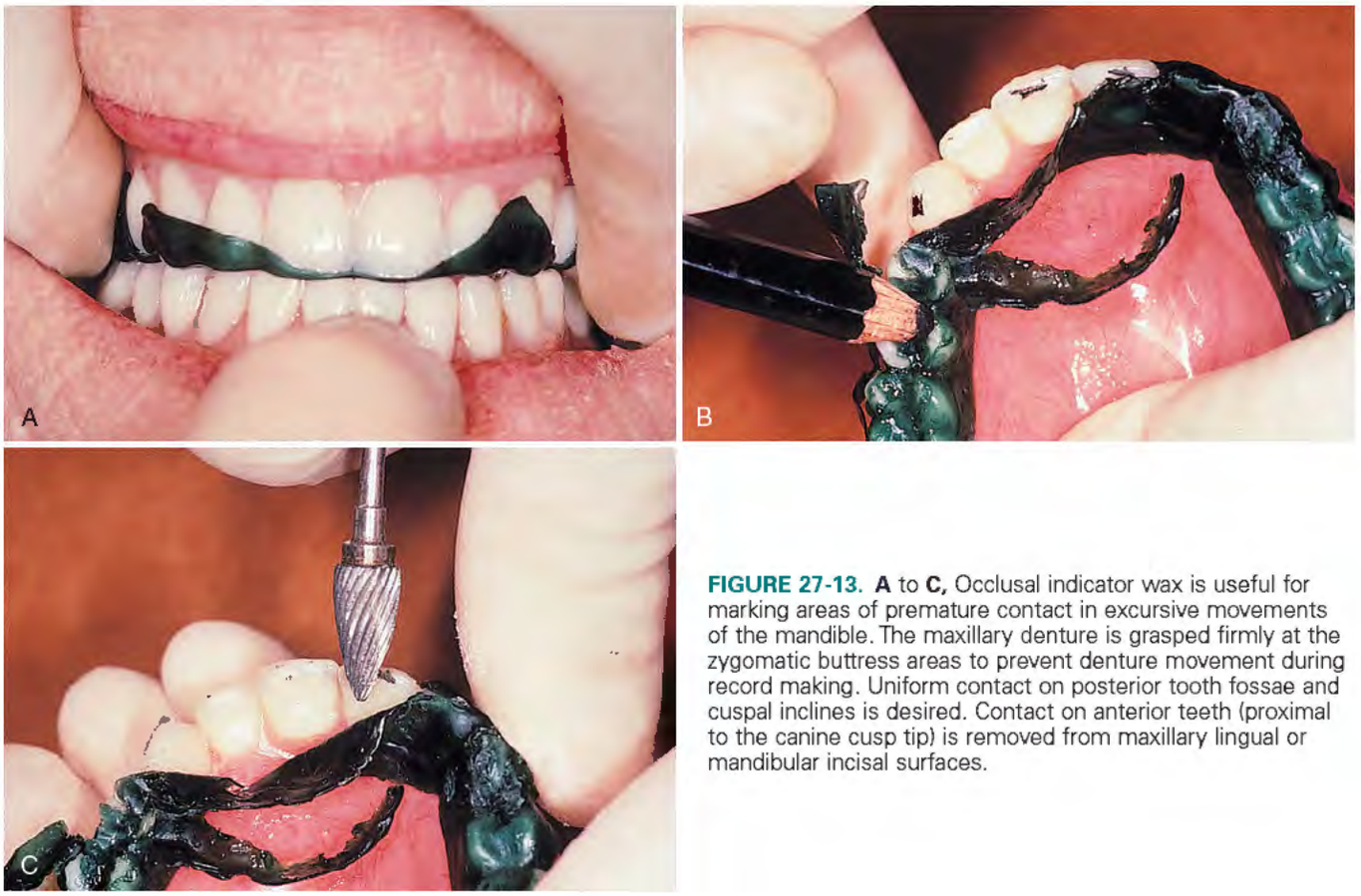


FIGURE 27-13. **A** to **C,** Occlusal indicator wax is useful for marking areas of premature contact in excursive movements of the mandible. The maxillary denture is grasped firmly at the zygomatic buttress areas to prevent denture movement during record making. Uniform contact on posterior tooth fossae and cuspal inclines is desired. Contact on anterior teeth (proximal to the canine cusp tip) is removed from maxillary lingual or mandibular incisal surfaces.

Acknowledgment

The authors would like to acknowledge Ival G. McDermott for previous contributions to this chapter.

Diagnosis and Treatment of Complications

28 CHAPTER

This chapter presents a variety of techniques that can be used if problems arise. The chapter is divided into three major parts:

1. Intraoperative complications
2. Short-term complications (those that occur during the first 6 months after surgery)
3. Long-term complications

CAVEATS

The dental surgeon should not attempt heroic efforts. It is always safer (personally, professionally, and legally) to remove a failing implant or to decide at the outset not to insert one.

Good sense and sound clinical judgment, tempered by experience, should be used in making a decision to perform a salvage operation.

At this juncture, reviewing the section on surgical anatomy in Chapter 4 and all of Chapters 6, 7, 8, and 9 would be useful.

ARMAMENTARIUM

Acrylic, self-curing
Bone files
Burs: 700L, 701L, 2L, 4L, 6L friction grip
Curettes: surgical and periodontal
Electrosurgical unit
Explorer/millimeter probe
Forceps:
  Adson toothed and nontoothed pickup forceps
  Gerald toothed and nontoothed pickup forceps
  Kelly and tonsil (curved) hemostatic forceps
  Rongeur side and end cutting
  Wire twisting forceps, heavy duty
Gelfoam, surgical bone wax, Avitene
Handpieces: high and low speed, straight and angled, Impactair
Hemostats: mosquito, Kelly
Hypodermic needles: 18 gauge disposable, 1½-inch
Local anesthetic syringes, needles, and solutions
Mallet: nylon covered
Mirror (front surface)
3½-inch, 18-gauge spinal needle with stylet (for the zygoma)
1½-inch needle (for the mandible)
Needle holders
Sterile rubber dam (1.5 × 4-inch strips)
Nerve hooks
Periosteal elevators
Osteotomes: curved and straight
Pliers:
College pliers with plastic tips
Titanium-tipped cone socket pliers (2)
Polyethylene (intravenous) tubing
Prep tray for sterilizing the operative site
Retractors: sweetheart (tongue), baby Parker, blunt (Mathieu) rakes, large blunt rakes, Army/Navy, beaver tail (Henahan), McBurney, vein, Leahy
Sable paint brush (0-0)
Scalpel handles (2): Bard Parker No. 3
Scalpel blades: No. 10, 11, 12, and 15
Scissors: Metzenbaum, curved, sharp tissue, and suture
Sponges: 2 × 2-inch, 4 × 4-inch
Suction tips: Yankauer and Frazier, plastic
Sutures: 3-0 black silk, 4-0 dyed Vicryl, 3-0 plain gut, 4-0 chromic gut on tapered and cutting needles
Towel clamps
Wire: monofilament No. 2 stainless steel in 12- to 18-inch lengths
Wire cutters, shears, and nippers

INTRAOPERATIVE COMPLICATIONS

Endosteal Implants

Oversized Osteotomy

Root Forms

The best way to manage problems is to practice avoidance. Most systems, including Nobel Biocare, Biomet-3i, Zimmer, Straumann, Neoss, and Camlog, offer implants of several diameters. If, during placement of a 3.5-mm diameter implant, the dental surgeon discovers that the endosteal threads have been stripped, a larger diameter implant is placed (if the ridge is 6 to 7 mm wide) that successfully retaps and grasps the internal environment of the osteotomy. Nobel Biocare offers a 4.3-mm implant as a replacement if the surgeon strips the bone while seating the standard 3.5-mm size. The Biomet-3i series is available in 3.25 and 4 mm and in larger diameters. An additional advantage of these implants is that they get wider toward the coronal end. The Camlog series 3.8-mm diameter implant has a threaded 4.3-mm backup size. However, a press-fit 3.8-mm implant also is available, and it can be used as a substitute for the stripped threaded implant site (Fig. 28-1).

Zimmer makes a 3.25-mm, small-diameter (SD) Spline implant, as well as one with a standard 4-mm diameter; both are press-fit implants coated with hydroxyapatite (HA). The larger size is used when frictional grip cannot be obtained with the SD implant.

A helpful hint when Nobel Biocare or Biomet-3i implants are placed in maxillae and in soft mandibles: The countersink and bone-tapping or threading instruments should not be used; rather, because maxillary bone usually is very compliant, the implants should be allowed to tap themselves into position. These systems are technique sensitive. The last two steps (i.e., bone tapping and implant seating) are performed with an ultra-low-speed handpiece or by hand. The threads are fine and closely approximated to one another. An electrical or piezosurgical motor diminishes the tactile sensitivity of even the most skilled surgeon.

If the bone lacks sufficient density to stop the rotation by frictional braking, continuing rotation of the bone tap or the implant itself may strip the internal bony threads. Therefore, the tapping and seating operations are performed with discrimination and care, and a mark on the rotary instrument is used to dictate the exact moment to reverse the motor's direction.

A safer approach is to stop the motor at a point four or five rotations from final seating and complete the procedure with the handheld ratchet wrench (Fig. 28-2). The wrench is held near its

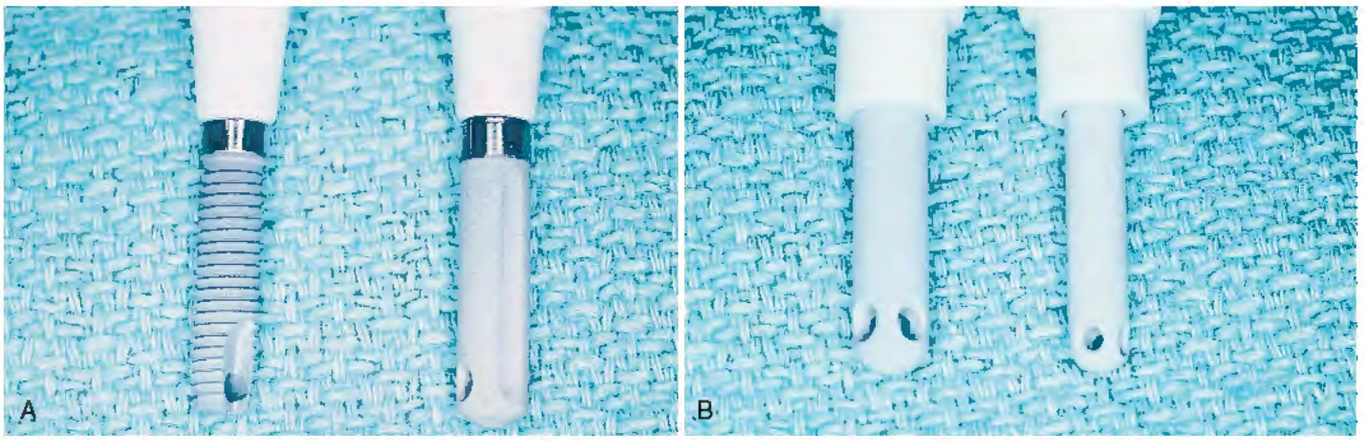


FIGURE 28-1. Larger diameter implants are important for oversized osteotomies. If an implant does not fit snugly, one with a larger diameter should be used. **A,** Steri-Oss implant: a press-fit implant was substituted for a stripped threaded implant. **B,** Integral implant: same design but a larger diameter implant.

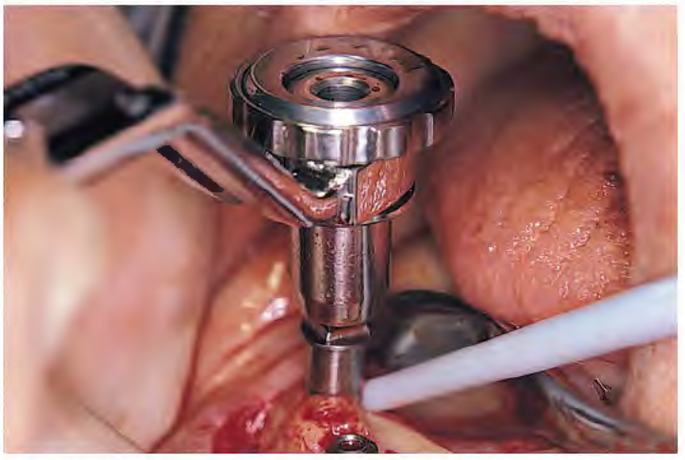


FIGURE 28-2. If resistance is too great to permit threading with the wheel wrench, the ratchet wrench is used. The greatest control is obtained by holding the wrench near its center and supporting it with the other, countertorquing hand. As leverage increases, tactility diminishes.

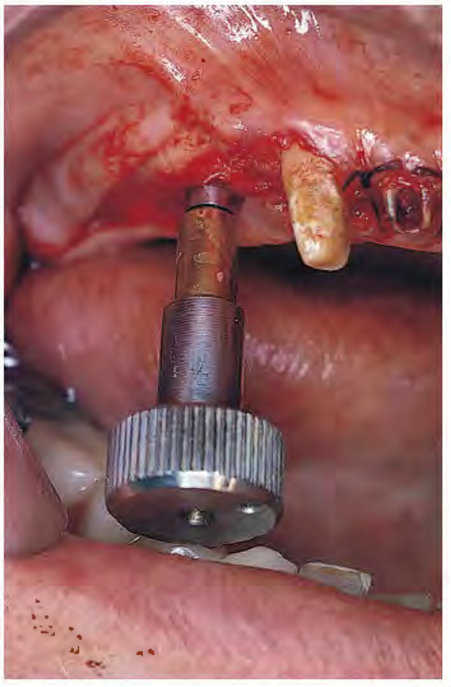


FIGURE 28-3. Threaded implant systems supply the clinician with wheel wrenches, which are used in less dense bone for discriminate rotation.

working end to neutralize the great leverage of its long handle. This leverage, if not governed carefully, may be responsible for stripping the internal bony threads. The preliminary efforts at placement are made by attempting to turn the implant with the wheel only (Fig. 28-3). If after all these precautions, the implant does not come to a final and firm stop, it should be removed, and the next-larger diameter implant should be inserted, placed without the formality of bone-tapping or threading devices. Practice and experience help flatten the learning curve.

If the osteotomy becomes oversized during insertion of a press-fit or threaded implant from a system without an available larger diameter, the implant should be removed, and some 250-to 500-μm tricalcium phosphate (TCP), particulate HA graft material should be placed against the internal walls of the osteotomy. The implant should be moistened with blood or saline and rolled in the particulate slurry until a thin layer of the slurry clings to it. The implant then is reinserted to achieve a frictional fit. Coverage of the osteotomy site with a guided tissue regenerative membrane (GTRM) can improve the chances of successful osseointegration. A maximum space of 0.5 mm is allowable for this technique (Fig. 28-4).

Blade and Plate Form Implants

The following suggestions are suitable for one-piece and submergible blades. If the osteotomy is larger than the blade infrastructure, a second Omni or Ultronics blade (these are supplied in "blank" form) should be trimmed longer or deeper to create a frictional fit in the bone slot (if anatomic structures permit). With all non-HA-coated blades, both custom and catalog, primary retention is achieved by bending the infrastructure into a gently curved S pattern. This provides a primary frictional fit by locking the blade into position while the process of osteogenesis takes place. Two titanium-tipped, cone socket pliers are used to bend the blades; very gentle but firm pressure is applied so that the bends are gradual rather than acute (Fig. 28-5).

If the interfacial void is more than 0.5 mm, the use of particulate graft material mixed with demineralized freeze-dried bone (DFDB) is strongly recommended as an osteoinductive grout.

FIGURE 28-4. Retention of press-fit implants coated with hydroxyapatite (HA) can be improved by moistening them in blood and rolling them in 40- to 60-mesh HA. The adherent particles help wedge the implant firmly into its host site.

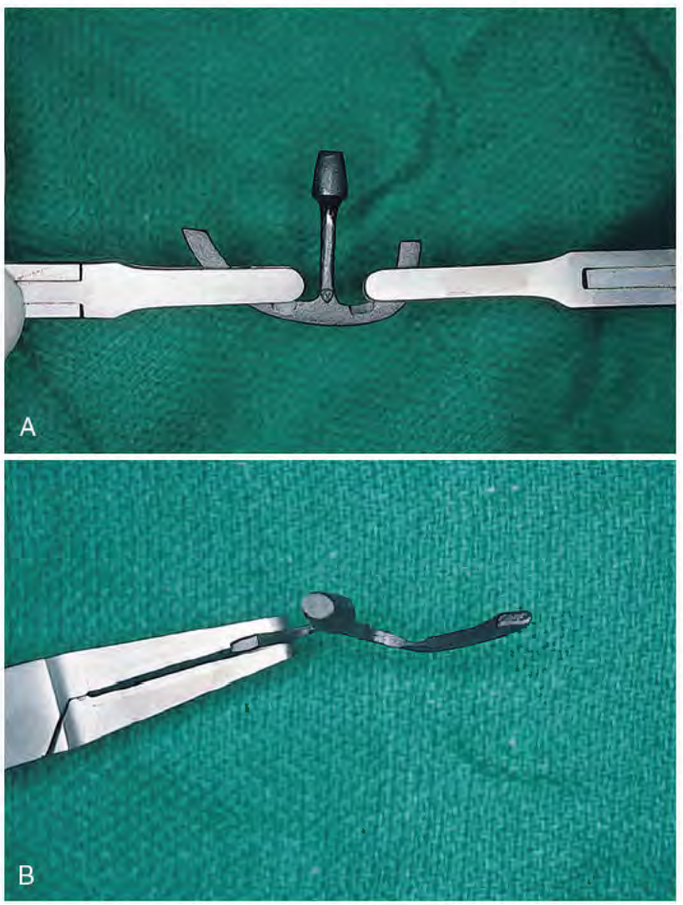


FIGURE 28-5. **A, B,** Blade osteotomies, if too wide, may require corrective maneuvers. Titanium-tipped, cone socket pliers can be used to bend gentle irregularities into the infrastructure, providing instant retention.

Perforations of Cortical Plates: Root Form, Plate Form, and Blade Implants

When osteotomies are performed for the seating of endosteal implants, whether laminar, grooved, slotted, or cylindric, a perforation is possible, even if the host site is capacious. The perforation, which can be medial, lateral, or apical, can occur because of misdirection of a drill or because of an unexpected anatomic irregularity (e.g., the submandibular fossa beneath the mylohyoid ridge) (Fig. 28-6).

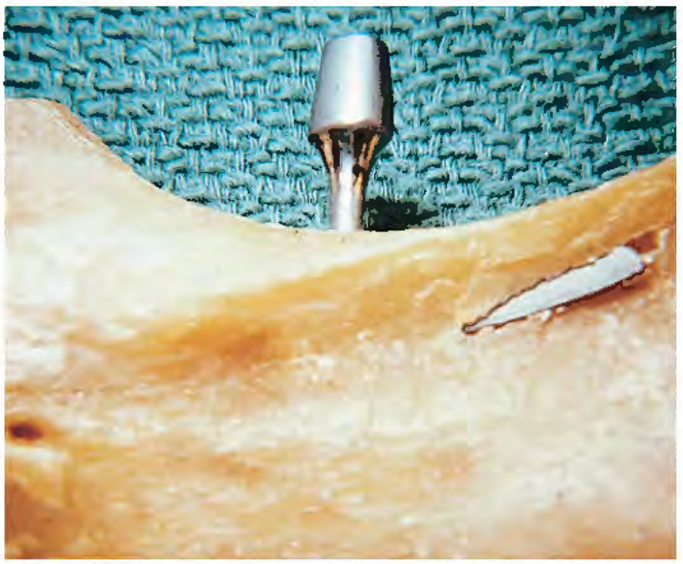


FIGURE 28-6. A constant awareness of anatomic characteristics prevents perforation of the cortical plate, which occurs with no signal to the dental surgeon. After osteotomies are completed and before implants are placed, soundings must be made with a blunt probe.

If the ridge width is inadequate when expansion techniques are started, fracture can occur, with displacement or even loss of the cortical segment. If periosteum is attached to the endangered cortical plate, replacing it after implant insertion and suturing presents a good prognosis for healing. If the fragment becomes detached, it can be wedged back into position, but the prognosis is guarded. If the implant's diameter prevents replacement, the bone segment should be particulated, and with DFDB used as an expander, it should be applied to the external surface of the defect. The patient's blood serves as a fibrinous grouting medium. Closure is performed after a resorbable membrane is placed over the entire graft complex.

Plate fracture often is difficult or impossible to avoid. It should be left untreated if no displacement occurs. However, the dental surgeon should always test for perforations. After each osteotomy is completed (for all implant types, including endodontic implants), its integrity is tested with a long, thin, blunt probe (e.g., the Kerr Dycal instrument or a 40-mm No. 50 endodontic reamer). If the tip falls through an inaccessible fault or perforation, it would be wise to cover the area with a membrane (see Chapter 8), tease a Colla-Plug over it, or gently tap some synthetic or autogenous bone at the base of the defect. The soft tissues are then closed, bone healing occurs for 6 months, and reoperation is performed. If the mandibular canal is involved, a Colla-Plug is placed gently into the base of the defect to avoid forcing graft particles into the neurovascular bundle. If the perforation is in a visible and operable location (e.g., the labial cortex), the implant is allowed to remain in position, and its exposed portion is covered with particulate bone (preferably autogenous), which can be harvested from the tuberosity. The repair is completed by covering the graft with laminar bone (Lambone), and primary closure is performed.

If an unintentional perforation occurs during preparation of an osteotomy beneath the antral floor, but the tip of the drill does not penetrate or injure the sinus membrane, the implant is placed and allowed to extend beyond the cortex for up to 2 mm, thereby "tenting" the sinus lining. If the implant progresses to integration, it remains in successful equilibrium with its environment. If it fails to integrate, the extension into the cavity space (which offered no additional bony retention) poses the threat of formation of an oroantral fistula (Fig. 28-7). An unintentional perforation is managed

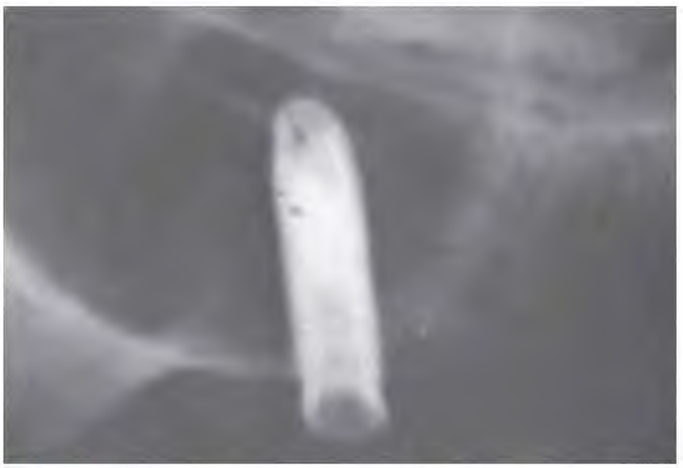


FIGURE 28-7. Antral floor perforations should be avoided. A few millimeters of overextension are allowable, because the sinus membrane can be pushed upward and remain intact. Greater penetration requires instant removal of the implant and primary repair with a pedicle graft.

in a predictable and acceptable manner, as recommended by the Summers technique (see Chapter 8).

Air bubbles leaking from the osteotomy indicate perforation into the maxillary sinus (Fig. 28-8). In these cases, an acceptable remedy is deep repair with a Colla-Plug and graft material, followed by placement of a shorter implant. If this appears to be unsatisfactory, a primary closure is made with a buccal (undermined) pedicle graft (see Chapter 7), the flap is sutured over intact bone, and the sinus regimen in Appendix G is prescribed. If osseointegration takes place, no treatment is necessary. If osseointegration fails to occur and a connective tissue interface results, the possibility of maxillary sinusitis arises. The patient should be told about the implant's proximity to the antral floor, and the symptoms of sinusitis should be described. If the symptoms occur at a later date, the implant's status is assessed, and if it is failing, it is removed. The communication between the oral and antral cavities is repaired with either a buccal or palatal pedicle graft. These procedures, as well as nasal antrostomy, the Caldwell-Luc procedure, and antral lavage are described later in this chapter.

Significant bleeding characterizes perforation of the mandibular canal, which can be confirmed by a periapical radiograph with a probe or gutta percha point in place. The best cure for this is avoidance. The following are the four most successful ways to prevent mandibular canal perforation:

- Measurements must be taken carefully in the planning and operating stages.
- Infiltration anesthesia, rather than block anesthesia, should be used, because the patient may be able to respond as an instrument approaches the canal.
- The tactile sense should be used to alert the dental surgeon of contact with the cortical bone superior to the canal.
- Undistorted intraoperative periapical films should be used.

If the canal has been entered, as indicated by inordinate bleeding, the implant should not be placed (Fig. 28-9). Rather, the incision is closed, because the nerve may heal spontaneously. If signs of regeneration (i.e., tingling or formication) do not occur within several months, the patient should be referred to a specialist who performs mandibular neurorrhaphy procedures.

(The discussion of surgical anatomy in Chapter 4 details the possible locations of the mental foramina and the peculiarities of the route taken by their neurovascular bundles.) When implants are to be placed in the region of the mental foramen, this structure is exposed so that its position is localized clearly when the osteotomies are performed. Even with viewing, however, the dental surgeon must bear in mind that the bundle often courses forward, anterior to the foramen, for 4 to 6 mm before curving back to its exit (Fig. 28-10, *A*). In some cases, two or more mental canals are present (Fig. 28-10, *B*). If the canal is entered or the nerve is injured, the implant should not be placed. Rather, the wound should be closed in the hope that the dysesthesia will correct with time. If the symptoms persist unchanged for 6 weeks, microsurgical neurorrhaphy should be considered.

If the bone perforation occurs in an area without a vital structure (particularly in the vertical direction) and a decision is made to seat the implant, or if discovery of the overextension occurs postoperatively, the patient is treated with antibiotics. After conditions appear to have stabilized (i.e., amelioration of postoperative ecchymosis, trismus, and edema), the perforation is evaluated.

If the perforation is through the mandibular inferior border, the surgeon should determine whether the implant can be palpated

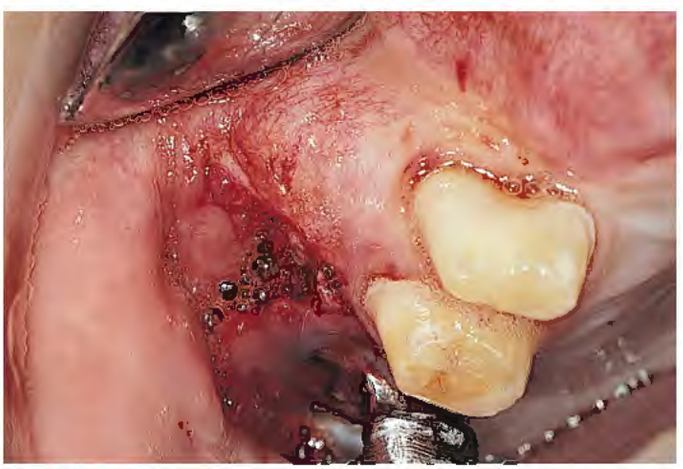


FIGURE 28-8. To prevent calamitous maxillary sinus complications, the surgeon should test the osteotomy by asking the patient to exhale gently through the nose while compressing the nares. Bubbling indicates an oroantral communication.

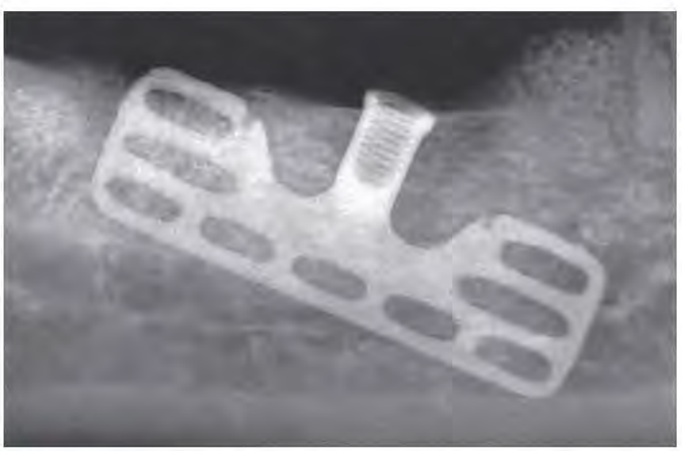


FIGURE 28-9. If operative perforations of the mandibular canal are not recognized before implant seating, grievous accidents may occur. Retrieval of this implant becomes an invasive procedure.

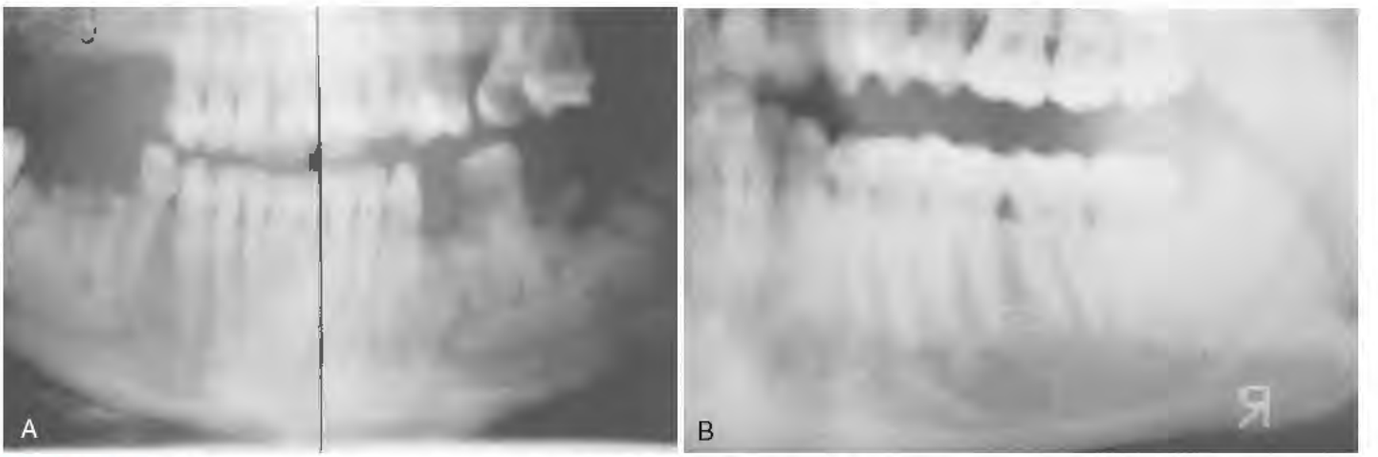


FIGURE 28-10. **A,** The location of the anterior mental loop can be very deceiving if the surgeon uses the clinical mental foramen as a guide. **B,** This panoramic view shows an inferior alveolar nerve that bifurcates before exiting at two separate mental foramina.

through the submandibular skin and whether it is sharp. If it is, it may cause chronic injury to the overlying musculature. If degloving through the intraoral route cannot be performed, a small skin incision may be required so that the extended segment of the implant can be trimmed with cooled diamond drills until it becomes level with the inferior border of the mandible. If it is not trimmed, the patient should be informed about the condition and asked to await the first recurrent episode of pain or swelling before taking action (Fig. 28-11).

If the perforation occurred through the nasal floor, a speculum with a source of good light is used to inspect the inferior nasal mucosa. If it has been penetrated and the implant can be seen, a method of trimming should be established. This is accomplished intranasally with a diamond drill (Atwood 473) or a pear-shaped bur in a water-cooled, straight handpiece or Impactair. The abraded nasal mucosa heals over the trimmed implant by secondary intention. Trimming also can be accomplished through an intraoral deep anterior vestibular incision. The pyriform aperture is exposed, and the nasal mucosa is elevated with a Freer elevator until the overextended implant can be seen. It is shortened with the same diamond drill. If the nasal mucosa has not been penetrated and the patient does not complain of nasal soreness, the site should be kept under observation until a symptom appears (Fig. 28-12).

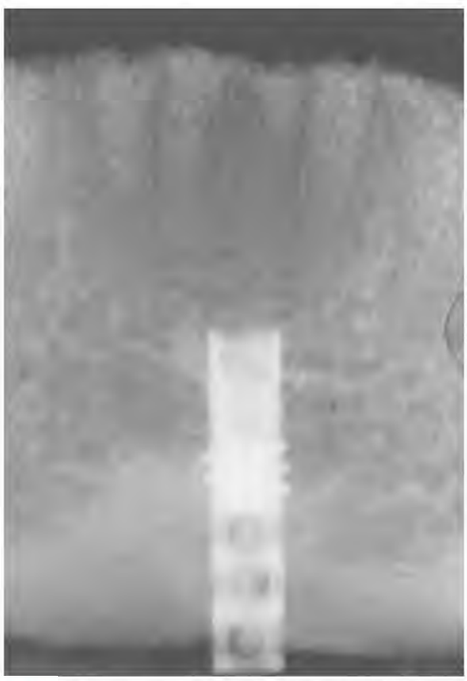


FIGURE 28-11. The inferior border of the mandible must be protected from penetration. Implants that occupy such positions may require removal and Colla-Plug and hard tissue replacement (HTR), or HA repairs may need to be performed. As an alternative, an overextended but otherwise satisfactory implant can be trimmed through a submandibular skin approach or by degloving.

Fractured Buccal or Lingual Cortical Plates

Fracture of the buccal or lingual cortical plates can occur with any kind of endosteal implant, but they most frequently happen when the dental surgeon places blades or performs ridge expansion. With this type of fracture, the best choice is to discontinue the implant placement procedure. If the fractured plate appears to be attached to the mucoperiosteal flap, there is a good chance of reattachment and subsequent healing. If the implant achieves firm seating, the procedure might be salvaged with use of a GTRM and bone graft material, precise tailoring and placement of the membrane, and impeccable closure (see Chapter 8).

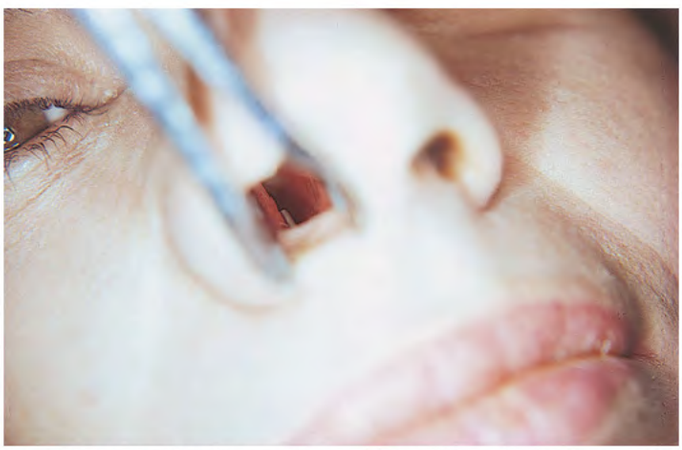


FIGURE 28-12. The floor of the nose is another inviolate structure. If an implant pierces the nasal mucosa, it must be removed immediately or repaired by resection of the apex.

Inadequate Soft Tissue Flaps for Implant Coverage

After incision and flap reflection, the soft tissue flaps may be inadequate to cover implants, even if the tissues have been handled with great care. If the incision is not made directly on the crest of the ridge through the avascular, white line of scar tissue (i.e., the linea alba), the tissue between the incision and the linea alba may pull away. Novel or unique crestal incisions, such as S-shaped or vestibular visor designs, should not be used. Recent research has indicated that lingual and facial flap capillaries do not anastomose at the ridge crest. Noncrestal incisions, therefore, may result in a loss of vascularity to the tissues of the elevated flaps.

In addition, when implants are placed into a site immediately after tooth extraction or in ridge expansion maneuvers, a scarce amount of the tissue required for primary closure exists. If the implant, whether subperiosteal or endosteal, is bulky enough that the tissues from the facial and lingual sides cannot be brought together, the buccal or facial flap should be undermined. For this technique, a pair of sharp, curved scissors or a Bard-Parker (BP) No. 15 blade is used to elevate the mucosa from the underlying buccinator or orbicularis oris muscle (Fig. 28-13). The mucosal flap is released from its underlying muscle fibers, which allows it to be brought over the implant and ridge crest. Tension-free suturing can then be performed. Closure is done in a continuous horizontal mattress configuration. This technique is outlined in the discussions of suturing in Chapter 6 and of soft tissue management in Chapter 7. Of course, vestibular integrity is lost, and a subsequent vestibuloplasty may be required.

Broken Burs

Burs can break during the pilot osteotomy in preparation for the placement of any type of endosteal implant. This happens most often when the bur (usually a fissure type) binds in bone. Bur fracture can be prevented when binding occurs. Using the thumb and forefinger, the practitioner should grasp the handpiece beneath its head at the point of bur emission and press the fingers together. The bur is pinched between its head and the bone, forcing it vertically upward and out of the bone in a non-torque-influenced movement. Attempts should not be made to remove the bur by wiggling the handpiece shank; this maneuver is the major contributing cause of bur breakage.

Another technique is to release the bur from the handpiece and facilitate trauma-free removal by rotating the bur counterclockwise with the fingers or Howe pliers.

When a bur breaks, it usually is deep in the osteotomy and possibly close to a vital structure (Fig. 28-14). Several technique-localizing radiographs should be taken, and then simple probing and suction should be tried. If these fail to dislodge the bur, the patient should be told of its presence, but only after completion of the procedure. The patient should be asked to sign a note acknowledging this information. If the patient is sedated, complete recovery must occur before the person is informed and the signature obtained. Aggressive attempts to remove broken burs or instruments destroy potential host sites and may be responsible for injuries to adjacent vital structures. Burs in noncritical areas can remain safely in place for years. Attempts to remove them should be made only if a local reaction is noted on an x-ray film at some later date.

Inoperative Instrumentation

Occasionally, handpieces bind, internal irrigators fail, and suction becomes clogged. The key to solving each problem is to anticipate it, take care of and check all equipment before surgery and, most important and despite the expense, have backup equipment, supplies, and implants on hand at all times.

Hemorrhage

Unusual bleeding may result from soft tissue dissection or intraosseous surgery. If a vessel is bleeding from within the soft tissues, it should be clamped with a fine hemostatic forceps and ligated or electrocoagulated. Often, however, simple tamponade solves such problems (Fig. 28-15). After approximately 5 to 10 minutes of pressure, most small vessels embolize. Firm pressure applied for 5 minutes or longer also usually stops hemorrhage within bone. If not, forcing bone wax into the

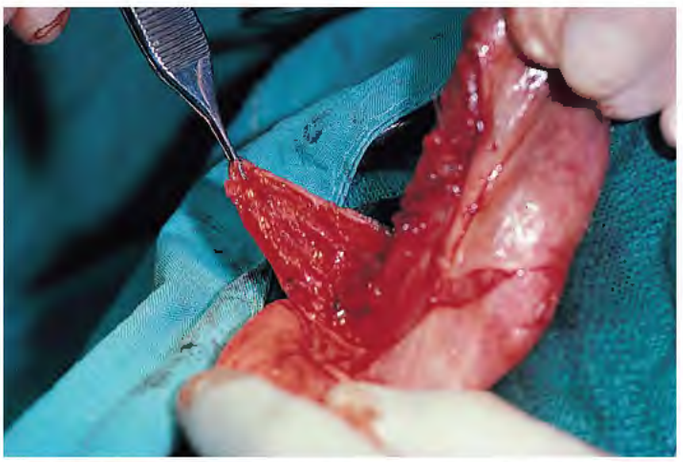


FIGURE 28-13. When implants need to be covered primarily and sufficient tissue is not available, the requisite flap can be obtained by undermining the mucosa from the adjacent buccal muscle surface. This flap can then be sutured without tension.

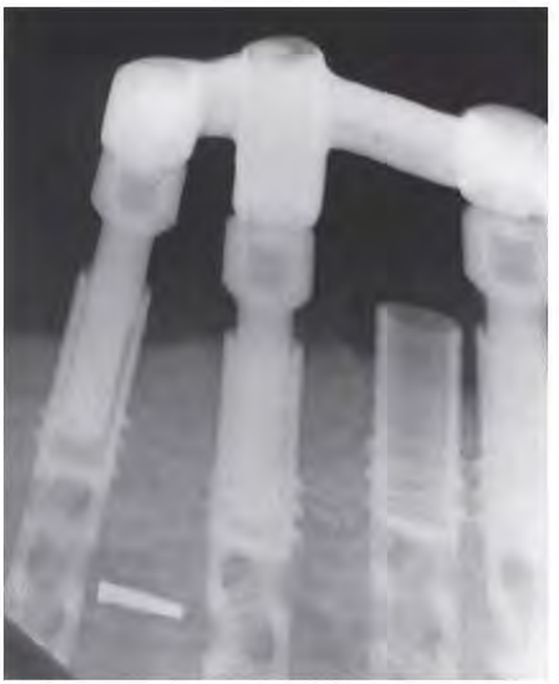


FIGURE 28-14. Burs occasionally break in the bone. This most often occurs when the bur is allowed to bind, and the handpiece is wiggled in an effort to remove it. If the broken bur is not in a critical location, it is best left untouched.

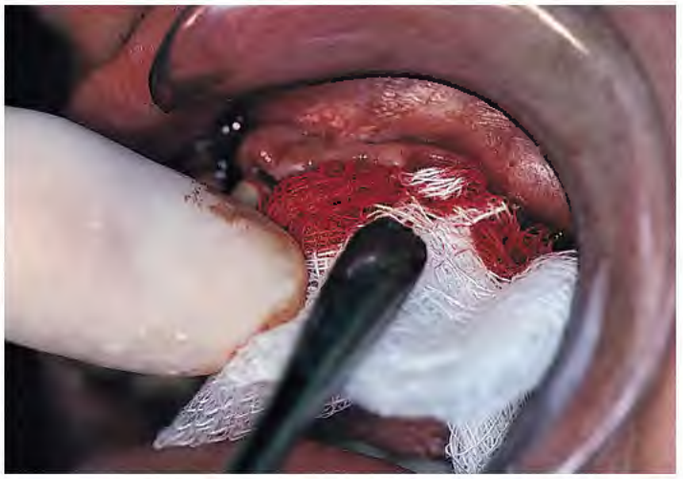


FIGURE 28-15. Continued bleeding can be treated effectively by applying pressure with persistence and patience for at least 5 minutes.

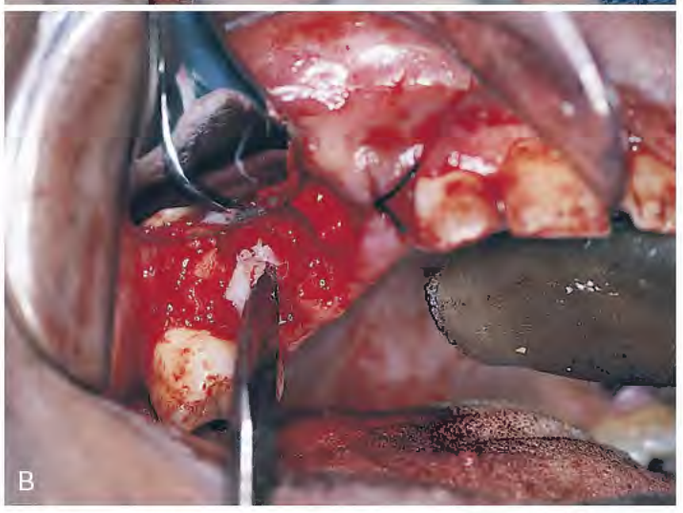


FIGURE 28-16. A satisfactory technique for managing bone bleeding is to force bone wax into the osseous site. **A,** Sterile bone wax is available in individually wrapped packages. **B,** Small amounts can be used effectively by creating tamponade (i.e., the wax is burnished into the bleeding site with the tip of a periosteal elevator), because this creates tamponade.

bleeding site always offers satisfactory results (Fig. 28-16). Gelfoam, Surgicel, and Avitene (spun collagen) also are effective hemostatic agents. Placement of the implant itself into the final prepared hemorrhaging osteotomy often serves as an effective form of management.

If the hemorrhage originates deep in the soft tissues (e.g., the facial artery pulsating from within the buccal musculature), a 2-0 Vicryl suture (on a large half-round needle [40 to 65 mm]) is placed deeply posterior (proximal) to the bleeding site and tied in a figure-8 or circumferential configuration. The suture must encompass a mass of proximal tissue that contains the bleeding vessel within its loop. When the knot is tightened, the surrounding drawn-in soft tissues obtund the bleeding artery.

Life-threatening airway occlusion from hemorrhage or iatrogenic emphysema can occur. All cases involving such a complication require careful intraoperative and postoperative observation. If any question of a compromised airway arises, endotracheal intubation or tracheostomy should be considered. To minimize edema from surgical trauma, the patient should be kept posturally erect and given dexamethasone (e.g., 20 mg, administered intramuscularly [IM] or intravenously [IV], for a 154-pound [70-kg] adult).

Poor Angulation or Position of an Implant

Blade and Plate Form Implants

Poor angulation or positioning of an implant is rarely a problem if the implant is a one-piece device, because blades are made of flexible, resilient, and compliant metals, and their abutments may be bent into positions of parallelism (Fig. 28-17). Titanium-tipped, cone socket pliers are used to bend the implant so that foreign metals are not deposited on the surfaces of the blade. Submergible blades are treated with friction-fit abutment inserts in the same way when they are inserted. However, the adjustment is made before the implant is seated so that if the abutment fractures and cannot be retrieved from its socket, a new blade can be selected. After the neck is bent to achieve parallelism, the abutment is removed and kept until the second stage, when it can be inserted into the infrastructure socket. Because it has the proper angulation, it can serve as a usable, parallel abutment.

Some companies offer 15-, 25-, and even 30-degree angulated, threaded abutments. A number of trial seatings with different abutments must be done at the time of surgery until the proper angulation is achieved.

Straight, screw-in abutments present problems when attempts are made to correct angulation. After the abutment has been placed in the implant, gentle bending should be attempted, but

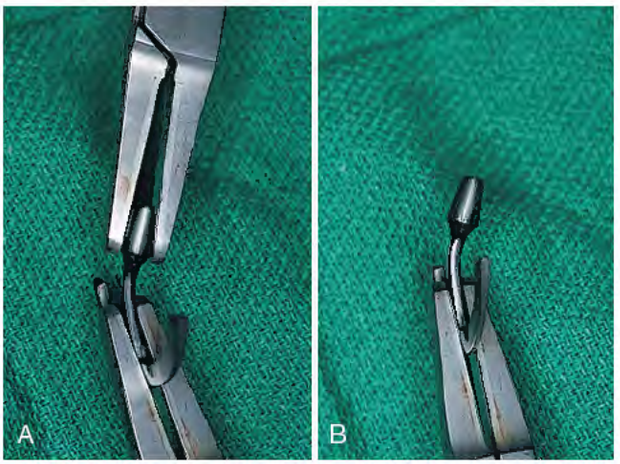


FIGURE 28-17. One-stage blade implant abutments may be malaligned. **A,** Malalignment can be corrected by using two titanium-tipped cone socket pliers to bend the cervix. **B,** Careful manipulation with controlled effort results in parallelism of the abutment to adjacent implants or teeth.

only before implantation. If angulation cannot be improved by bending or by use of an angled abutment, correction may be possible after integration by making a casted, telescopic, cementable coping in proper alignment.

Root Form Implants

The guidelines for blades can be applied in making angulation corrections for most root forms that have been placed in anatomically unacceptable positions. If press-fit implants with external threading and without antirotational devices (e.g., Spline) are used with angled one-piece abutments, the abutment is inserted into the implant before it is seated. The implant is rotated to a position that makes the abutment parallel to the adjacent teeth and tapped into its osteotomy (Fig. 28-18). The abutment is unscrewed, replaced with a healing screw, and maintained until integration, when it is replaced into the specific implant from which it had been taken.

Another alternative that can be used after integration is to make a direct impression for casting an angled, frictional-fit abutment that would require cementation. Sometimes placement of implants in the most appropriate position in bone (midway between the facial and lingual cortices) causes their abutments to be located too far to the labial or lingual or to emerge from unstable mucosa. If soreness or inflammation results, this problem can be solved with free palatal tissue grafting (see Chapter 7). In addition, angled abutments are available that can be rotated on the implant's cervical platform; when appropriately positioned in one of a half dozen fixed stops, it is fastened by its fixation screw into the implant's internal threading receptacle (see Chapter 22).

As outlined in Chapter 4, the nature and dimensions of the patient's residual bone determines where, at what angle, and the number of root form implants that provide the best prognoses. Because the angulation of the ridge does not always allow ideal implant trajectories, a problem may exist that classic prosthetic procedures cannot solve. The implants may be canted in eccentric directions that would result in the retaining screws emerging from the labial surfaces of the completed prostheses or at other unacceptable sites when fixed-detachable techniques are the choice of reconstruction.

A more frequently chosen approach to the difficulty of poor angulation is to ignore (within reason) the optimum intraosseous site for implant placement and to insert the implant at an angle that offers the optimum emergence posture. This, however, may result in perforation of one of the cortical plates (management of perforations was discussed earlier in the chapter).

Prevention (i.e., not placing implants if their angulation problem appears to be insoluble), selecting blades or root forms that allow the use of significantly angled abutments, abutments with adjustable necks, angular corrections made with bone-grafting materials, or using subperiosteal implants all are alternatives that help guide operative decisions. Even though accurately made surgical templates should prevent improper placement of implants, occasionally implants are placed too close to one another. The proper distance is a full implant width between each root form (i.e., 3.25 to 5.5 mm). In cases involving closer proximity or poor angulation, the implants should be allowed to remain buried and left unused as "sleepers" (Fig. 28-19).

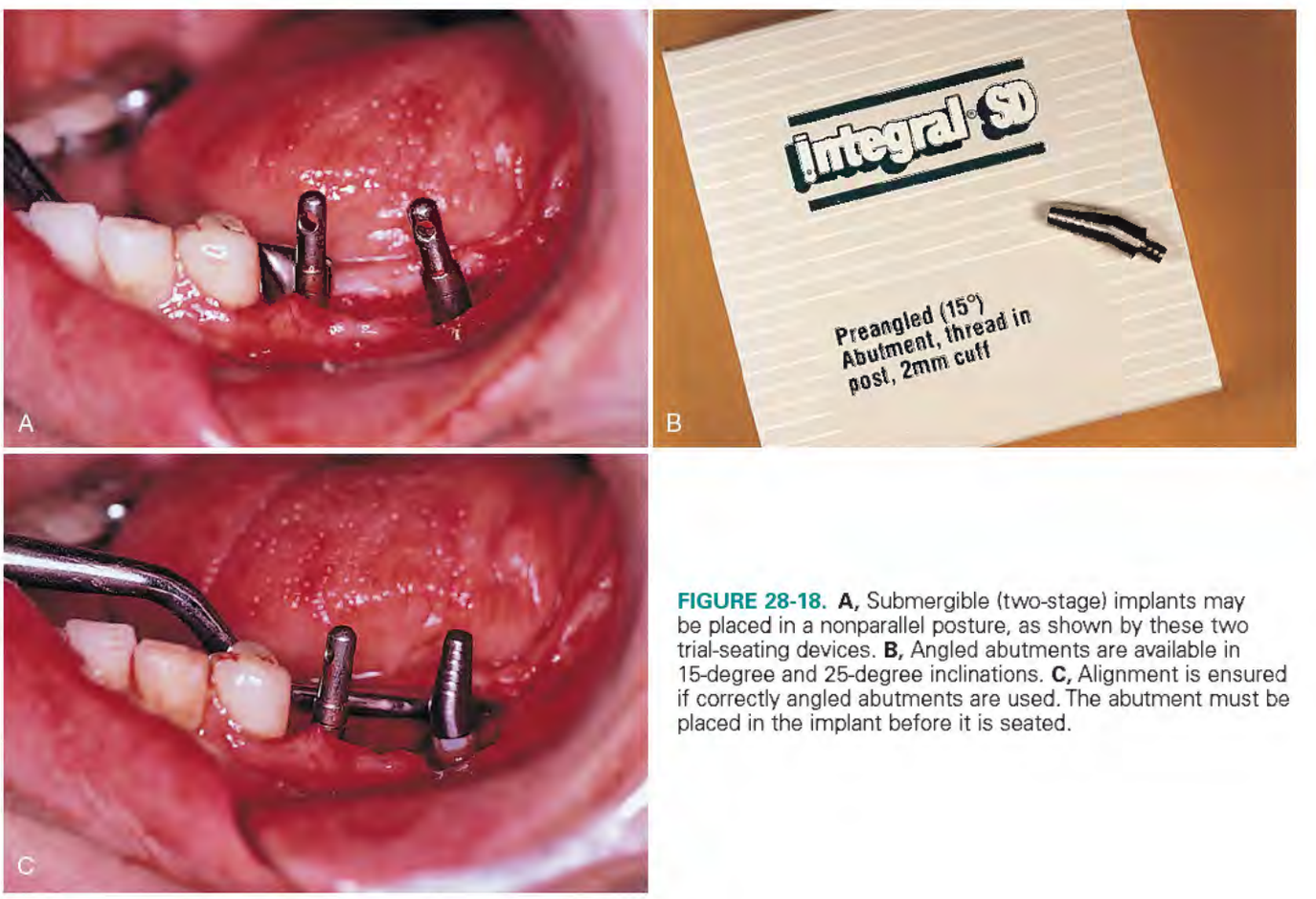


FIGURE 28-18. **A,** Submergible (two-stage) implants may be placed in a nonparallel posture, as shown by these two trial-seating devices. **B,** Angled abutments are available in 15-degree and 25-degree inclinations. **C,** Alignment is ensured if correctly angled abutments are used. The abutment must be placed in the implant before it is seated.

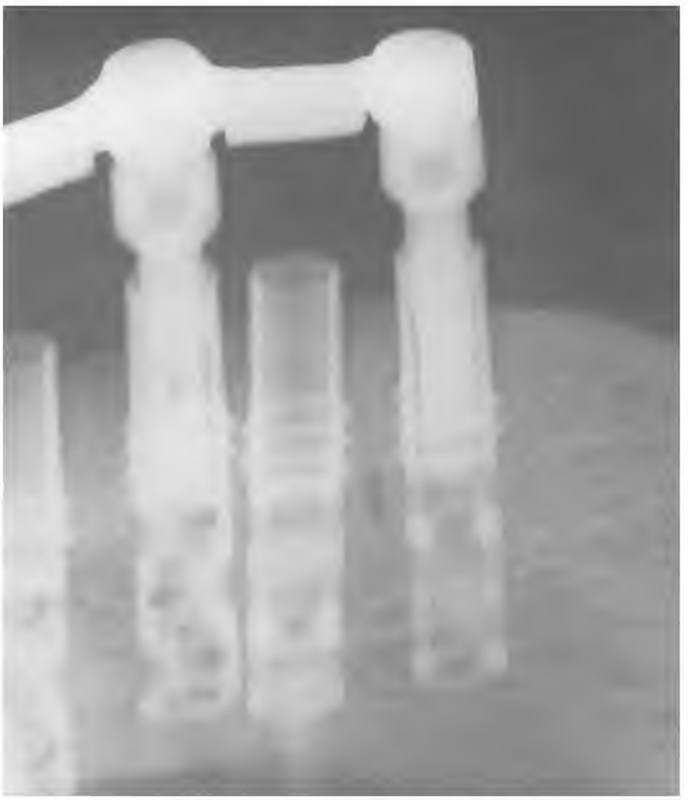


FIGURE 28-19. Implants placed in awkward positions may be left in position to "sleep" and possibly be put into function in the future.

Injuries to the Mandibular Neurovascular Bundle

When an implant or instrument unintentionally penetrates the mandibular canal, the implant is removed, and the patient is informed of the possibility of dysesthesia. Dysesthesia is less common, however, when infiltration, rather than nerve block, anesthesia is used.

If a nerve has been injured or cut and is within the bony canal, it may heal with time. The chance for healing is less if the injury occurs to a neurovascular bundle in soft tissues, such as the mental branch.

If the dysesthesia has not diminished or changed in depth, nature, or character after 6 weeks, exploration and possible repair should be considered. Although specially skilled oral and maxillofacial surgeons most often perform these procedures, knowledge of this technique is important. If the mental or other soft tissue neurovascular bundle is totally or significantly torn or separated, it should be repaired immediately. The tissues are reflected carefully, already opened, to below the foramen level, exposing the entire nerve complex. The mental neurovascular bundle is moderately resistant to injury, and gentle reflection exposes it fully. The distal portion of the nerve complex is made available, if any of it should be in evidence in the soft tissues lying lateral to the mandible. This gentle, blunt dissection can be easily performed with a mosquito hemostat grasping a moistened, 2 × 2-inch sponge and using a pushing maneuver.

If the proximal bundle offers insufficient length from within the foramen, the periosteum adjacent and posterior to it is elevated to the mandibular inferior border. A small, half-curved, blunted chisel or suitable elevator is inserted into the distal portion of the mental foramen to protect the bundle. A saline-cooled, Impactair or straight air turbine handpiece with a No. 4L round surgical bur then is used to brush the bone from behind the elevator (Fig. 28-20, *A*). The goal is to extend the mental foramen into the mandibular canal by removing its posterior lateral bony wall. With patience, care, and experience, this can be done with consistency. After 180 degrees of the canal has been removed (Fig. 28-20, *B*), a nerve hook is slipped beneath the neurovascular bundle so that it can be gently teased from its crypt. Usually, the sheath must be wrested carefully from internal bony spicular attachments.

Once the portion of the nerve bundle that occupied the canal has been extricated, it is made contiguous with the mental branch. After the vascular elements are dissected free, a generous additional length is present to facilitate repair of the nerve that had been sectioned or compressed iatrogenically. If 1 cm of distal (tissue) bundle is available and another 2 cm of the proximal portion can be exposed, an end-to-end anastomosis is made with 10-0 Vicryl or Prolene. At least six sutures are required, and four-power magnification must be used to guide their placement. Enclosing the repaired segment in a polyethylene tube (made from a piece of slit IV catheter) offers additional stability and a mortise form to influence unobstructed healing (Fig. 28-20, *C* to *E*). The tube and its contents are tucked into the widened canal, and the wound is closed primarily (Fig. 28-20, *F*). Positive results may not be seen for 18 to 24 months.

If the length is deficient even after exposure of both ends, a sural nerve graft is arranged.

Elective exposure of the intact bundle is performed when a deeper zone of usable bone is required for placement of a long endosteal implant or a transosteal implant for the posterior mandible.

Subperiosteal Implants

Loss of Anesthesia

Regional anesthesia occasionally dissipates during stage one if repeated impressions are required. If anesthesia begins to fade before the procedure is finished, reinforcing or reinstituting it becomes difficult because of the change in pH in the surgically exposed tissues. Attempts can be made to supplement anesthesia with additional doses, but the procedure may have to be terminated before its completion. The dental surgeon must keep in mind that no more than eight anesthetic cartridges of 2% lidocaine (or less than 300 mg) should be given to an average weight (154-pound [70 kg]) adult at any one time. Additional amounts can be given with time as the drug is hydrolyzed. Local anesthetics also work more effectively if preoperative analgesics and IV sedatives are used.

Probably the best way to prevent loss of anesthesia is to use bupivacaine (Marcaine) or ropivacaine (Naropin) along with lidocaine at a ratio of 1:1; this combination makes anesthesia last three to four times longer. If anesthesia cannot be re-established, even with the addition of IV sedation, the procedure is halted, the wound margins are closed with sutures, and an attempt is made to complete the operation another day. At least 1 week must pass before the surgeon operates again. This interim allows a greater possibility of success, because a more accurate tray can be made on the model derived from the failed impression.

Inability to Make an Accurate Impression

If a satisfactory bone impression cannot be registered after three attempts, the surgeon should seek help; if that is unavailable, the wound should be closed.

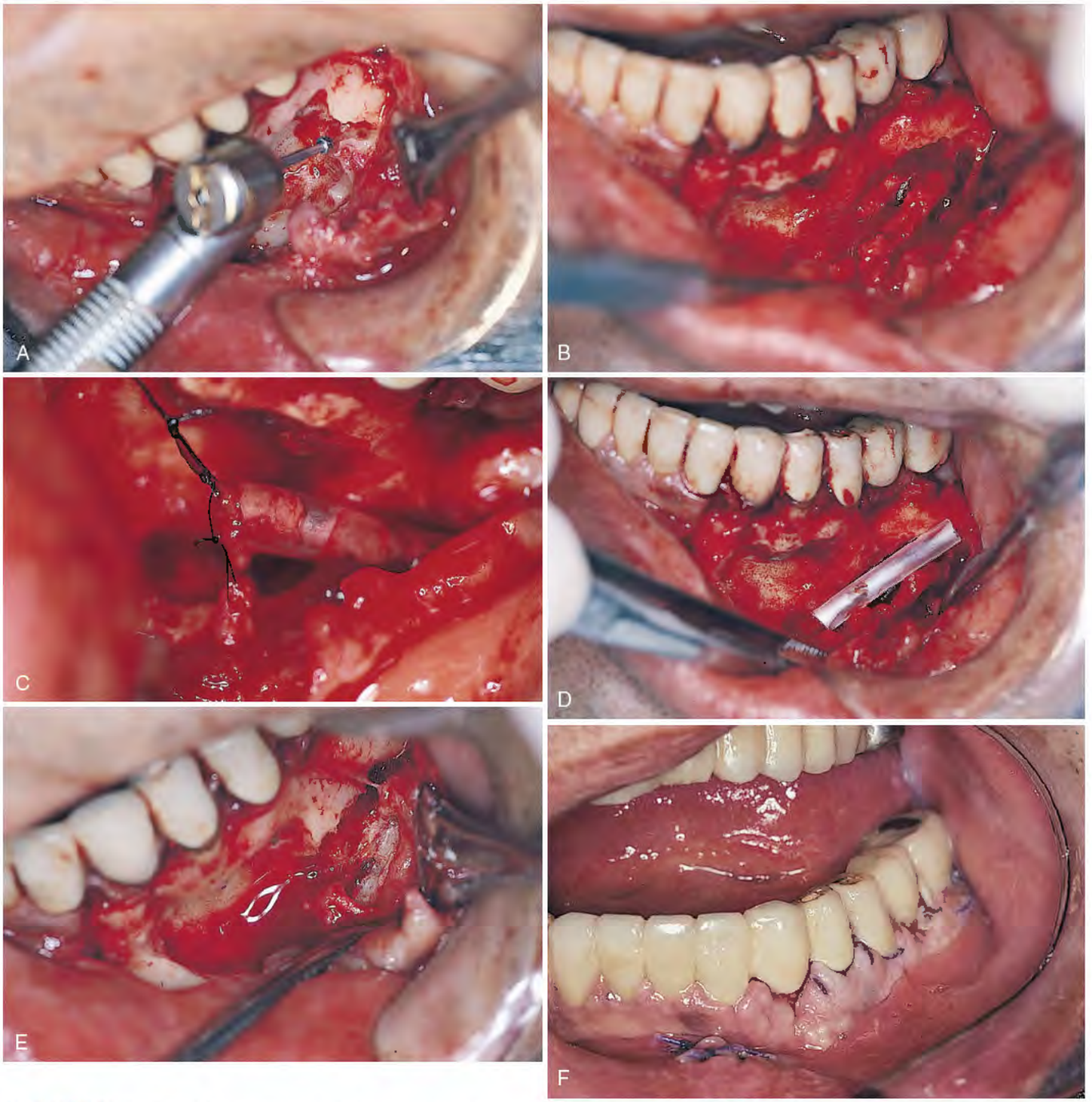


FIGURE 28-20. Repair of the mentomandibular nerve requires careful tissue management. **A,** An Impactair with a round bur is used to brush away the bone overlying the canal. **B,** After exteriorization of the canal, the neurovascular bundle becomes visible. **C,** The nerve sheath is separated from the bundle, the two cut ends are brought together in an end-to-end anastomosis, and the neurorrhaphy is made with 10-0 black silk ophthalmic sutures. Magnification is essential for this operation. **D,** A slit polyethylene sheath is placed around the repaired nerve to protect it and to act as a conduit for unobstructed healing. **E,** The repaired nerve is replaced into the canal. **F,** Closure of the overlying soft tissue completes the operation.

Inability to Remove an Impression or Seat a Tray Either for Full Upper (Pterygohamular Design) or Full Lower (Lateral Rami Design) Subperiosteal Implants

Both pterygohamular and lateral rami designs present the possibility of undercuts that can discourage a path of seating or removal. Sectioning the tray into halves or even into three parts for the mandible may solve this problem, with each of the parts fitting its own area of bone accurately (Fig. 28-21). After the tray segments are placed in position and fitted closely, or even allowed to overlap, they are removed. A number of protruding copper tubes or similar retentive devices are processed with heat or luted to their exterior surfaces. Each segment is filled with impression material and reseated. After the impression material has set, an index is taken over the tubes, using additional tray material to engage them. These indices must be removable. After removal of the tray segments, the retention tubes serve as guides for accurate reassembly with the indices. Suturing the wound completes the procedures.

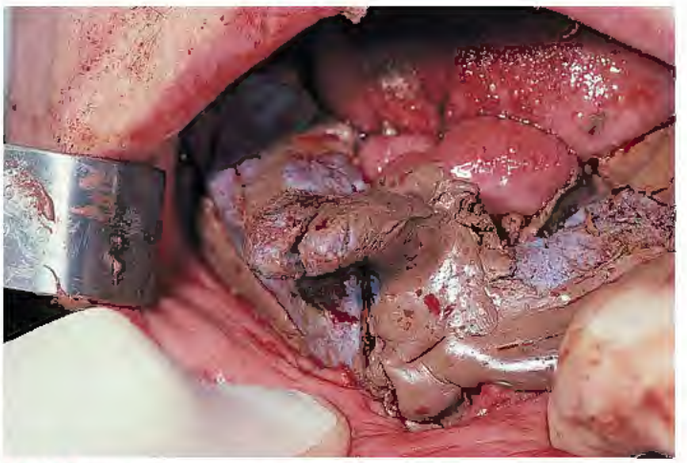


FIGURE 28-21. When undercuts prevent placement or removal of a one-piece tray during the two-stage subperiosteal operation, the tray can be split into two or more sections, each seated separately, indexed, removed, and collated on the laboratory bench.

Using this technique, the surgeon can make the most complex impressions in sections and place them together for accurate completion of the casting by the laboratory.

Antral Perforations

When the mucoperiosteum is reflected in preparation for a maxillary subperiosteal implant impression, some eggshell-thin maxillary cortical bone overlying the sinus may lift away attached to the flap. The intact antral membrane often is noted; it is bluish gray and expands with each expiration. If it is torn, the margins are brought together gently with a nontoothed forceps, and it is covered with a square of Colla-Cote (collagen sheet) or a resorbable membrane (e.g., Surgicel or Vicryl mesh) (Fig. 28-22). The bone fragment is allowed to remain attached to the periosteum.

The implant impression is made in the usual manner, with the Colla-Cote replaced as required at each step. On completion, the flaps are brought together with the cortical bone still in place, and the bone is positioned anatomically and sutured. The bone reattaches over the antrum in its proper location. The final casting design must not include struts placed over the repaired area or over any of the eggshell-type cortex overlying the antrum. If this design characteristic cannot be avoided, a sinus floor elevation and graft procedure is indicated (see Chapter 8). These procedures are performed at the first stage or just before implant placement during stage two.

Inaccurate Adaptation of Full or Unilateral Subperiosteal Implants

If an implant fails to go into place, particularly in maxillae, it is tapped with a mallet and an orangewood stick. Often, the implant snuggles into place after tapping because of the compliance of the supporting bony structures. In either jaw, if the implant obviously has been seated to its fullest extent and a rocking movement occurs when it is tested for stability, the fulcrum should be sought and an attempt should be made to adjust it by eliminating a bony protrusion or by cutting away a strut (but only if that strut is a noncritical component of the casting) and the remnants are fixed to the jaws with titanium bone screws. If the rocking cannot be eliminated, a new impression is made. This procedure is simplified by fabricating a tray from the cast on which the discarded implant had been made.

If the implant does not move into place fully but no instability is noted (i.e., it has at least three widely spaced points of simultaneous contact and the defects between struts and bone are no greater than 3 mm), the defects are filled and the entire infrastructure is covered with a nonresorbable, particulate, synthetic bone-graft material (e.g., 20-mesh HA), and suturing is performed (Fig. 28-23). Implants coated with HA cannot be seated by tapping.

Inaccurate Adaptation of Tripodal Subperiosteal Implants

A tripodal implant does not fit well if the two- or three-part impression segments are not reassembled accurately. When feasible, the segments should be removed in one collated piece after intraoral assembly. In most cases, however, each segment or islet of the casting fits accurately on an independent basis. Assessment should reveal which of the islets is causing the rocking or inaccuracy (it probably is only one of them). After this has been established, the Brookdale bar is sectioned, separating that component from the other two, and the infrastructural parts are seated individually. If the two remaining connected segments still rock, they should be separated as well.

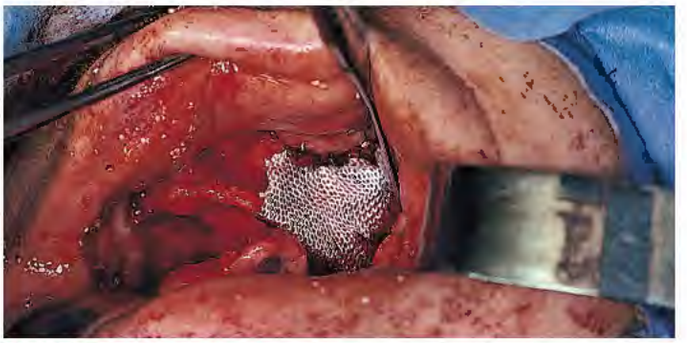


FIGURE 28-22. Often during the tissue reflection phase of the maxillary or pterygohamular subperiosteal implant, the lateral sinus wall lifts away with the elevated mucoperiosteal flap. Before closure, a sinus elevation procedure is performed; if that is not appropriate, a sheet of Vicryl mesh or similar resorbable membrane is laid over the defect.

FIGURE 28-23. Subperiosteal implants may not fit as accurately as desired, particularly because their designs have become more complex. Also, CAD/CAM-generated castings are not as accurate as those made from direct bone impressions. For such discrepancies, particulate grafting materials are effective fillers.

The surgical assistant stabilizes the separated components by finger pressure; or, if this is impractical, the components can be screwed temporarily to their proper positions on the bone. The disconnected bar segments are luted with RC Prep or GC Pattern, with care taken not to allow the exothermic reaction to injure the sensitive oral mucosa (Fig. 28-24). After polymerization, the newly assembled castings are removed in one piece and sent to the laboratory for welding of the bar. Because the rejoined bar is supragingival, no adverse host site effects result. Because of potential galvanism, infrastructural components should not be welded. If the surgeon is inserting a one-stage implant and the laboratory is near the operating theater, the tissues can be packed with saline-moistened sponges while the implant bar is welded. If this can be done within 2 hours, implant insertion is completed after the implant once again had been defatted, passivated, and sterilized (see Appendix E).

Injury to the Infraorbital or Mental Nerves

Great care must be taken when the mucoperiosteum is reflected in the canine fossa for impression making for the maxillary subperiosteal implant or in the premolar area for the mandibular type. The most superficial portion of the adjacent foramen is exposed so that a protective periosteal elevator can be placed at its rim to shield the neurovascular bundle. If the infraorbital or mental bundle is injured and examination shows discontinuity of the segments, it is repaired immediately. However, if the sheath shows continuity, closure is performed after the procedure has been completed. If the patient complains postoperatively of dysesthesia and no subjective change occurs within 6 weeks, repair is performed as described earlier in this chapter, or an expert should be consulted (Fig. 28-25).

Careful planning and impeccable surgery generally prevent accidents to the mandibular or mental branches. Occasionally, mobilization and repositioning of a neurovascular bundle may be desirable to facilitate impression making or to allow a more rigid infrastructure.

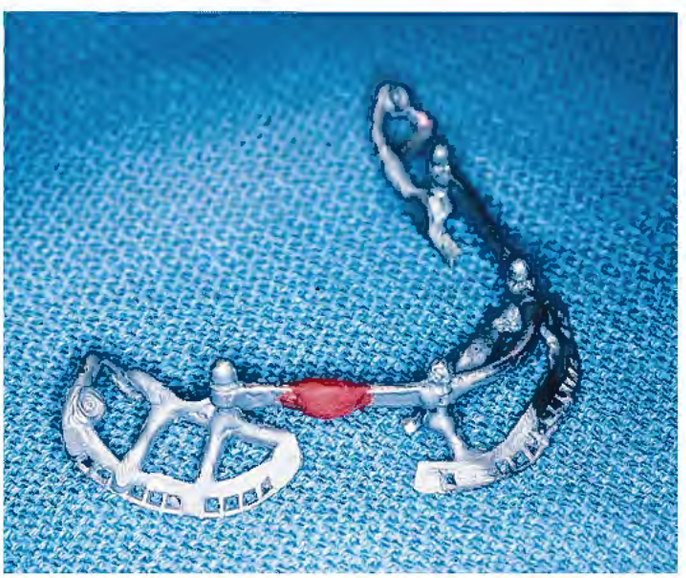


FIGURE 28-24. Tripodal subperiosteal implants produced from two- or three-part impressions may not fit the bone accurately. The poorly adapted segment is separated by cutting the Brookdale bar, refitting the islets individually, and collating them with red Duralay or GC Pattern resin. The laboratory welds the bar, sometimes while the patient still is anesthetized.

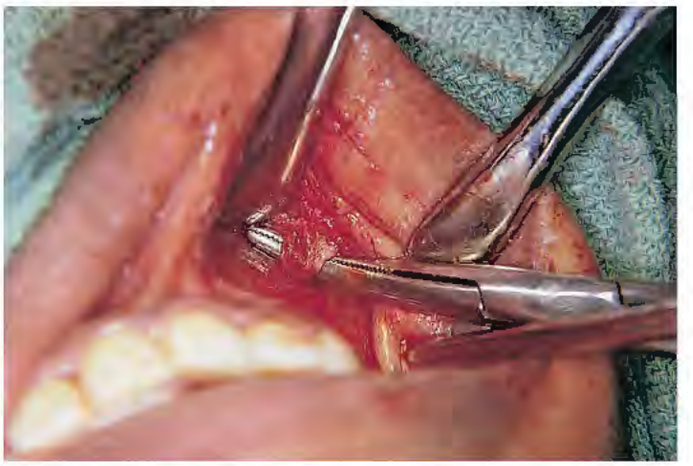


FIGURE 28-25. The infraorbital nerve occasionally is encountered during maxillary implant surgery. It must be carefully protected with a retractor.

SHORT-TERM COMPLICATIONS (FIRST 6 POSTOPERATIVE MONTHS)

Endosteal Implants

Postoperative Infection

Infection can manifest as drainage, swollen tissues, or pain. The normal postoperative sequelae of edema, trismus, and pain must be distinguished from new symptoms representing a pathologic problem. If an abscess develops, it is incised and drained (Fig. 28-26). Antibiotic therapy (e.g., amoxicillin, 500 mg every 6 hours for nonallergic patients) also is essential. When manifest drainage is present, it should be cultured and tested for bacterial sensitivity. Early infections do not necessarily mean that the implant will fail, but prompt and aggressive therapy is mandatory.

Intermediate drainage (i.e., 2 to 3 weeks after surgery) occasionally occurs, particularly after a root form implant has been inserted. The problem usually is superficial; it is investigated by taking a periapical radiograph with a gutta percha point inserted into the fistula or opening of the drainage site. The source of the drainage may be a bit of unresorbed or residual suture, a loose healing screw (Fig. 28-27), a speck of cement, or other debris. Such isolated areas do not respond to antibiotics; rather, they must be opened and inspected so that the cause can be determined and eliminated. Often the problem can be solved by simply incising the area and irrigating it with saline and povidone-iodine (50%), uncovering the site and packing it with a ¼-inch iodoform gauze strip, or simply tightening a screw.

The management of conditions in which the radiograph indicates a more significant lucency or pain or drainage persists was discussed earlier in the chapter.

Dysesthesia

Dysesthesia during the postoperative period most often is a result of the patient failing to notice or report it immediately after surgery because of an inability to sort out this symptom from among others, such as pain and swelling. If it is an accurate complaint after edema has abated, the dental surgeon should suggest immediate removal of the implant. If the symptoms do not seem to abate within 6 weeks after removal of the implant, exploration and repair are indicated.

If paresthesia begins to develop during the long-range postoperative period, chances are subimplant resorptive influences

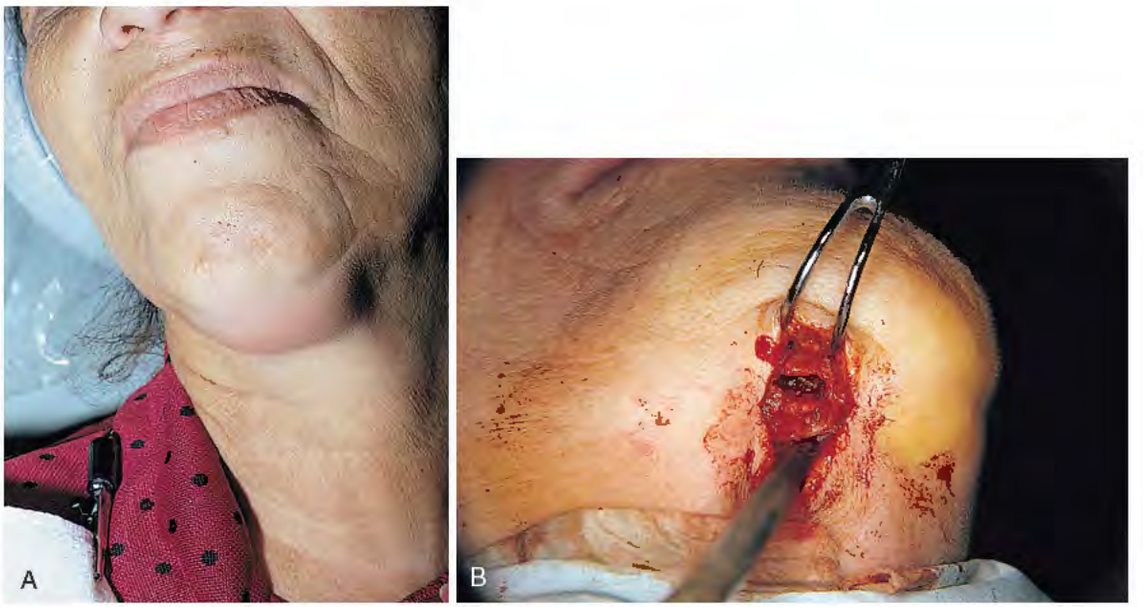


FIGURE 28-26. **A,** An overextended endodontic implant has caused a short-term postoperative abscess. The area is hot, inflamed, and fluctuant. **B,** An incision is made to drain the purulent material. After resolution of the acute phase, a definitive corrective procedure is performed. The extra length of the implant is reduced, the bone is curetted, and primary closure is performed through a submandibular approach.

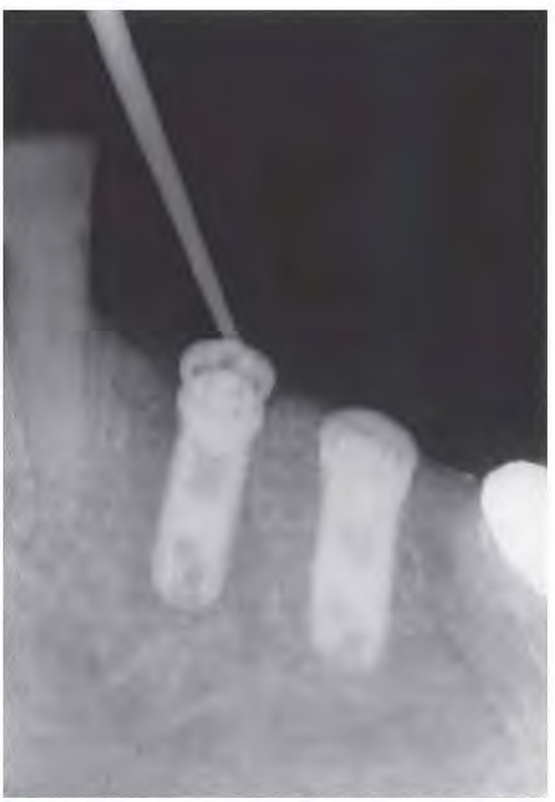


FIGURE 28-27. Most often, inflammation over a submerged, recently placed implant is caused by a loose healing screw. This can be verified by placing a gutta percha point in the fistula and taking a radiograph. Treatment consists of tightening the screw, followed by light curettage.

are responsible because of the implant's proximity to the mandibular nerve. Although paresthesia most often is a long-term complication, removal of the implant should be suggested as soon as symptoms become evident. The implant is resected with great care to prevent further insult to the nerve complex (Fig. 28-28).

If pain should occur after it had abated postoperatively or at any time during the period after healing, infection should be suspected as the cause. Other reasons may include injury caused by an opposing tooth or pressure from a temporary superstructure or denture. A postoperative radiograph is indicated. The overlying tissues should be examined, and the problem should be treated as the patient's symptoms dictate. Continuing insoluble pain is managed by removal of the implant. If this fails to help, an amputation neuroma should be suspected, which usually indicates surgical exploration and removal.

Dehiscent Wounds

In the immediate 10-day postoperative period, a wound sometimes breaks down and the underlying implants are exposed (Fig. 28-29, *A*). This most often results when visor or other noncrestal incisions are used; when a GTRM is used; or when the flaps are sutured under tension. At this point, primary closure cannot be regained, and if it is attempted, the tissues investing the implants will recede even further, exposing them to significant additional risk. The wound should be left untouched surgically, and the patient should be seen frequently for irrigation (i.e., every day or two). Gentamicin is a good choice for irrigation. The solution is made by diluting 80 mg of the antibiotic in 50 mL of saline. The exposed metal or membrane is cleaned with a cotton-tipped applicator, and the patient is instructed to do the same at home, using a rubber ear syringe and saline (1 quart of boiled water to 1 level teaspoon of salt). Peridex also can be used. Usually, the wound fills in by secondary intention, either completely or at least adequately so that the bone is covered and the only remaining dehiscent structures are the implant healing screws or the membrane.

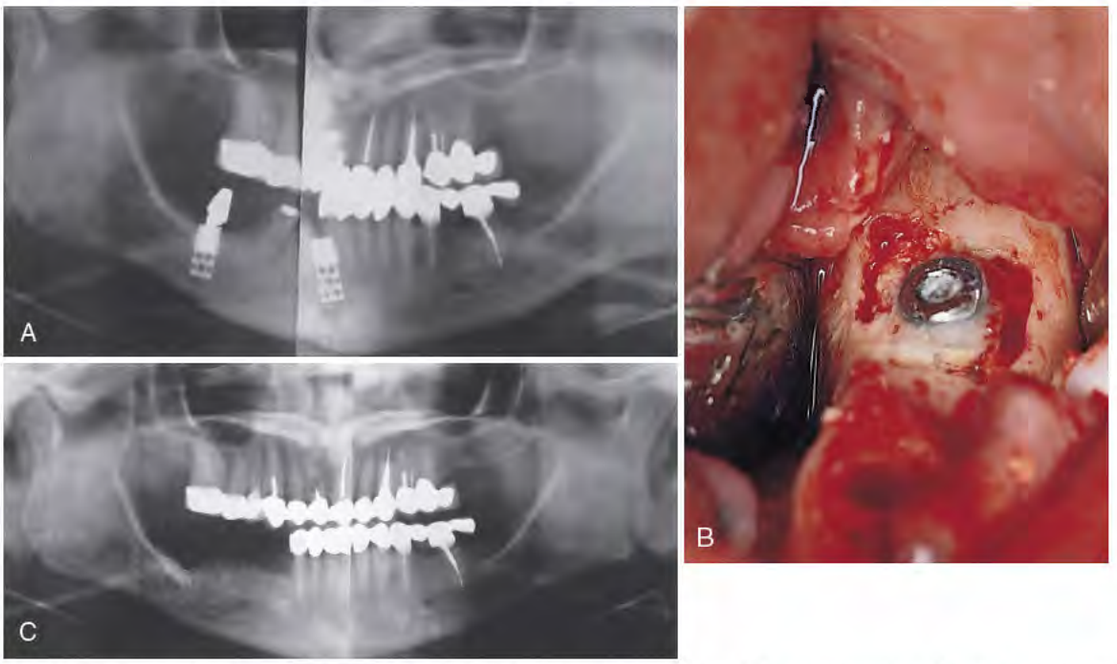


FIGURE 28-28. **A,** If a postinsertion paresthesia persists, the implant should be removed. This panoramic radiograph suggests proximity of the implant to the neurovascular bundle. **B,** This Core-Vent implant resisted removal even with reverse use of the ratchet wrench. It required en bloc removal because of osseointegration. **C,** A postoperative radiograph shows the grafted host site. To ensure that no particles communicated with vital tissues, a barrier (Colla-Cote) was used at the base of the osteotomy before the graft material was placed.

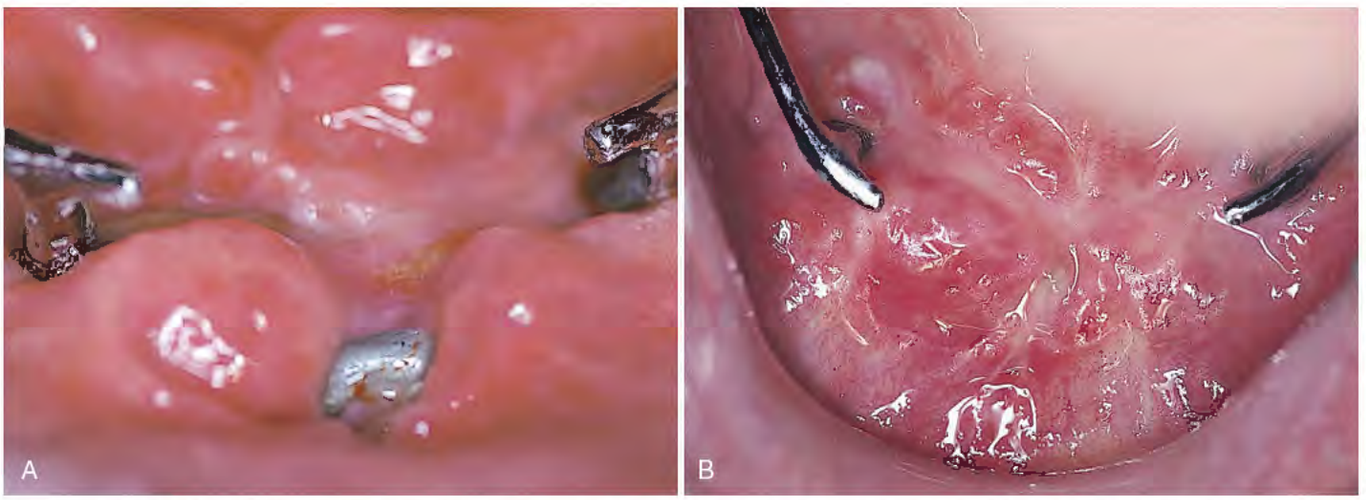


FIGURE 28-29. **A,** Shortly after suture removal, some wound margins fail to heal by primary intention. The underlying struts of this subperiosteal implant and bone are dehiscent. **B,** Conservative treatment, which includes gentle rinsing, cleansing with cotton-tipped applicators, and good hygiene, encourages epithelization by secondary intention.

With a strict hygiene regimen, such implants most often proceed to integration and even demonstrate reasonable epithelial recovery (Fig. 28-29, *B*). Membranes are removed if they lose stability and appear to be the nidus of the problem. If their presence does not seem to be the cause, they are maintained for at least 3 months.

Dehiscent Implants

From time to time, a two-stage blade or root form implant does not remain buried beneath the gingival tissues. The patient may not have signs of distress or infection, but a distinct implant component, usually the healing cap or screw, is seen. This does not indicate failure or loss of the implant. A good chance of osseointegration remains, despite this complication. No attempt should be made to close the site surgically. Instead, the implant is kept clean, and the patient is taught to use a dry, cotton-tipped applicator to clean it of material alba (Fig. 28-30). Peridex applications follow. The site should be evaluated monthly, both clinically and occasionally with radiographs.

Radiolucencies

If the radiograph at the 4- or 8-week postoperative examination shows peri-implant lucency, the surgeon should assume that osseointegration will not occur. With a root form implant, the patient should be informed that the implant may have to be removed (Fig. 28-31, *A*). If the lesion remains unchanged, continued observation occasionally reveals evidence of idiopathic resolution. In some cases, a small gingival fistula is seen without

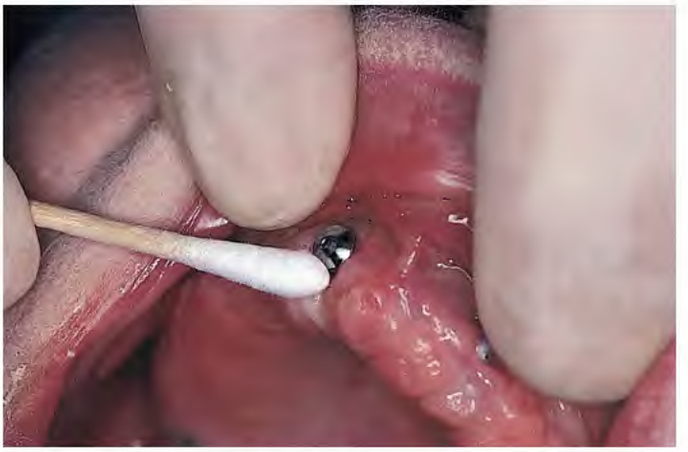


FIGURE 28-30. In some cases, dehiscent root forms do not encourage re-epithelization. However, this does not change their prognosis, particularly if the patient conscientiously and regularly uses dry, wooden, cotton-tipped applicators to cleanse the area and then applies Peridex.

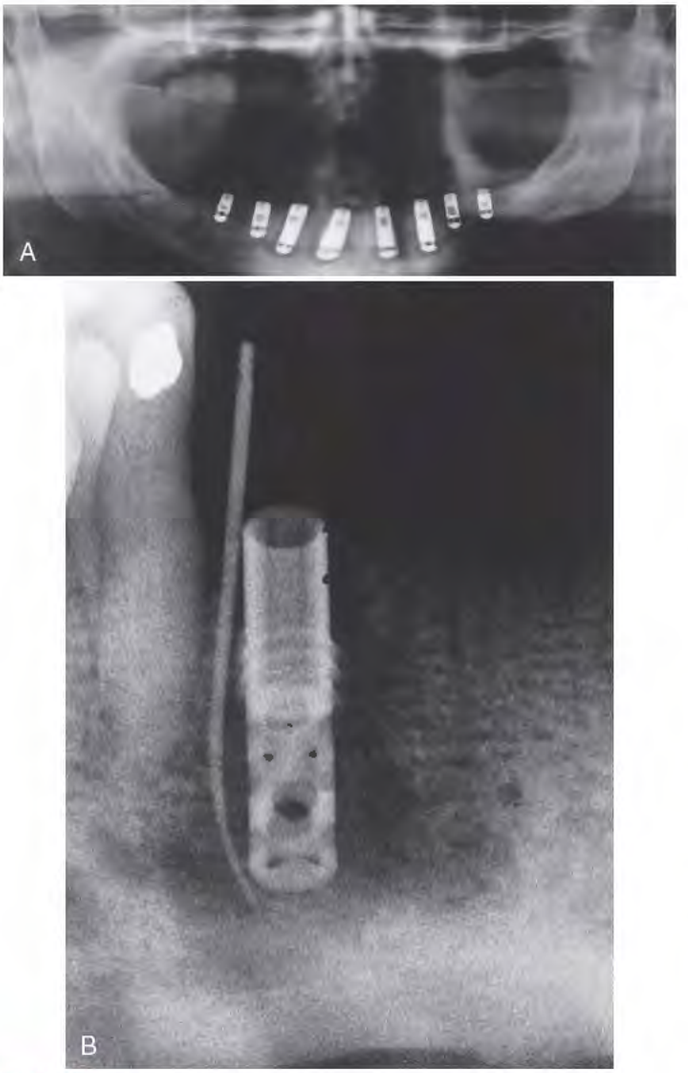


FIGURE 28-31. A, A panoramic radiograph taken during the eighth postoperative week in an asymptomatic patient shows significant peri-implant lucencies. The prognosis for these implants is poor. Rarely do defects of this magnitude resolve spontaneously. **B,** Occasionally, a symptom-free implant has a tiny fistula or inflammatory lesion over it. A radiograph with a gutta percha point directed firmly can be very revealing.

positive radiographic findings. However, a gutta percha point, if lodged deeply as shown by radiography, may dictate removal of the implant or at least an exploratory and repair procedure (Fig. 28-31, *B*). A lucency that appears at the apex of the implant only often represents a perforation of the cortical plate or the introduction of some epithelial cells, probably at the time of operation. An apicoectomy-like repair, using bone replacement materials to fill the defect, often is effective in managing this finding (Fig. 28-32).

Antral Complications

If the surgeon enters the maxillary sinus during insertion of an implant, a postoperative infection may occur even if no portion of the implant appears to be in the sinus cavity. Such a complication also may result after elevation of the sinus floor or use of the Summers technique, particularly if the integrity of the sinus membrane was breached. This problem is characterized by facial pain, purulent nasal drainage, a foul smell or taste, fever, and sensitivity to palpation of the oral and facial tissues that overlie the antrum that is exacerbated by lowering of the head. These findings are confirmed by taking a Waters' view radiograph. If the antral area appears cloudy or opaque, active therapy should be started (Fig. 28-33).

In addition to the sinus regimen presented in Appendix G, surgical drainage may be indicated. The surgeon's adage that "penicillin doesn't cure pus" must serve as guidance. One method is antral lavage. Local anesthesia is induced by blocking the infraorbital and greater palatine (second division) nerves. An 18-gauge, 1½-inch, disposable hypodermic needle is placed against the maxilla through the areolar tissues high in the vestibule (never through fixed gingiva) in the region above the second premolar apex. The needle often pierces the cortical plate, and its tip enters the antrum if its hub is tapped with a mallet. A resistant cortex requires a small incision at the site with a BP No. 15 blade. The tips of a mosquito hemostatic forceps are inserted. Opening the instrument allows the beaks to serve as retractors. With the assistant maintaining the forceps, a No. 2 round bur in the Impactair is used to perform a microantrostomy through the lateral wall. A short length of IV extension tubing is attached to the needle, and at the other end of the tubing, a 20-mL syringe filled with warm saline is attached (Fig. 28-34, *A*). The patient's head is bent down over the lap so that the forehead almost touches the knees, and a kidney basin is placed beneath the nostrils (Fig. 28-34, *B*).

The saline is injected slowly and gently. With the needle tip in the antrum, the effect is a thorough irrigation. The purulent and infected matter is washed out through the natural ostium beneath the middle nasal turbinate and collected in the kidney basin. Irrigation is continued with four or more full syringes until the return is clear of purosanguinous material. The patient then is brought into an upright position, and the needle is removed. No dressings or sutures are required. Relief is almost instantaneous. Culture and sensitivity testing should be ordered for the washings, and the antibiotic should be changed if the result requires it (Biaxin, 500 mg taken orally twice a day, is particularly beneficial). The irrigation may have to be repeated daily for several days, but often a single treatment suffices.

If this treatment should fail to ameliorate the symptoms and subsequent Waters' views do not show a clearing sinus, Caldwell-Luc and nasal antrostomy procedures may be required.

The Caldwell-Luc procedure is indicated for antral infections that are resistant to medical therapy, retrieval of foreign bodies

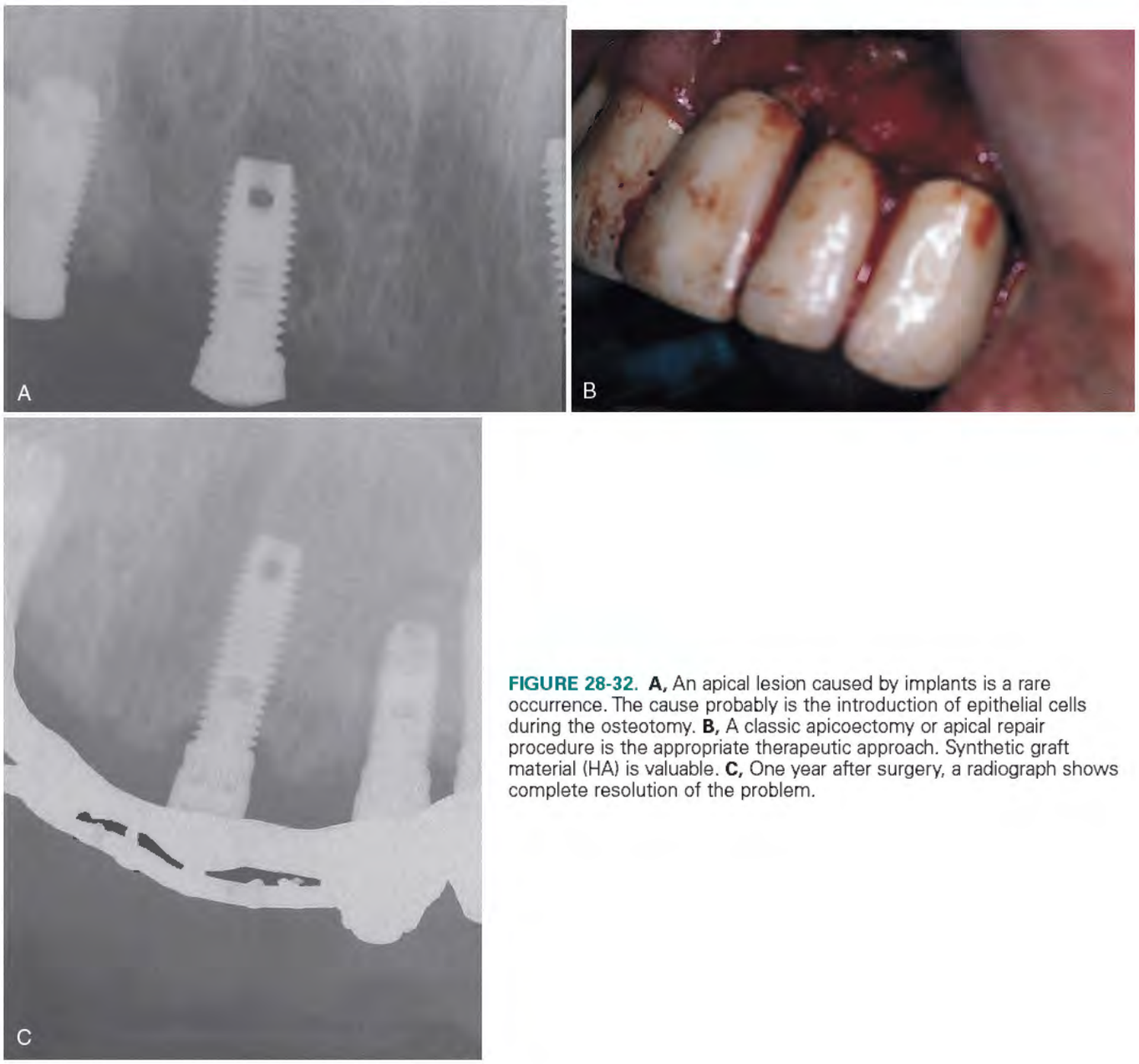


FIGURE 28-32. **A,** An apical lesion caused by implants is a rare occurrence. The cause probably is the introduction of epithelial cells during the osteotomy. **B,** A classic apicoectomy or apical repair procedure is the appropriate therapeutic approach. Synthetic graft material (HA) is valuable. **C,** One year after surgery, a radiograph shows complete resolution of the problem.

(e.g., dental roots or implants), removal of polyps, and evacuation of purulence. It requires a significant osteotomy (at least 25 mm in diameter) through the maxillary wall in the canine fossa.

Using a scalpel or Bovie tip, the surgeon makes a curved, horizontal incision at least 5 mm above the attached gingival level through mucosa to bone (in several layers), starting at the canine and proceeding to the zygomatic buttress. After the periosteum is incised with a blade, the canine fossa is exposed with an elevator. Care must be taken not to injure the infraorbital neurovascular bundle.

With the assistant retracting in an upward direction, the antrum is entered using a Crane pick or, if the tissue is resistant, with bur holes. The bone opening is enlarged with back-biting Kerrison rongeur forceps (Fig. 28-35, *A*). When the opening is large enough to allow insertion of an index finger to the first joint, a fiberoptic antroscope is used to inspect the internal environment. The foreign body is removed, polyps are curetted, or whatever procedure is needed is performed; the antrum is then irrigated with warm saline.

Often a lost implant is not readily visible but may be nestled beneath the sinus membrane, which requires incision and exploratory elevation. Once this procedure has been done and the internal environment is free of debris and gross infection, additional drainage may be required, particularly because of the preference for primary closure of the oral wound. To achieve this, a nasal speculum is inserted into the nostril and the inferior turbinate is lifted with a Freer elevator. The Crane pick is used to punch through the thin nasal wall beneath the turbinate level with the nasal floor. The opening is enlarged with increasing sizes of curved rasps and Kerrison rongeurs (Fig. 28-35, *B*). Then, an opened, 4 × 4-inch, cotton-free sponge is passed from the nose through the mouth by introducing it through the opening in the nasoantral wall with a tonsil forceps. The sponge is grasped through the Caldwell-Luc opening with a Kelly forceps, and the tonsil clamp is released from the nasal end. The sponge is pulled back and forth in shoeshine fashion to smooth irregular bone margins.

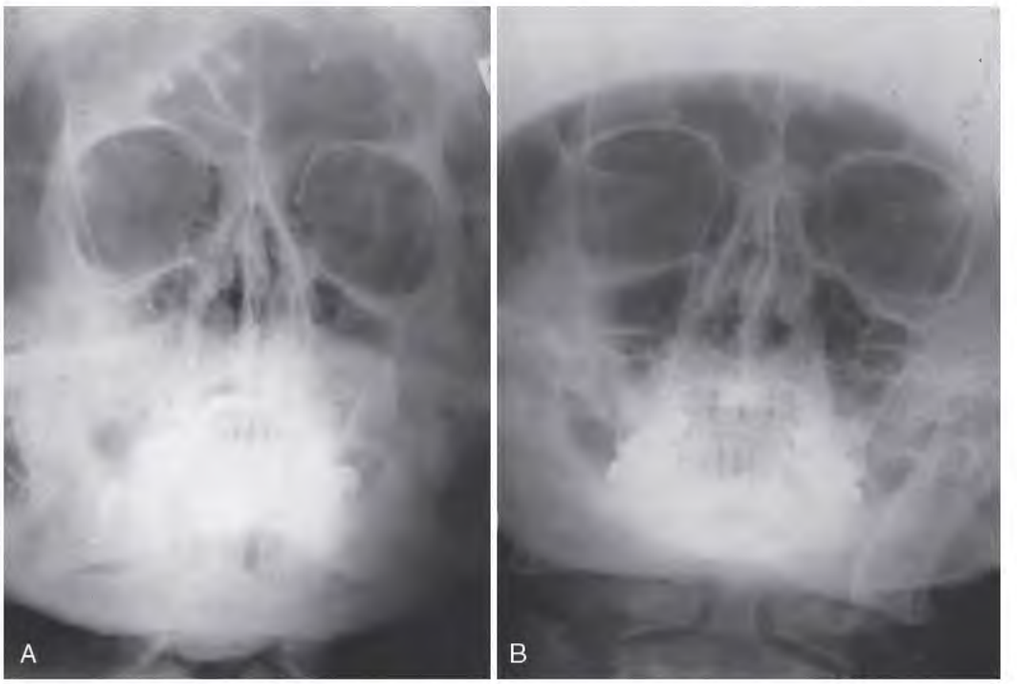


FIGURE 28-33. **A,** Infections, empyema, and inflammation of the maxillary sinuses can accompany implant surgery. If the diagnosis is questionable, a Waters' view can be taken using a standard 70 kV 15 ma dental x-ray machine and a high-speed 8 × 10-inch cassette with intensifying screens. The patient's chin is placed on the cassette with the nose raised about 2 cm from it and the tube at 0 degrees aimed through the head directly at the midface. The resulting x-ray film shows a cloudy antrum. **B,** After appropriate treatment, the antrum appears clear bilaterally.

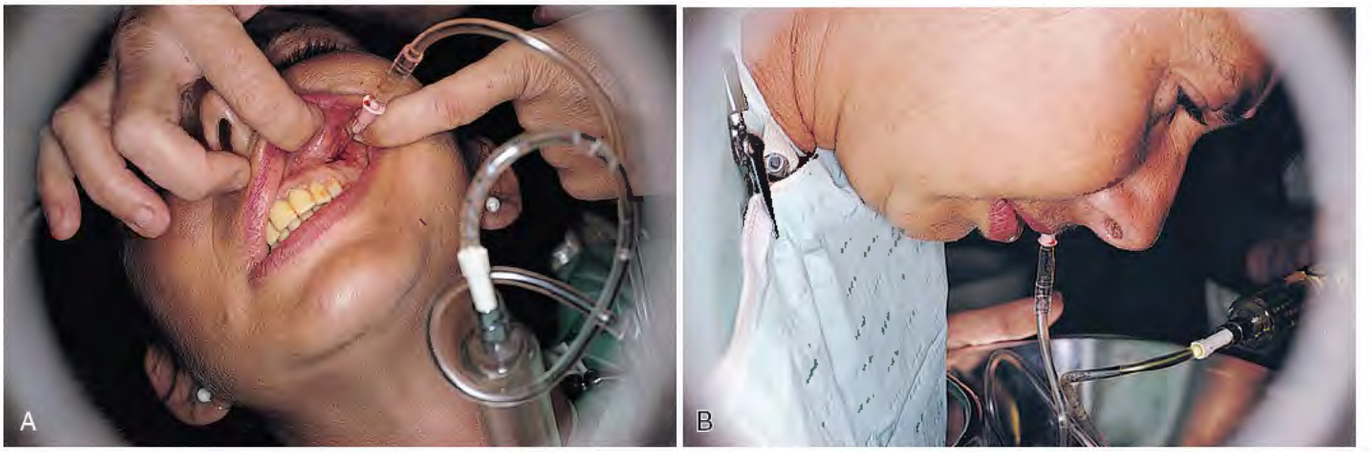


FIGURE 28-34. **A,** Acute sinusitis and empyema require more aggressive therapy than antibiotics; lavage must be done. This is accomplished by using a mallet to tap an 18-gauge needle through the antral wall above the areolar tissue level. An intravenous extension tube is attached to the hub. **B,** The patient's face is positioned forward so that the nose is lower than the mouth, and a 20-mL syringe is used to introduce warm saline. The return from the nose, which at first is purulent and then becomes increasingly clear, drips into a kidney basin. This is a simple but effective method of antral irrigation without the need for a Caldwell-Luc procedure or nasal antrostomy.

The surgeon should allow 2 inches of fenestrated, ¼-inch Penrose drain to protrude from the sinus through the nasal antrostomy and out to the nostril rim. It is stabilized with a single 2-0 black silk suture that is passed through the nasal mucosa just inside the ala. The antrum is irrigated thoroughly, and the oral wound is closed in two layers with 3-0 dyed Vicryl suture using a continuous horizontal mattress configuration. Closure is simple, because the incision was made in the areolar tissues. Had it been made in fixed gingiva, suturing would be fraught with difficulties and the possibility of wound failure and antral fistulization would be amplified.

The drain is used as a conduit for irrigation for 3 to 5 days and then it is removed.

If an oroantral fistula has developed because of a failed implant, the techniques described for soft tissue pedicle grafting (see Chapter 7) should be followed, after completion of appropriate sinus manipulation as described earlier in this chapter (Fig. 28-35, *C* and *D*).

An implant that is responsible for maxillary sinusitis, either endosteal or subperiosteal and that does not respond to antibiotics and corrective irrigation or antrostomy must be removed.

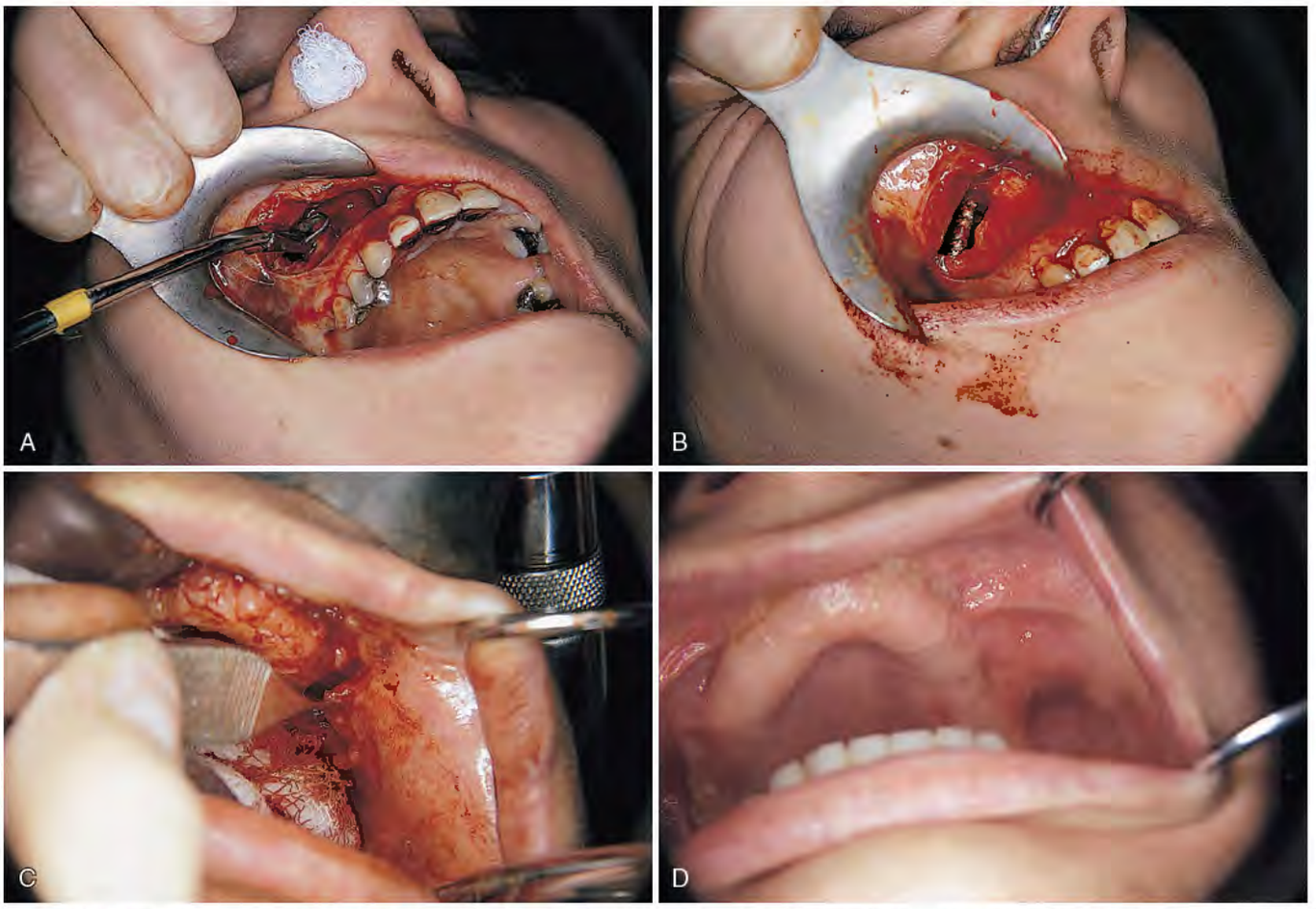


FIGURE 28-35. **A,** In cases involving a chronic infection, foreign bodies (teeth or implants), or polyposis, a more aggressive approach is necessary (i.e., the Caldwell-Luc procedure). A window is opened in the lateral wall of the maxilla by a puncture from a Crane pick and is enlarged with back-biting Kerrison forceps. The full size of the fenestration should allow comfortable entry of the first joint of the surgeon's forefinger. Corrective procedures can be done, foreign bodies removed, and a primary closure completed. **B,** If drainage is anticipated or desirable, a nasal antrostomy should be done before oral closure. This is performed with curved rasps and Kerrison forceps beneath the inferior turbinate. A thin drain may be allowed to protrude from the nose. **C,** A buccal pedicle graft is fashioned by undermining, and after fistula excision, it is brought across the debrided bony defect host area. Interrupted sutures complete the graft procedure. **D,** Ten days after suture removal, the well-vascularized graft has obtunded the fistulous area. A secondary vestibuloplasty may be required. (For a description of a palatal graft and vestibuloplasty, see Chapter 7).

The measures described here should lead eventually to a Waters' view radiograph that indicates a healthy maxillary sinus (see Fig. 28-33, *B*). Advanced fiberoptic nasal antrostomy techniques may be indicated. In some cases, they simplify both the intraoperative and postoperative courses.

Implant Mobility

One-piece endosteal implants (e.g., blades, the ramus group) or screws may become mobile before the end of the initial healing phase (3 to 6 months). If this is noted, the chance of re-establishing firmness is virtually nonexistent. At this juncture, the patient should be informed of the finding, and permission to remove the implant should be requested. Mobility with submergible implants, although it occurs less often, also requires removal (Fig. 28-36).

Postsurgical Scar Contracture

Pterygomandibular Raphe

The pterygomandibular raphe may undergo scar contracture 4 to 6 weeks after surgery on the retromolar or posttuberosity areas (Fig. 28-37, *A* [line *P-R*]). The patient may complain of being unable to open the mouth fully or of a feeling of tightness in the area. Z-plasty is a technique designed to eliminate this linear contracture. In this operation, for which infiltration anesthesia can be used, two, full-thickness, horizontal incisions are made parallel to one another, below and above the scar and at right angles to it (Fig. 28-37, *B*). Then, an incision is made from the lateral end of the superior incision diagonally down to the medial end of the inferior one, creating two triangles. The apex of each triangle is at the lateral end of the superior incision and the medial end of the inferior one. Each apex is grasped with a Gerald forceps and, starting at that point, the tissue is undermined as a full-thickness flap to the fullest extent possible (Fig. 28-37, *C*). Each of the triangles is transposed, held by the forceps, moving the lower medial point up to the medial end of the upper horizontal incision and the upper lateral point downward to the lateral end of the lower incision (Fig. 28-37, *D* and *E*). Each is tacked into place, and they then are fixed into their new relationships by suturing. The scar contracture will have become so disoriented that it will seem to have disappeared. After the fifth postoperative day, physiotherapy (jaw stretching) should be started. By the tenth day, the patient should be able to open the jaw with increasing facility, and the appearance of the operative site should indicate ablation of the scar (Fig. 28-37, *F*).

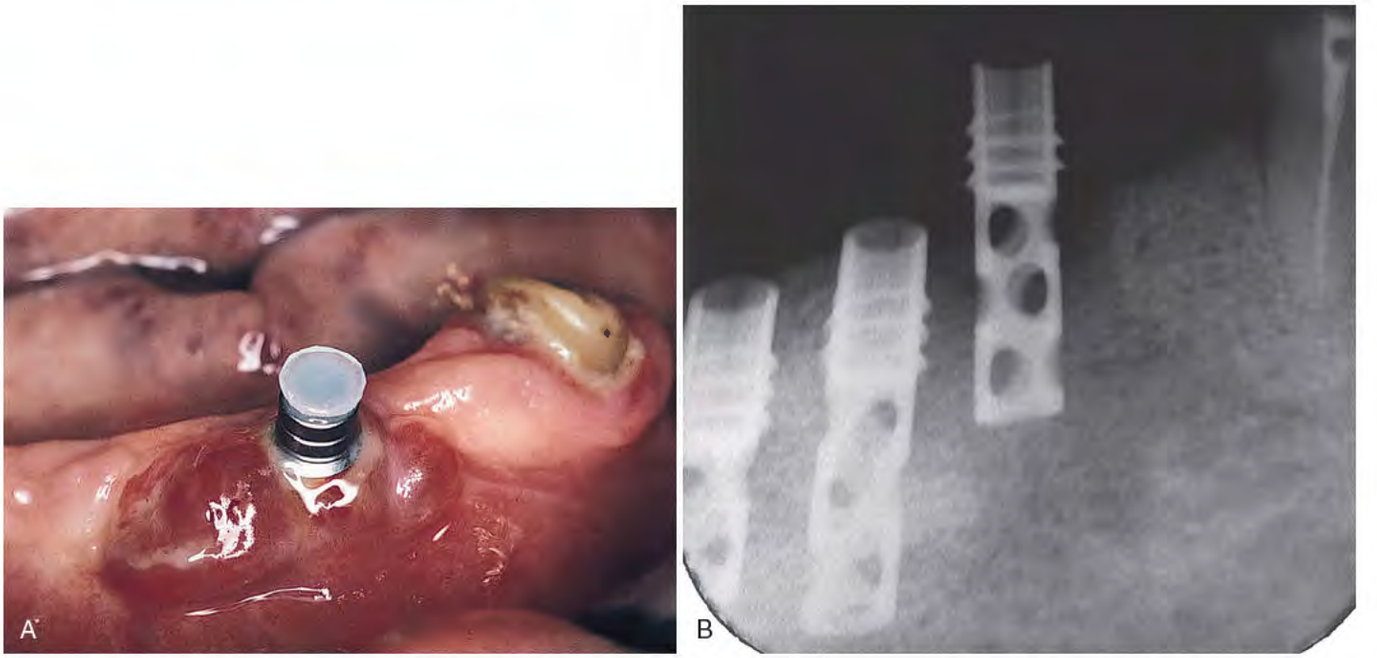


FIGURE 28-36. **A,** Occasionally, a two-stage submergible implant becomes mobile, loosens, and begins to extrude. **B,** A radiograph confirms the hopeless prognosis of this root form device.

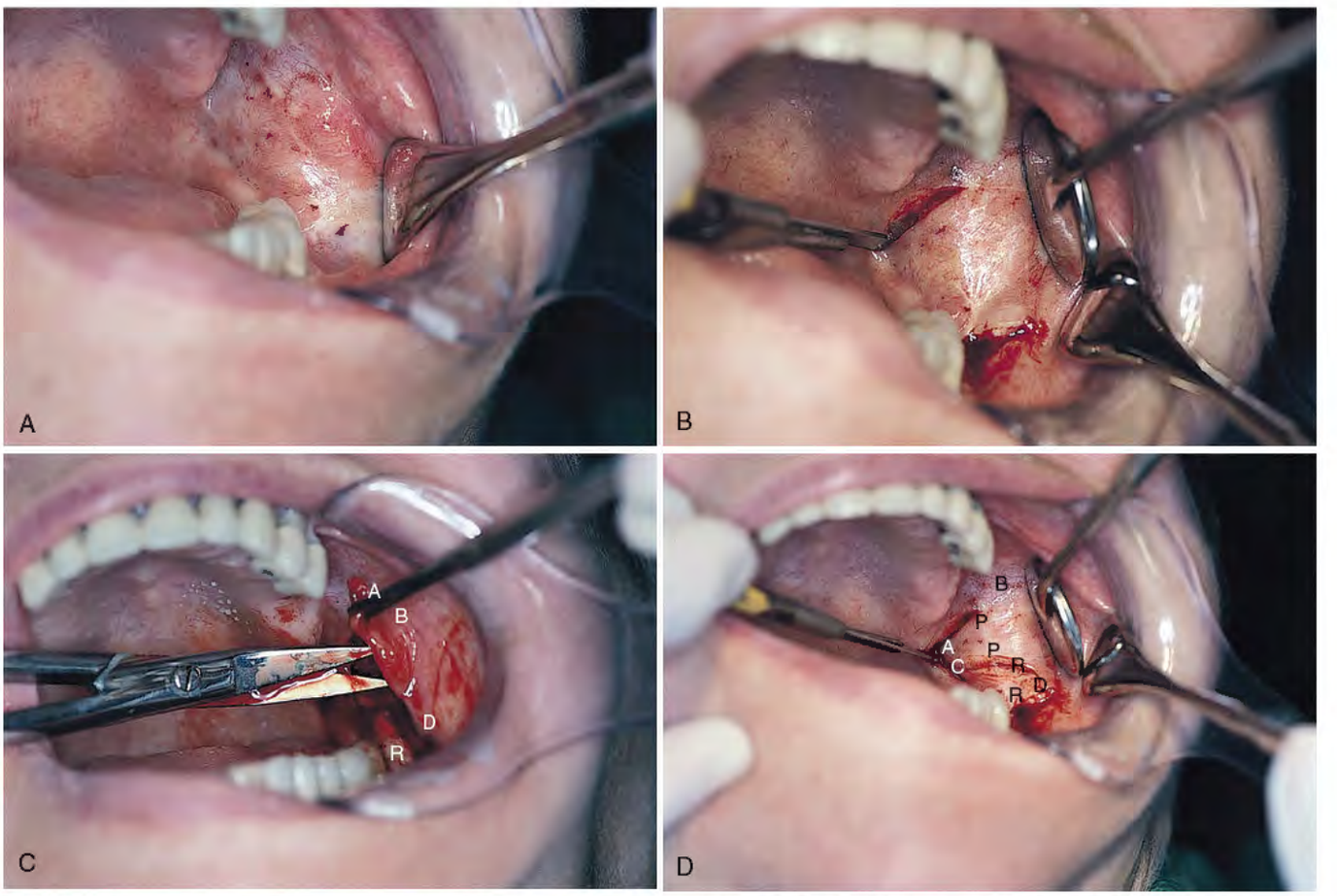
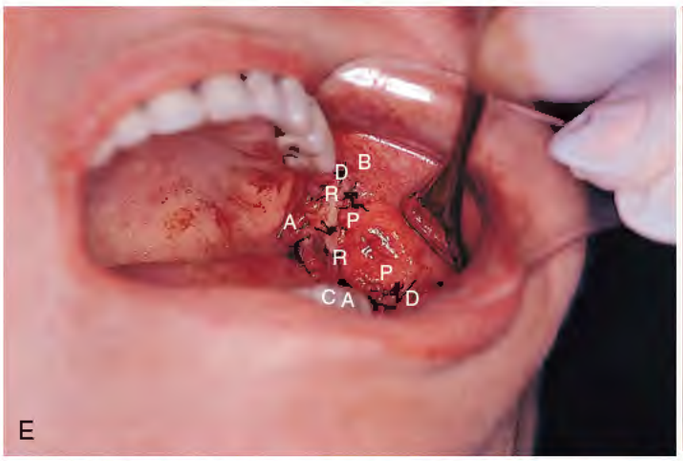
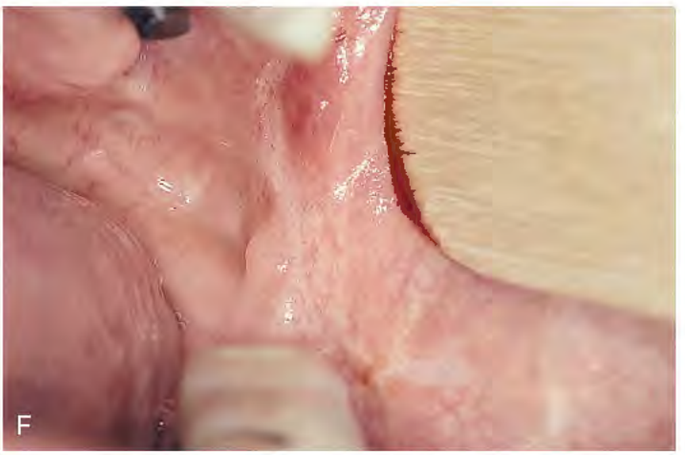


FIGURE 28-37. **A,** Scar contracture, as indicated by an easily palpable, dense white line *(P-R),* prevents a patient from opening the mouth with ease. **B,** Corrective **Z**-plasty is begun by making incisions perpendicular to *P-R* above it *(A-B)* and below it *(C-D).* **C,** Points *A* and *D* are connected by a diagonal incision, and point *A* is immobilized with a Gerald forceps. Curved, sharp scissors are used to undermine flap *BAD* up to line *B-D.* This is followed by creation of flap *CDA* in a similar manner. **D,** Point *A* is grasped and moved to corner *C.* In the same fashion, point *D* is carried to corner *B,* transposing the two triangles. This creates a discontinuity of the newly sectioned scar (*P-P* and *R-R* may be noted).





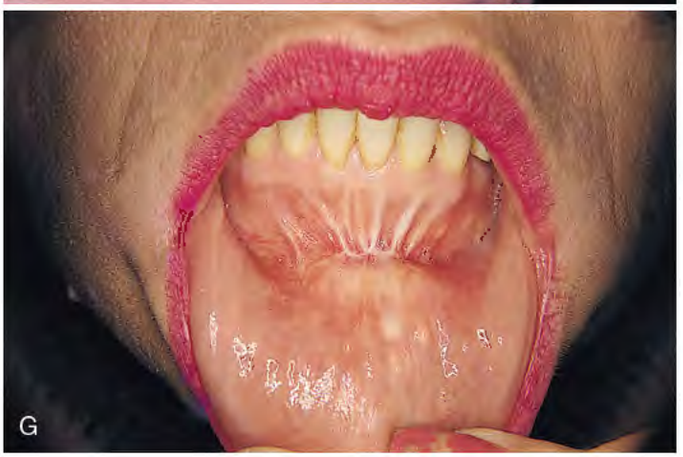


FIGURE 28-37, cont'd. E, When the transposed flaps are closed, *BAD* become *BCD,* and *CDA* become *CBA.* The flaps are sutured into their new positions, which causes corner reversal of the two scar halves: *R-R* acquires a position superior to *P-P.* **F,** The postoperative appearance shows elimination of the original contracture. **G,** Poor incision location (e.g., in fixed gingivae) or suturing under tension may be responsible for severe scar contracture, with consequent facial deformity and inability to use the lips for labial seal, smiling, and speaking. Vestibuloplasty is required in these cases (see Chapter 7).

Anterior Vestibule

Anterior mandibular contracture occasionally occurs after placement of a root form subperiosteal implant or on closure of the incision made for harvesting symphyseal bone for grafting. Symptoms include altered mobility of the lower lip, a change in labial posture, or loss of the labiomental fold. If these symptoms occur, a vestibuloplasty (see Chapter 7) can be therapeutically beneficial (Fig. 28-37, *G*).

Subperiosteal Implants

Strut Exposure

Subperiosteal implant strut exposure occurs as a result of wound breakdown, which often can be prevented by creating and properly suturing tension-free flaps. As stated earlier in the chapter, secondary surgical closure should not be attempted. The exposed strut should be cleaned of material alba with cotton-tipped applicators, followed by Peridex rinses, and the patient should be instructed to do this at home (Fig. 28-38). The patient's ability to perform this care should be determined; if the efforts are satisfactory, epithelial tissues may slowly grow over and even seal an exposed strut. If this does not happen, the dehiscent member is treated just as if it were another permucosal component of the implant. Such exposed parts can survive for years without additional hard or soft tissue loss.

If soreness arises or persists and the strut is not a strategic one, it can be resected. This can be done using a local anesthetic. The assistant should protect soft tissues with an elevator or retractor, and the mucosa is pushed back 3 mm along the strut proximally and distally. The exposed segment of strut is then removed by stroking each end, just beneath the overlying mucosa, with a well-cooled, high-speed tapered diamond drill. Cut metal ends require smoothing with the diamond, which also causes mucosal abrasion. The resultant bleeding initiates healing and coverage of the altered strut ends.

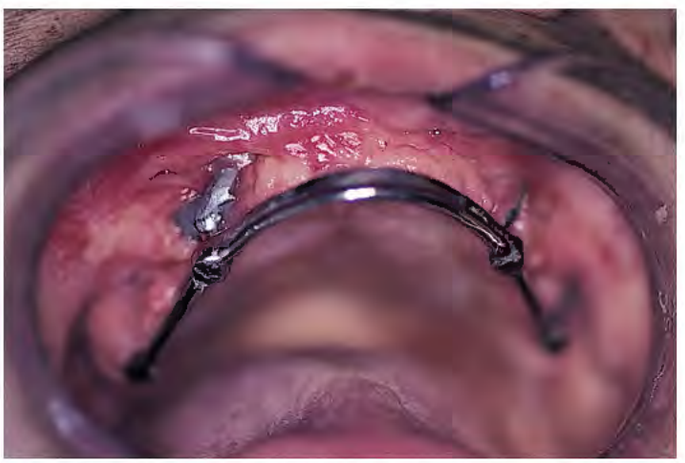


FIGURE 28-38. Exposure of the struts of subperiosteal implants occurs with some frequency. Good hygiene keeps such conditions stable for many years.

Postoperative Infection

The treatment of short-term postoperative infections of the tissues surrounding subperiosteal implants is essentially the same as that outlined for endosteal implants.

Scar Contracture, Pterygomandibular Raphe, or Anterior Mandibular Vestibule

Raphe and vestibular contractures occasionally are seen after insertion of mandibular subperiosteal implants. Management is the same as that described in the section on endosteal implants.

LONG-TERM COMPLICATIONS

Endosteal Implants

Ailing, Failing, or Failed Implants

Bone loss around implants often begins with gingival inflammation. Hyperemic decalcification is one of the contributing factors leading to demineralization of bone that lies beneath inflamed skin or mucosa. Other factors can be related to nutrition or age, occur secondary to systemic disease (see Chapter 3), or caused by bruxism, traumatic occlusion, improperly designed superstructures, unacceptable oral hygiene, or physiologically incompetent implant design.

Most of the possible causes can be managed by an innovative practitioner who adds implants, corrects occlusion, revises superstructures, performs definitive periodontal therapy, and, with persistence, trains and retrains the patient until the person performs the home care regimen satisfactorily.

Implant design has been the subject of debate for over a decade as a cause of saucerization. Brånemark initial 0.5 mm of bone loss was supposed to settle into a physiologic pattern of 100 μm per year thereafter. Acceptance of that concept appeared to be universal. No one could anticipate with validity, host sites that showed absolutely no change in bone level.

Therefore, implants that are manufactured with irregular exteriors (HA or titanium plasma spray [TPS] to produce greater surface area and retention) brought to their tops often portended failure. As the bone level drops, as predicted, the investing soft tissues become the interfacial components apposing the roughened implant surfaces. Professional and home care prophylactic measures become impossible to practice, and local problems are exacerbated, introducing increasingly rapid bone loss. Some remedies are preventive, leading to machined or polished titanium collars of from 1 to 2 mm in height and, more recently, hybrid implants that have threads placed up to the collar and surface treatment of varying microporosities all the way to the top to the neck of the implant.

Roland Meffert recognized the serious and self-promulgating nature of the host site problems adjacent to coated implants of both the press-fit and threaded variety and contributed some sound regimens for the management and maintenance of ailing, failing, and failed implants. He defined *failed* as the presence of mobility. (This can be determined clinically by tapping and receiving a dull sound, by manipulating with two mirror handles and detecting movement, no matter how slight, and by use of the Periotest and eliciting a response of + 9 or higher.) All failed implants require instant removal with site repair by thorough debridement and grafting.

Failing implants are firm; osseointegration develops apically and is responsible for the implants' stability. However, purulence exudes from the pericervical gingival crevices, and bone loss is progressive.

The *ailing* implant demonstrates diminished but static levels of bone on follow-up radiographs.

Failed Implant

If either a root form or blade implant is mobile, the only acceptable treatment is removal (Fig. 28-39). A major cause of loosening of a successful implant is cement failure on an adjacent natural abutment tooth. Castings should fit well, be cemented carefully, and be checked frequently for evidence of mobility or the tell-tale sign of fluid that appears at their margins when they are depressed. An alternative, which discourages cement loosening, is generous use of interlocks between the superstructure elements of natural and implant abutments. Bottomless female attachments lend additional benefit because they allow independent removal of either component.

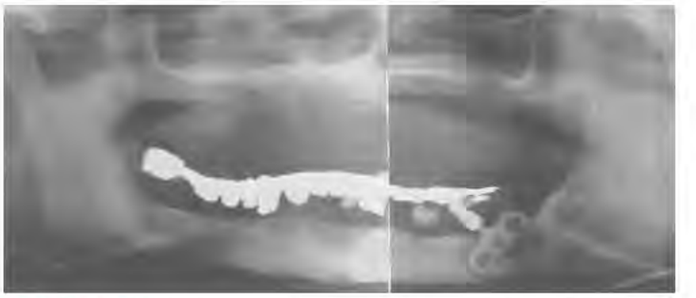


FIGURE 28-39. Many endosteal implants in less than dire straits must be removed. This 16-year-old implant rotated slowly into this unusual position. It was very firm and resistant to elevation.

If a decision is made to remove an endosteal implant, all of the granulomatous and connective tissues lining the host site walls also must be removed. To retrieve an implant, even if it is mobile, a full-thickness incision is made, and the mucoperiosteum is reflected to reveal the entire host site. X-ray films and a clinical examination can reveal any sites of bone bridging or similar impediments to removal. Then, using a No. 2L round bur in the high-speed handpiece, the bone is brushed away until the implant can be lifted out without undue force.

If deeper bony protrusions lock the implant to the host site, extra long, surgical No. 700XXL fissure burs must be used apically in a light brushing movement running directly against the implant. Occasionally, en bloc removal is required, such as for implants that are truly osseointegrated but have fractured or are causing dysesthesia, pain, or allergic symptoms (Fig. 28-40). This is done with extreme care, making the block outlines or using trephine drills of a diameter as close to the implant as possible because of the potentially highly destructive nature of such a procedure.

After removal of the implant, all debris and attached granulomas are removed, and repair is performed with DFDB and TCP or other alloplasts, followed by placement of a resorbable membrane (Fig. 28-41, *A* to *C*).

Nine or more months later, after the site has matured, root form implants are placed (Fig. 28-41, *D* and *E*). After osseointegration, they can be restored in the classic manner (Fig. 28-41, *F* to *H*).

After removal of a mobile implant or one encased in soft tissue, a scalpel with a No. 12 blade is used to incise the mucosa from the gingival margins in an oblique pattern downward directly to the bone that had surrounded the implant. The back of a surgical curette is inserted from the incision down to the residual bony rim. From there, the curette is extended carefully to the base of the recently vacated defect. Next, a curved hemostat is used to grasp the tissue, now in a glovelike configuration, and, while it is elevated, the No. 12 blade is used to dissect it from its few remaining fibrous attachments to the bone. If the incision was made efficiently, the soft tissue lining comes away cleanly in the form of a sac, leaving an unlined bony defect in the jaw. If an intact mandibular canal or antrum appears at the apex, a resorbable bone substitute material (e.g., TCP) is placed in the defect and, when full, it is tamped gently to eliminate

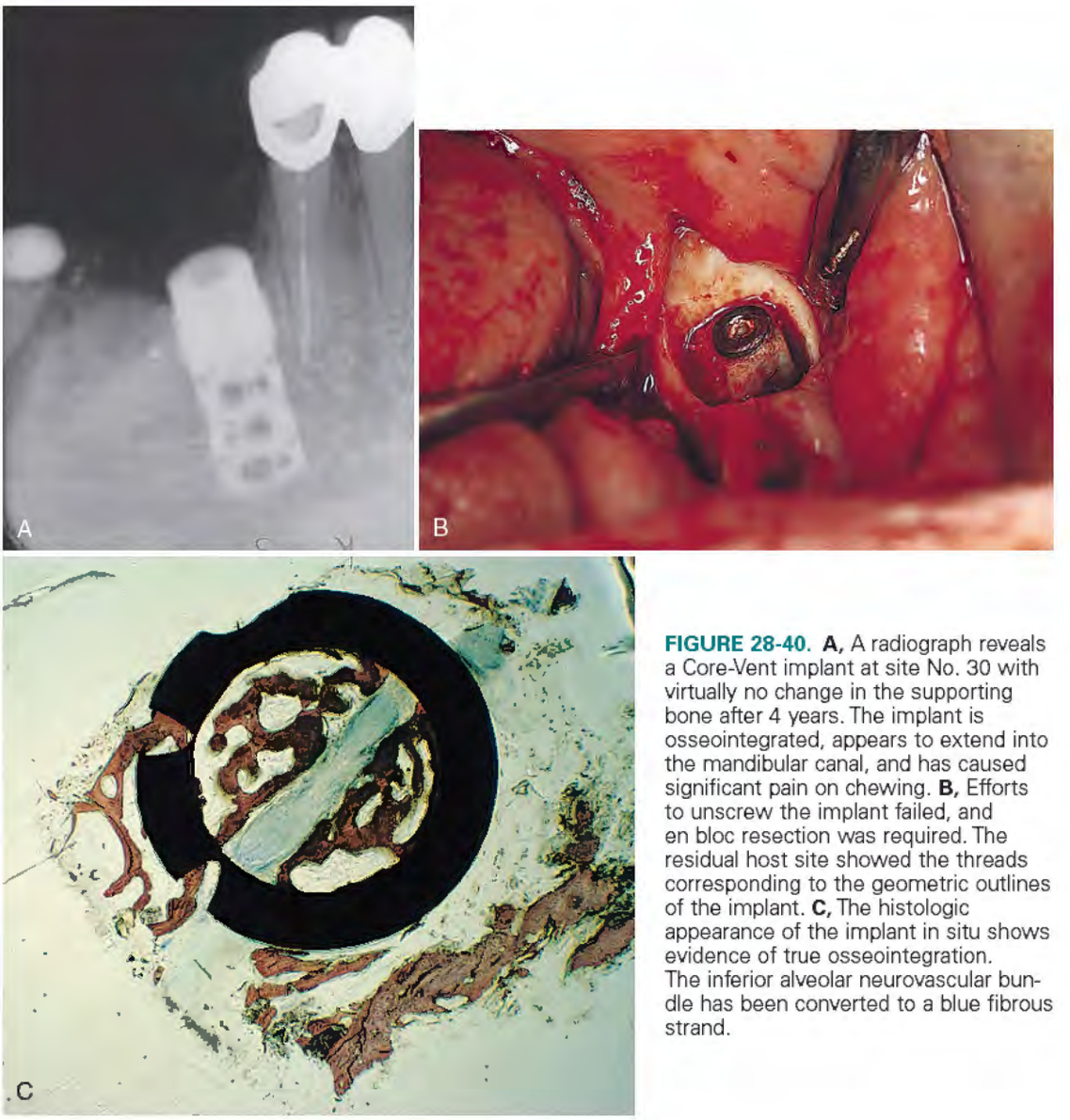


FIGURE 28-40. **A,** A radiograph reveals a Core-Vent implant at site No. 30 with virtually no change in the supporting bone after 4 years. The implant is osseointegrated, appears to extend into the mandibular canal, and has caused significant pain on chewing. **B,** Efforts to unscrew the implant failed, and en bloc resection was required. The residual host site showed the threads corresponding to the geometric outlines of the implant. **C,** The histologic appearance of the implant in situ shows evidence of true osseointegration. The inferior alveolar neurovascular bundle has been converted to a blue fibrous strand.

voids. After placement of a resorbable GTRM, a continuous horizontal mattress suture is placed, with flap undermining, if necessary, to gain complete primary closure (Fig. 28-42, *A* to *D*). The area should mature for about 6 months. At that time, after clinical and radiographic analysis, placement of a new implant can be considered (Fig. 28-42, *E* to *I*).

If an antral communication has resulted, a closure should be planned after completion of the steps just listed for implant removal. The intraosseous granulomas must be excised aggressively, or a primary closure of the antral defect will not be successful. On excision of this soft tissue, a completely denuded ring of bone, 360 degrees around and with a 2-mm wide zone of exposed rim, should be evident. Then, depending on the location of the communication (palatal or buccal), a pedicle graft is designed and elevated so that primary closure can be performed. These procedures were discussed earlier in this chapter and elsewhere in this text, and they should become a part of every implant surgeon's skills. The usual antral regimen (see Appendix G) should be prescribed.

Failing Implant

If routine radiography demonstrates progressive bone loss around the cervical area of an implant (the failing implant), the cause should be sought (e.g., traumatic occlusion, poor hygiene) and remedied. Corrective surgery dictates the creation of full-thickness facial and palatal or lingual flaps as for periodontal operations. Cervical granulomas are curetted down to bone, but care must be taken not to scratch or injure the implant's surfaces (Figs. 28-43 and 28-44). With HA-coated implants, the particulate material is removed. Thin, water-cooled, fine diamond stones are effective. If no sign of purulence is seen, the area is primed with an application of saturated citric acid for 5 minutes, followed by saline irrigation. Fresh bleeding should be evident. Particulate TCP or DFDB should be tamped into the defect to the highest level of the bone (Fig. 28-45).

If purulence had been present and after thorough preparation of the exposed portions of the implant, hemostasis is established and tetracycline is introduced (100-mg soluble tablet in 5 mL of sterile saline) carried between the beaks of a college pliers into

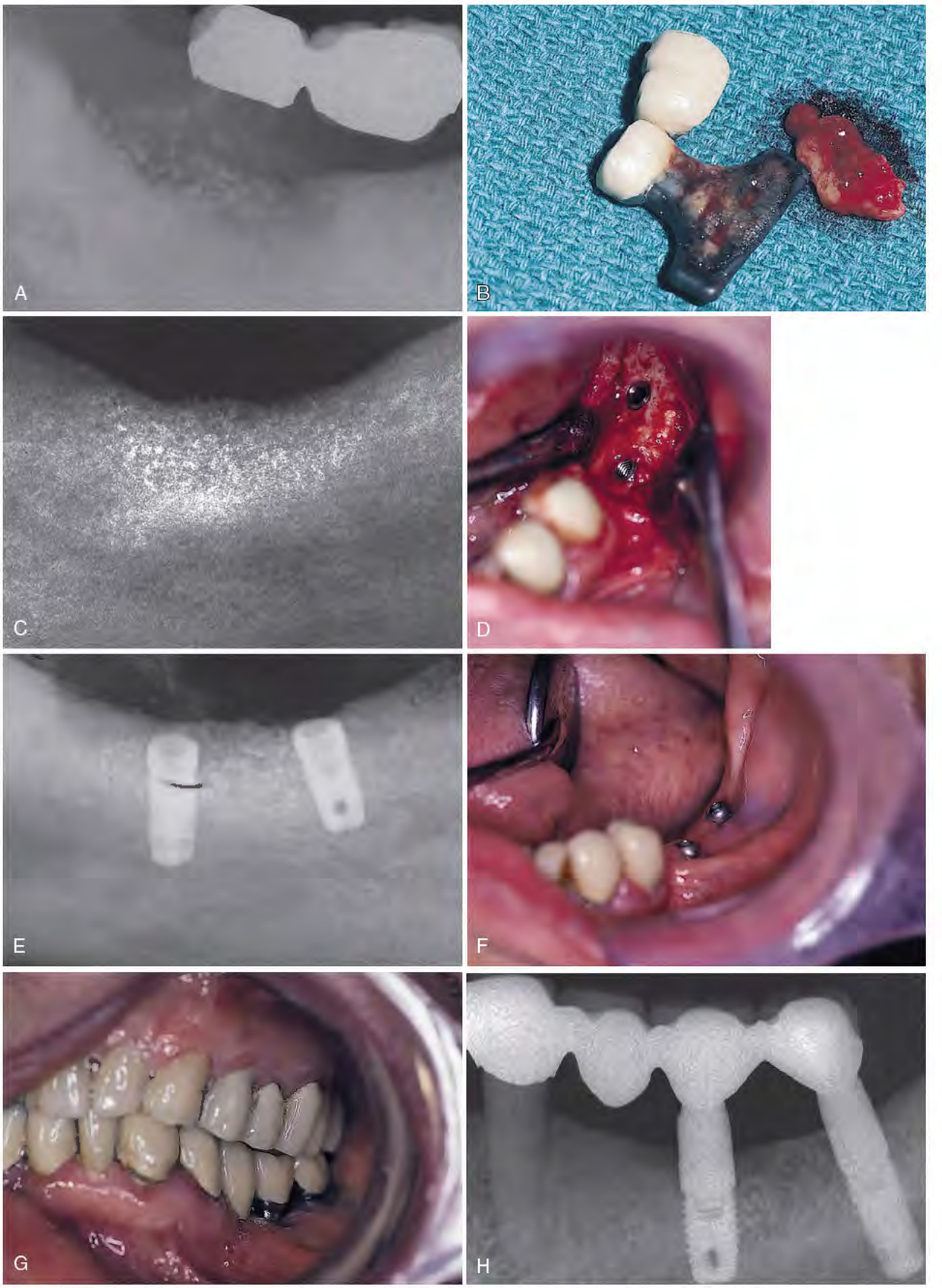


FIGURE 28-41. **A,** A radiograph of a failing, radiolucent, carbon blade implant shows a large, round, lytic host site. **B,** Granulomas are the lesions that most commonly surround such failing endosteal implants. To restore the area, thorough curettage must be incorporated into the operative plan. **C,** The host site may be grafted (hard tissue replacement [HTR] and Osteogen) only after complete debridement. **D,** Nine months later, replacement root form implants may be inserted. **E,** The resulting well-ossified host site supports the new implants. **F,** Six months are required to ensure osseointegration. At that time, second-stage surgery allows placement of healing collars. Periotest scores indicate true bony support. **G** and **H,** The clinical and radiographic appearances of this restored mandibular left quadrant demonstrate a firm, fixed prosthesis that is functioning satisfactorily in its seventh year.

the defect for 5 minutes. This is followed by insertion of the graft material soaked in additional tetracycline. Pressure is applied for several minutes to allow fibrin to serve as a grouting medium for the graft material, and after placement of a resorbable membrane, the operation is completed with a careful, tight, anatomic, primary closure. If a removable abutment is present, it is replaced with a healing screw. If not, the GTRM is prepared as a poncho. The patient should be followed carefully, with clinical examinations and periapical films, at intervals of 3 to 6 months (Fig. 28-46). Probing should not be done.

Ailing Implant

The ailing implant is in the least serious of the three pathologic states. Nothing more than radiographic evidence of bone loss may direct the implantologist to be suspicious. The problem, if minor, can be tracked down with duplicable, serial periapical radiographs. If local conservative measures maintain the status quo, continued observation plus the use of the pocket watch system (see Chapter 29) for surveillance may be all that is required. On the other hand, if slow but consistent bone loss with deepening pockets is evident, a flap is made and soft tissue correction is completed, but the surface

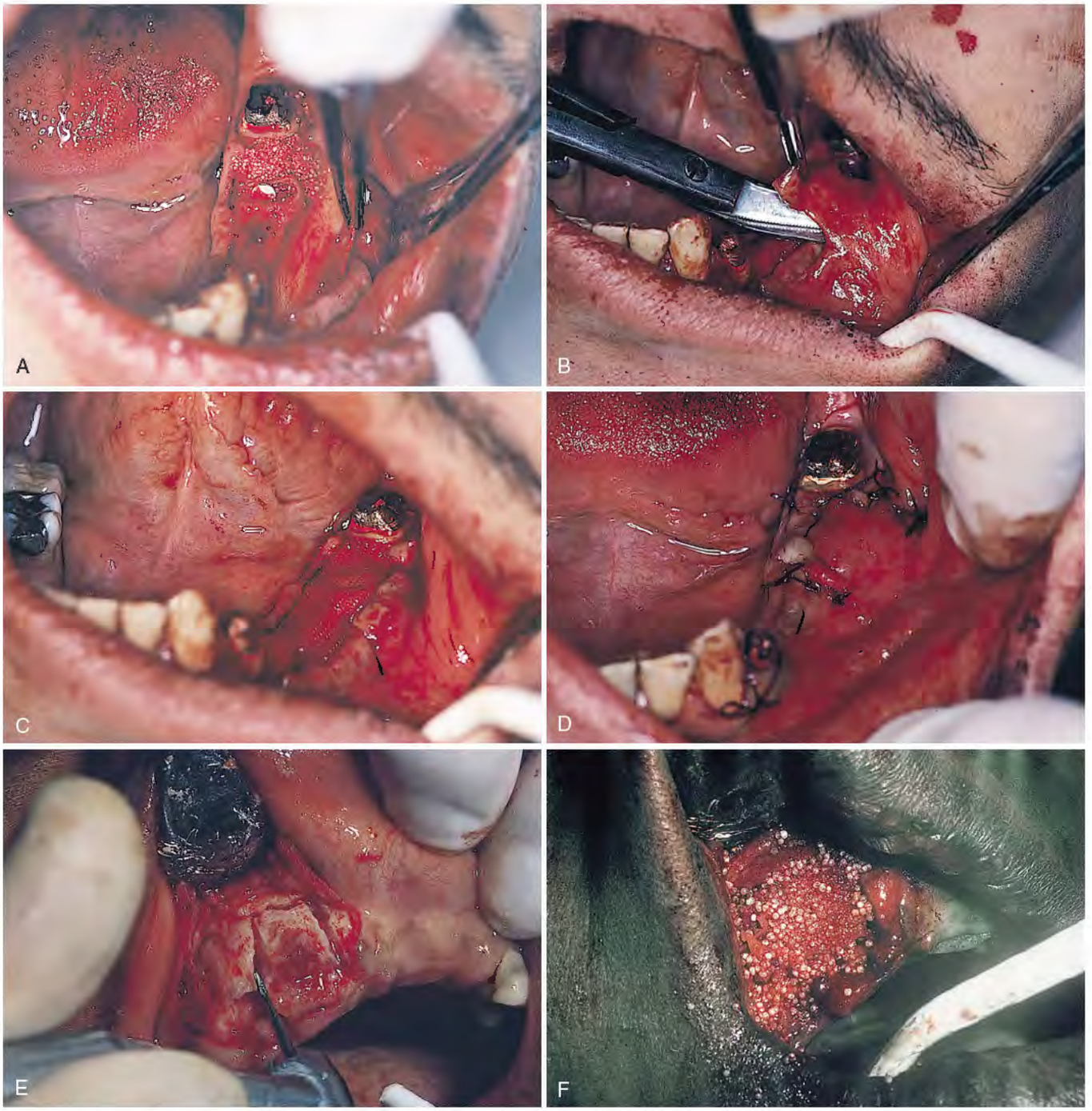


FIGURE 28-42. **A,** A posterior mandibular operative area after a root form implant was removed and grafting was performed. **B,** The buccal flap was undermined to achieve a tension-free closure. **C,** Just before closure, a properly sized piece of membrane (Vicryl mesh) was tucked under the flaps. **D,** A tension-free closure was performed with 4-0 dyed Vicryl suture. **E,** This en bloc resection was required because of nasal impingement by an osseointegrated root form implant. **F,** An immediate repair was performed with a porous block graft, which was tailored to fit into the defect by frictional attachment.

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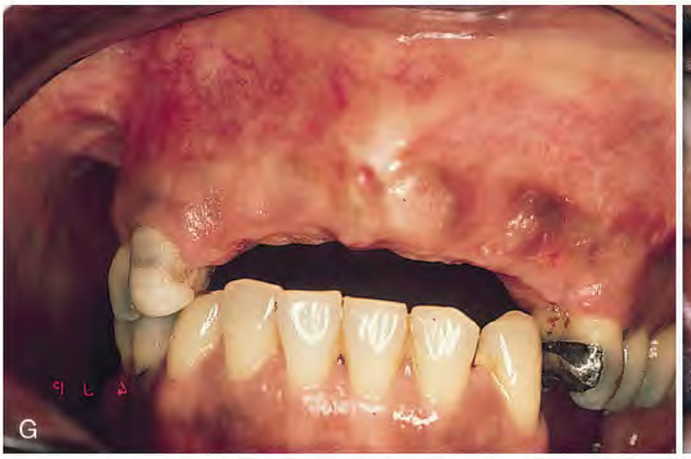


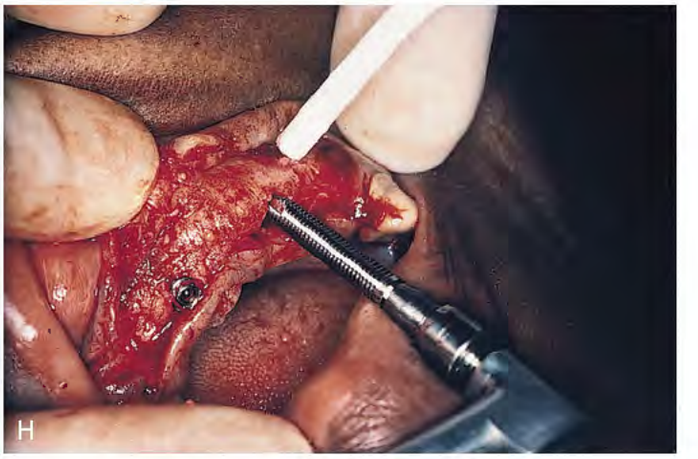
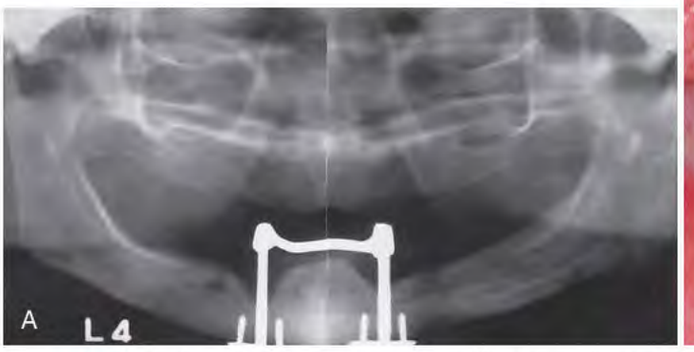


FIGURE 28-42, cont'd. G and **H,** A well-healed closure indicates consolidation of the graft to the surrounding bone. A commercially pure (CP) titanium implant was accepted readily at this site 9 months later. **I,** A postoperative radiograph shows that the graft site has provided a satisfactory support mechanism for this osseointegrated Nobel Biocare implant.



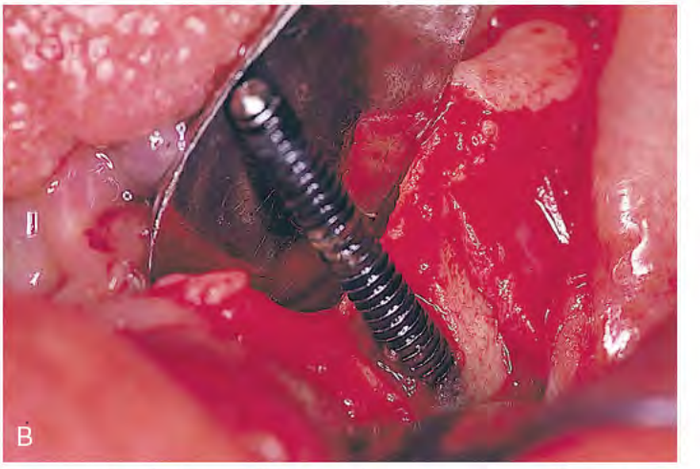


FIGURE 28-43. A, Fourteen-year-old transosteal implants show significant pericervical saucerization lesions on a radiograph. **B,** Surgical correction of peri-implant bone loss is initiated with an incision and granulomectomies.

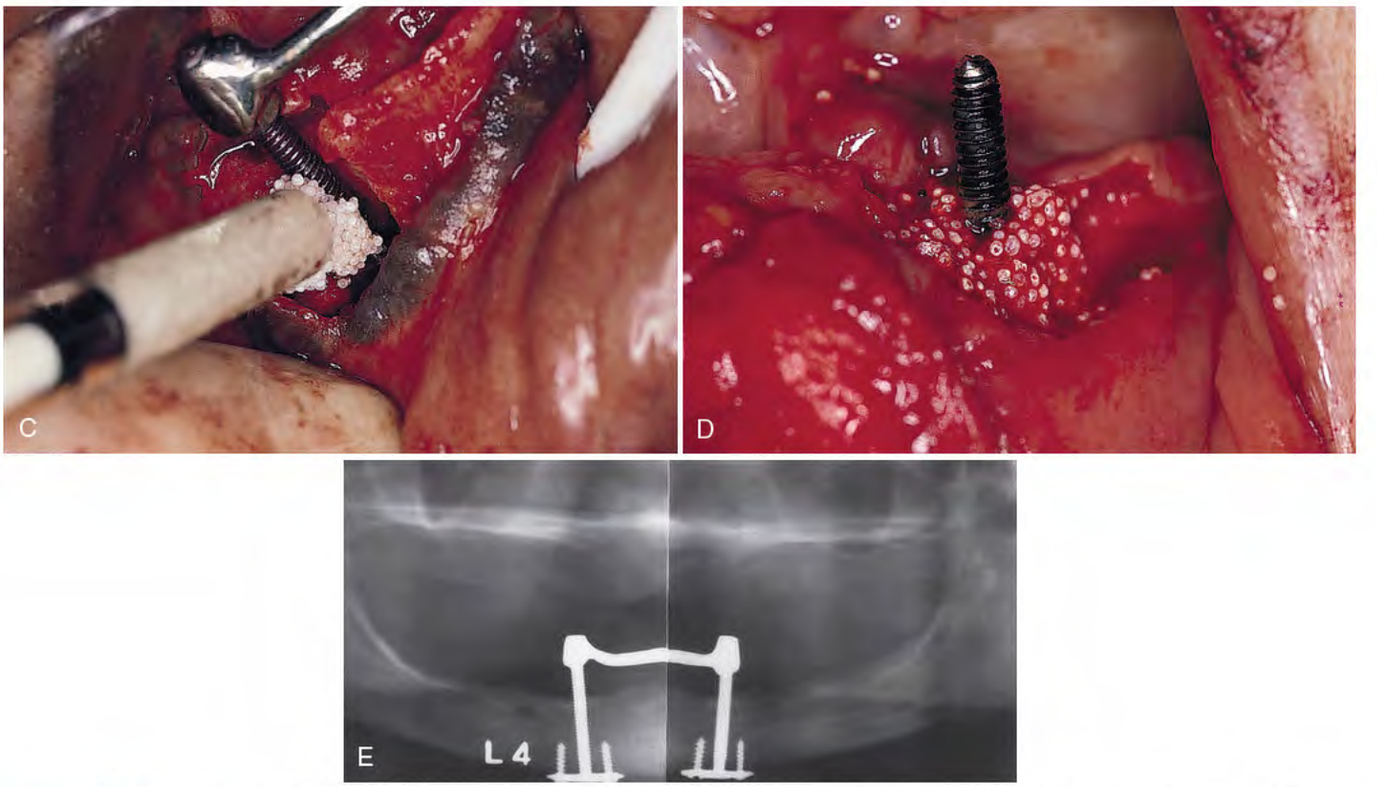


FIGURE 28-43, cont'd. **C,** Hydroxyapatite (HA) in saline is dispensed accurately with a syringe. **D,** The particles become stabilized by allowing fibrin to serve as a cementing medium. **E,** The postoperative x-ray film indicates a much-improved support mechanism for these transosteal implants.

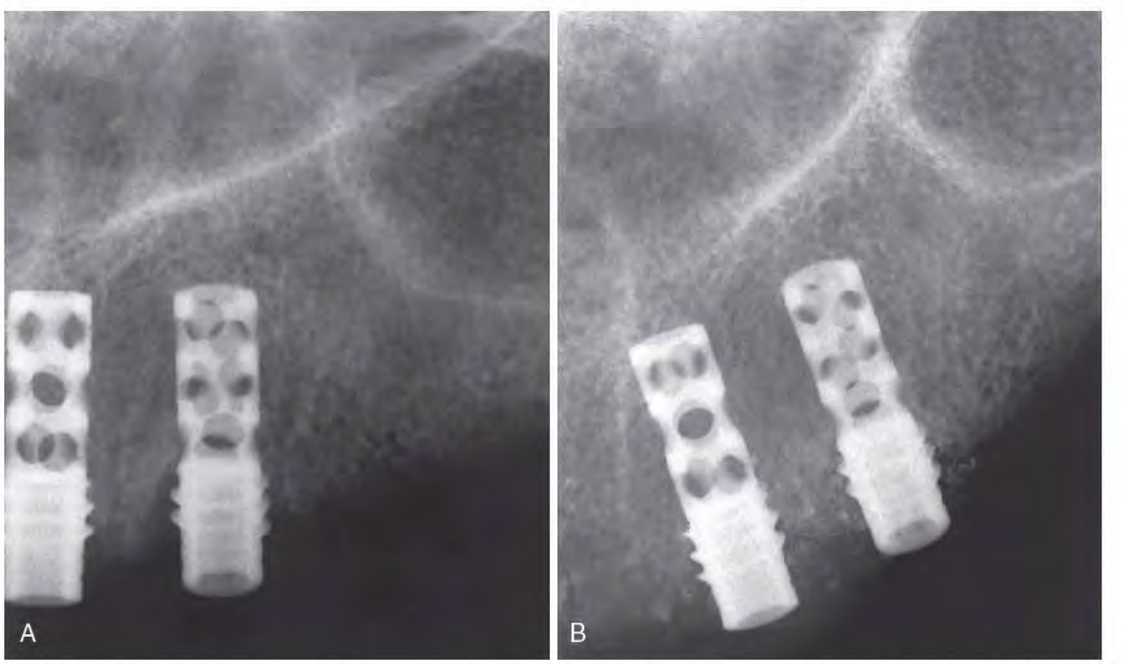


FIGURE 28-44. Preoperative **(A)** and postoperative **(B)** radiographs of two Core-Vent implants repaired with hydroxyapatite (HA) in a classic periodontal manner.

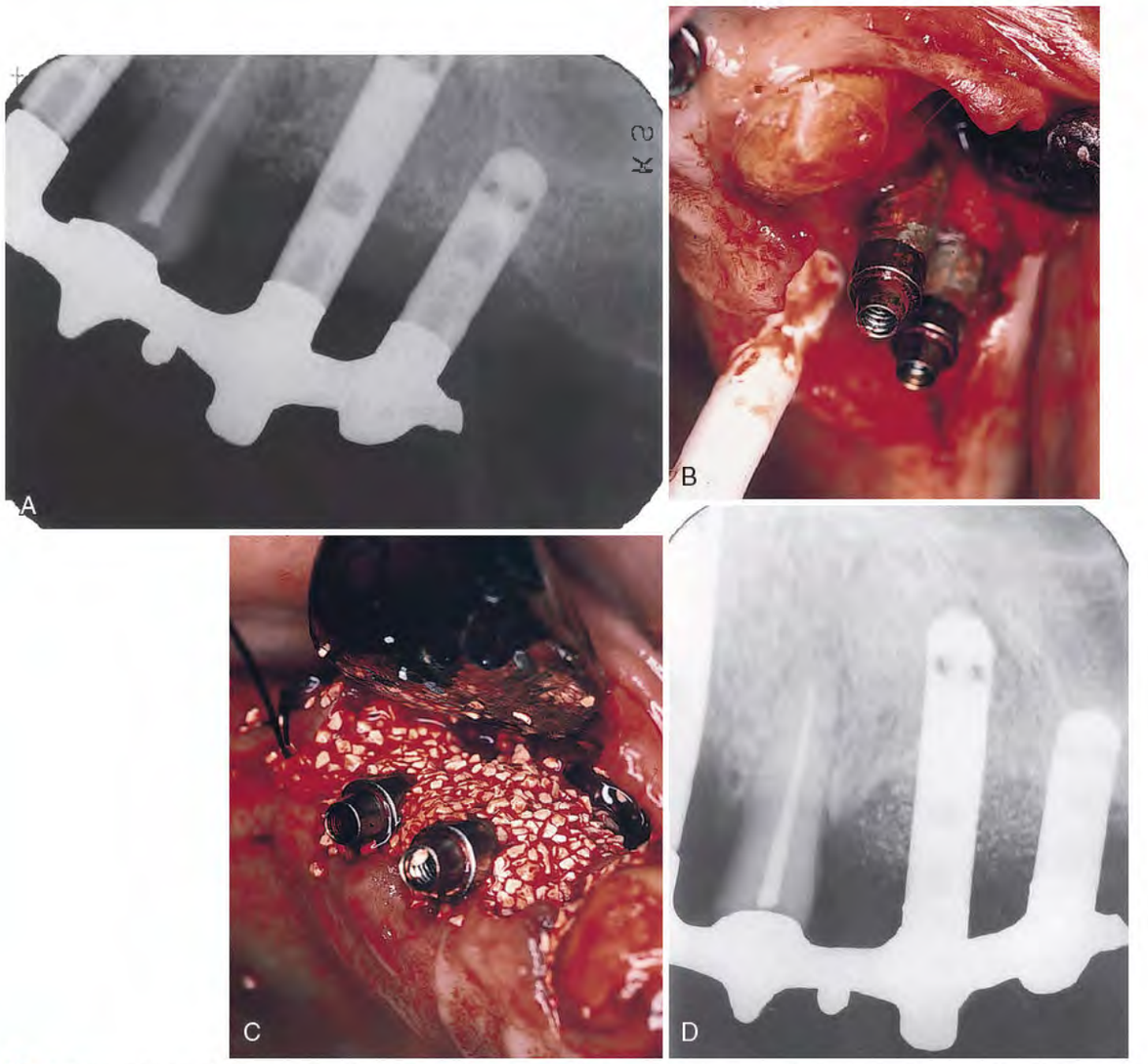


FIGURE 28-45. **A,** This radiograph shows significant bone loss around Integral implants coated with hydroxyapatite (HA). **B,** A generous, well-vascularized flap is elevated as an introduction to treatment. The HA coating is removed with an ultrasonic tip. If no sign of active infection is seen, citric acid treatment can be used. **C,** Particulate HA in an autogenous blood slurry is used as a graft material. **D,** A postoperative radiograph shows an improved environment.

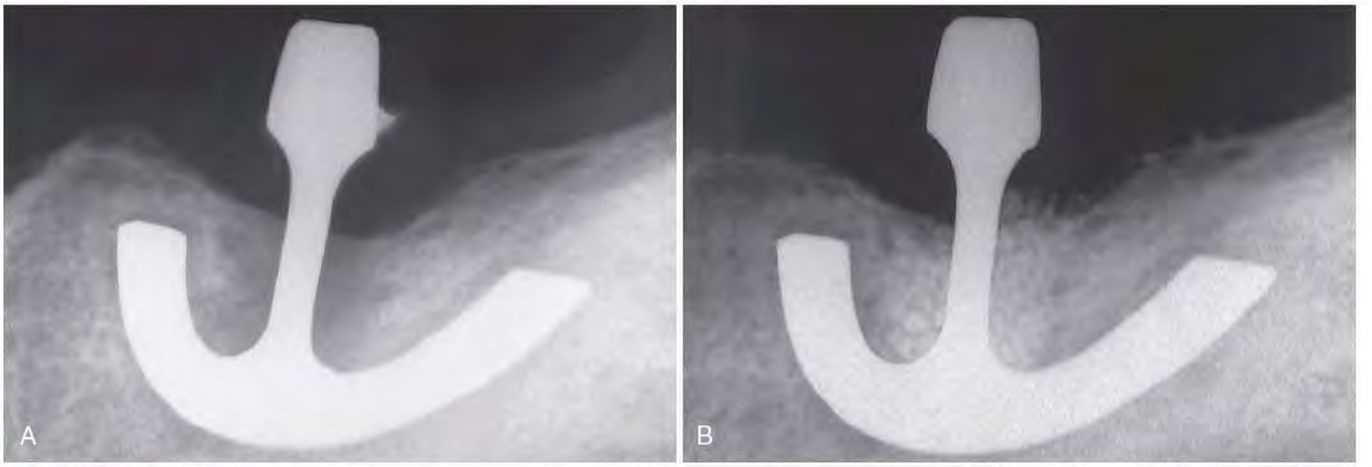


FIGURE 28-46. **A,** After 17 years, a chrome alloy anchor implant has a saucerization defect. The shoulderless infrastructural design made maintenance and repair viable alternatives to removal. **B,** Postoperatively, the graft has successfully contributed to further function of this anchor implant.

coating is not removed. Instead, the local environment is exposed to citric acid for 5 minutes, followed by irrigation, grafting, and closure. Again, the treated implant is taken out of function by removal of the abutment and substitution with a healing screw, which contributes to the stabilization of a mandatory membrane if managed in a poncho design.

Locally Applied Antibiotics: Arestin and Atridox

Shallow pockets, which must be debrided with plastic or gold-plated curettes, can be treated effectively with a sustained-release, highly concentrated, locally applied form of doxycycline. These locally applied antibiotics (LAAs) are available as a powder (Arestin [minocycline hydrochloride, 1-mg microspheres]) or a gel (Atridox [doxycycline hyclate 10%]). LAAs kill the most common pathogens associated with periodontal disease and with their unique drug chemistry, maintain therapeutic drug concentrations for up to 21 days.

Using these forms of antibiotic, which are placed and allowed to remain within the peri-implant, can significantly reverse symptoms. After the pockets have been curetted, the bleeding is stopped (e.g., with racemic epinephrine cord), and the areas are isolated and dried. The LAAs are injected into each pocket firmly and to their full depths with a plastic instrument or another instrument of choice. The pockets should be filled to the top, and the antibiotic material should be allowed to protrude if a shallow portion of a pocket forces this to occur.

After placement is complete, cyanoacrylate (Crazy Glue) cement is applied for stabilization with a tiny, disposable, plastic-tipped applicator. The therapeutic plastic filaments must remain in place for at least 7 days, and preferably for 10. Reapplication every 3 to 9 months and maintenance of oral health often solve the problem of chronic infection.

Prosthetic Management of Implant Loss

The loss of one or several implants requires a change in prosthetic strategy. First, the status of the newly acquired support mechanism is assessed. The options are to shorten bars, eliminate cantilevers, or change the locations of ERAs, O-rings, or other retentive devices from terminal bar positions to pier or intraimplant locations. If bars are retrievable, these changes can be made in the laboratory with the assistance of pickup impressions. Cemented bars may require the use of a pneumatic, reverse hammer, crown remover.

As an alternative, implants can be retrofitted into existing coping or crowns. This may be a departure from the impeccable prosthodontic practices demanded by implantology, but experience has shown it to be an effective technique. The coping bar, hybrid prosthesis, or fixed bridge is removed, the failed implant is lifted from its crypt, and the surrounding granulomas are completely resected. If the residual site reveals healthy, bleeding bone and sufficient dimensions in width and length to satisfy the 40% rule (see Chapter 12), an immediate replacement implant is inserted, grafting is performed, and closure completes the process. Such replacements should be threaded, and they should be the maximum height and length permitted by the host site. After 3 to 6 months for osseointegration, stage two surgery is performed. This allows the fixation of a three-piece, angled abutment (see Chapter 22).

Collared abutments (e.g., Zimmer) allow 18 different angulations, one of which should allow retrofitting into an existing crown or coping. Some diamond point alterations of the abutment may be required to bring it into conformation. Also, a fixed-detachable unit made for it can be torqued into place after the old unit is removed from the prosthesis and a classic dental floss or GC Pattern verification-type assembly has been performed, leading to soldering of a new superstructure.

If immediate support is required after a tooth or implant is removed from beneath a conventional fixed bridge, the occlusal surface of the crown is cut away completely, the bridge is placed in position, and the crown is used as a surgical template for accurate seating of a replacement implant. If 40% or more of the implant can be seated in freshly cut bone, the voids are grafted with autogenous bone from the tuberosities or elsewhere, and a straight or angled (if needed) tapered abutment is placed; with adjustment, this abutment should fit into the existing crown. The reconstruction is completed with a composite lining and cementation with a filled composite resin.

Fractured Root Form Implants

Infrastructure fracture has been reported with all types of root form and blade implants. The most common area of fracture is just below the abutment level (Fig. 28-47). Usually, the remaining apical portion is osseointegrated and should be left behind when the fractured elements are removed. If replacement of such an implant is the intention, removal of the remaining apical implant segment requires an aggressive and traumatic en bloc osteotomy. This is followed by repair with a grafting material and a 6-month period of observation before placement of a new implant is undertaken.

Improper Angulation of Implants: the Double-Bar Technique

The problem of angulation may have been anticipated at the time of surgery; however, usually not until the try-in stage of the prosthetic reconstruction does it become manifest (Fig. 28-48, *A*). This problem can be solved with a double-bar technique. The laboratory should be instructed to obtain three screw attachments from Attachments International or the European company Cendres & Metaux, S.A (Ors Dentaires, Biel Bienne, Switzerland).

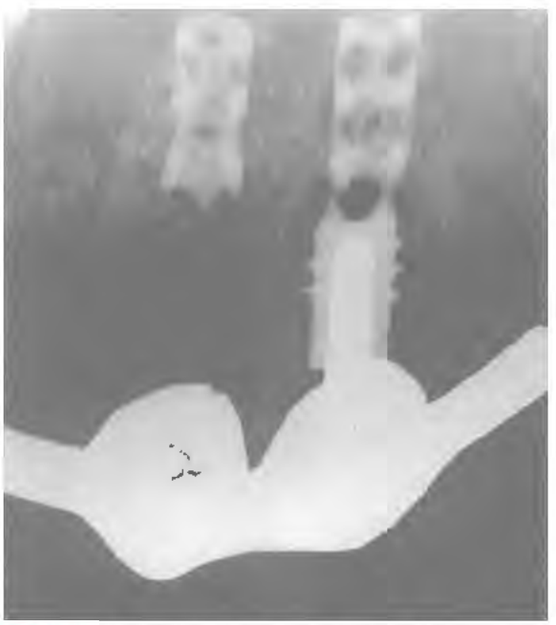


FIGURE 28-47. Some root form implants may fracture because of design or manufacturing problems, poor prosthetic engineering, bruxism, or trauma.

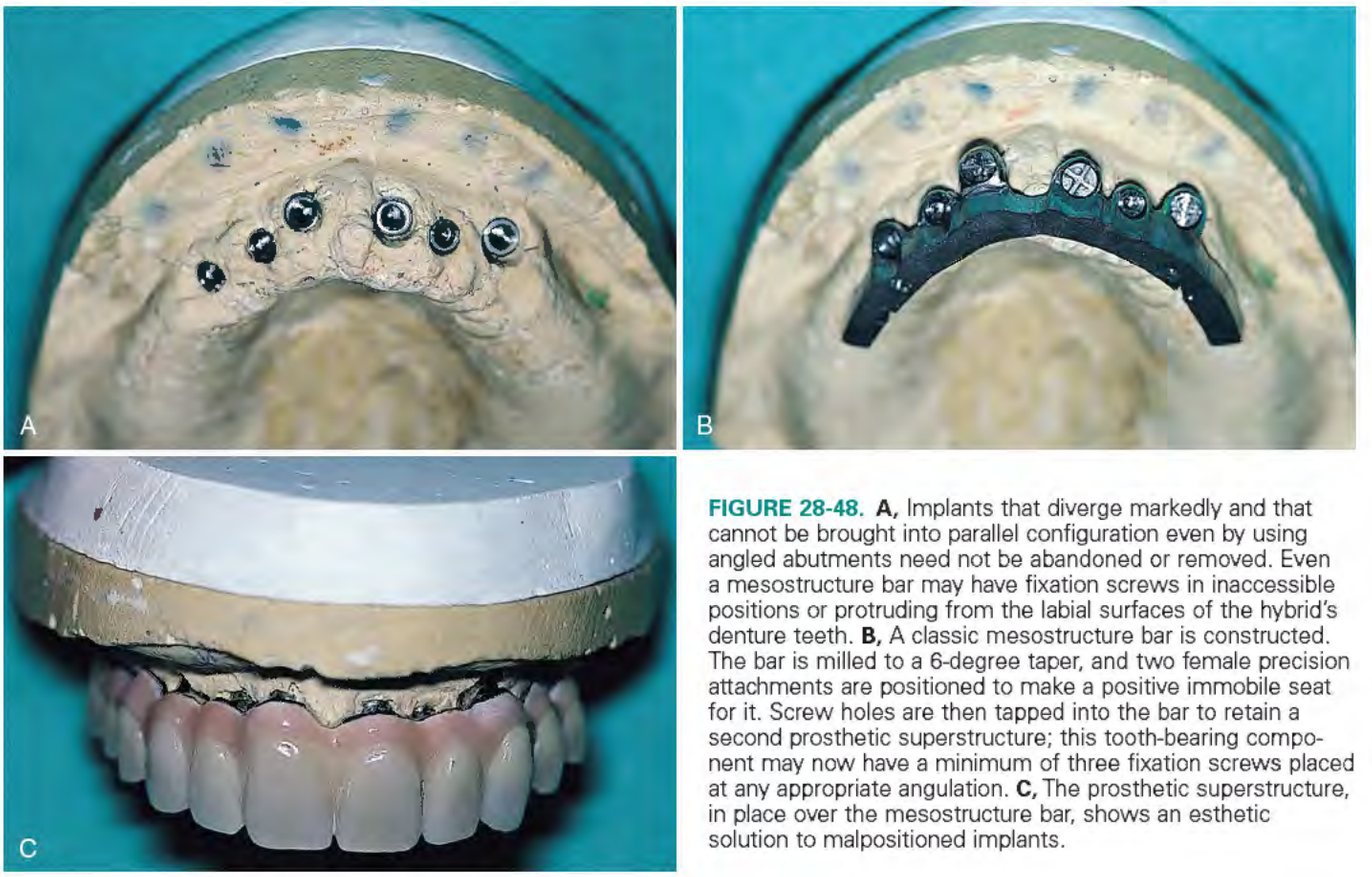


FIGURE 28-48. **A,** Implants that diverge markedly and that cannot be brought into parallel configuration even by using angled abutments need not be abandoned or removed. Even a mesostructure bar may have fixation screws in inaccessible positions or protruding from the labial surfaces of the hybrid's denture teeth. **B,** A classic mesostructure bar is constructed. The bar is milled to a 6-degree taper, and two female precision attachments are positioned to make a positive immobile seat for it. Screw holes are then tapped into the bar to retain a second prosthetic superstructure; this tooth-bearing component may now have a minimum of three fixation screws placed at any appropriate angulation. **C,** The prosthetic superstructure, in place over the mesostructure bar, shows an esthetic solution to malpositioned implants.

Each attachment is made in three parts: (1) an internally threaded cylinder or tube, (2) a smooth cylindric collar, and (3) a fixation screw. The three internally threaded cylinders (part 1) are affixed to the original malposed superstructure bar in positions that are angled lingually to allow esthetic placement of the fixation screws. In addition, they are placed as far from each other as possible and not in a straight line, so that optimum support and stress distribution is encouraged. When the positions and angulations appear acceptable, these three threaded tubes are soldered to the bar (Fig. 28-48, *B*).

The next step is to have the laboratory transfer the location of these threaded tubes to the underside of an acrylic resin or cast metal second superstructure that is fitted onto the original bar, which now bears the threaded tubes. Holes are made that pass through this second superstructure, each one directly over one of the threaded tubes. The smooth cylindric collars (part 2) are processed into these holes with acrylic or solder, depending on whether the material chosen for the second bar is a polymer or a metal. At this point, the original cast bar is seated on the implant abutments in the normal manner and screwed into place, making sure that the screw heads are flush with the bar. Next, the second superstructure bar is placed over the first one, and the new fixation screws (part 3) are used to attach it through the three attached collars into the internally threaded cylinders now on the original bar.

If the severe lingual angulations do not allow the use of a conventional screwdriver, an offset screwdriver can be made by machining a No. 8 round, latch-type bur and using it in a contra-angle. It is turned by rotating the spindle at the top of the handpiece.

If this technique is to be used with the Zimmer system, the titanium screw housings supplied by this company should be used. The technique is used for that system in precisely the same manner as described for the Swiss technique except that no cylindric collars are required. The housings (TSFH), which should be soldered at correct angulations to the first bar, are available with fixative screws that have large enough heads to lock the secondary bar in place through simple holes made in it. If the second-bar option is chosen, acrylic is preferable to cast metal, because it is lighter in weight, less costly, and more forgiving with regard to fabrication and repair (Fig. 28-48, *C*).

Broken Prosthetic Inserts

Root form and submergible blade implants have three types of abutments: threaded, cementable, and frictional. If an internal flaw in the cervix occurs because of abuse (e.g., bending more than 20 degrees, overbending and straightening, or moving the pliers too sharply), or an abutment fractures at the implant body level because of metal fatigue, the fractured insert may have to be retrieved so that another can be placed (Fig. 28-49).

If a threaded implant is fractured, which occurs far less frequently, a half-round bur is used to cut a groove into the superior surface so that a screwdriver can be used. An instrument handle is machined into a screwdriver of the proper width and breadth, allowing the remaining broken portion of the insert to be backed out of the abutment receptacle. (Throat curtains must always been used when dealing with small parts intraorally to prevent their aspiration.) If the implant's angulation or position makes the use of a manual screwdriver difficult or impossible, a screwdriver can be machined from a large (No. 8) latch-type round bur; this can be placed in the Implant

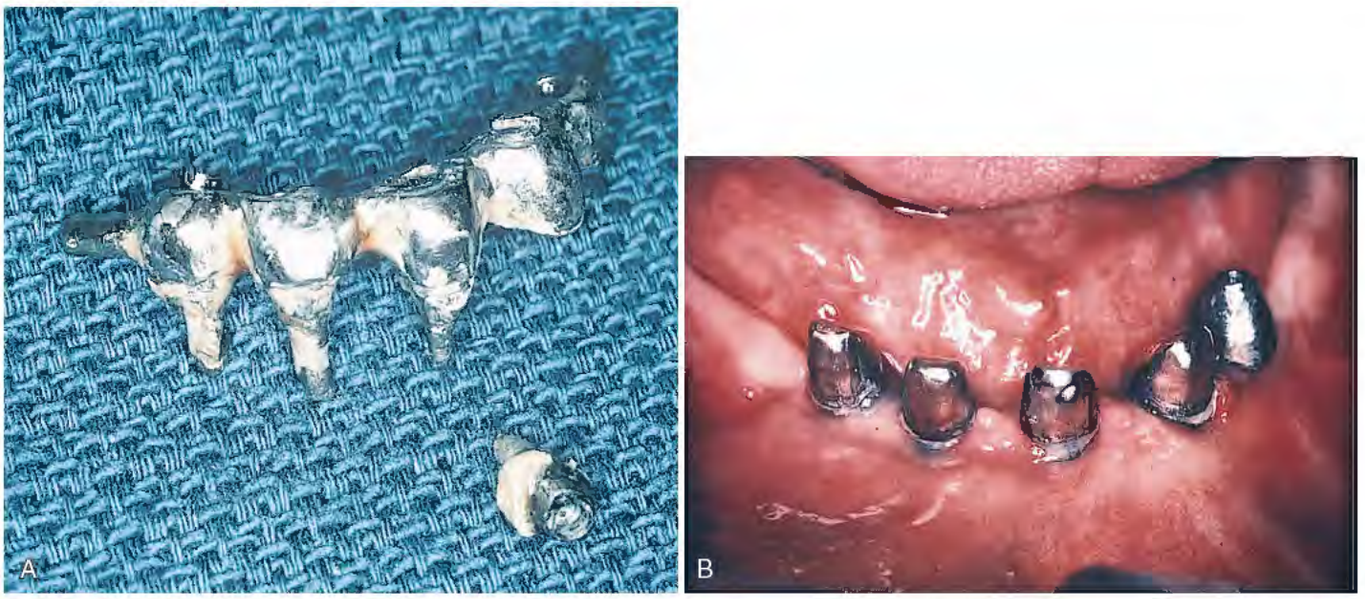


FIGURE 28-49. **A,** Fracture of cemented prosthetic abutment inserts is an occasional complication. **B,** After removal with cooled burs, direct Duralay patterns are made, cast in noble metal alloys, and cemented, and the prosthetic reconstruction is placed over them.

Innovations contra-angle, and the wheel at the back can be used to rotate the fragment out (Fig. 28-50).

Cemented or frictional cold-weld (Morse taper) types of implants present far greater problems. Residual fragments are drilled out bit by bit, using carefully directing, well-cooled half-round and 700 dentate fissure burs in the long axis of the receptacle (Fig. 28-51). After these burs, thin, tapered diamonds are used. The components of the fractured post come out a bit at a time when flushed with irrigant, finally leaving the receptacle free of metal.

Perforation of a lateral implant wall is a major problem, one that can result in a subsequent parietal abscess or fistula. Should this happen, a flap with an HA/GTRM repair becomes necessary (see bone grafting in Chapter 8). After the broken component has been removed, standard impression making procedures are performed to allow the laboratory to cast a precious metal post and core replacement. It is angulated to a position of optimum prosthetic parallelism.

Screw Problems

One of the most common problems in the postoperative period is the fracture or stripping of screws or screw housings. This can occur during manipulation or simply while the prosthesis is functioning.

Breakage of Retention Screws in Fixed-Detachable Bridges

Breakage of retention screws in fixed-detachable bridges is a common problem that can occur when distal cantilevered segments are used. As stated in previous chapters, the maximum extension of the cantilever should be 15 mm in the mandible and none in the maxilla. If the posterior extensions are too long, the retention screws may loosen or break. This happens because posterior biting forces (especially if a balanced centric occlusion is not established properly) cause nonvertical loading, which affects the anterior segment. This places shearing forces on the retention screws, leading to loosening and finally to fracture.

If the superstructure loosens repeatedly, a properly balanced centric occlusion must be established. New retention screws should be inserted. Implaseal (Lifecore, Chaska, Minnesota) can be used to coat the fixation screws. It serves as an antibacterial sealant but does not interfere with screw placement or removal. The material peels away like rubber and must be reapplied with each reseating of the superstructure.

After completion of these corrective steps with balanced occlusal forces, the result will be lighter and more evenly applied stress to the retention screws.

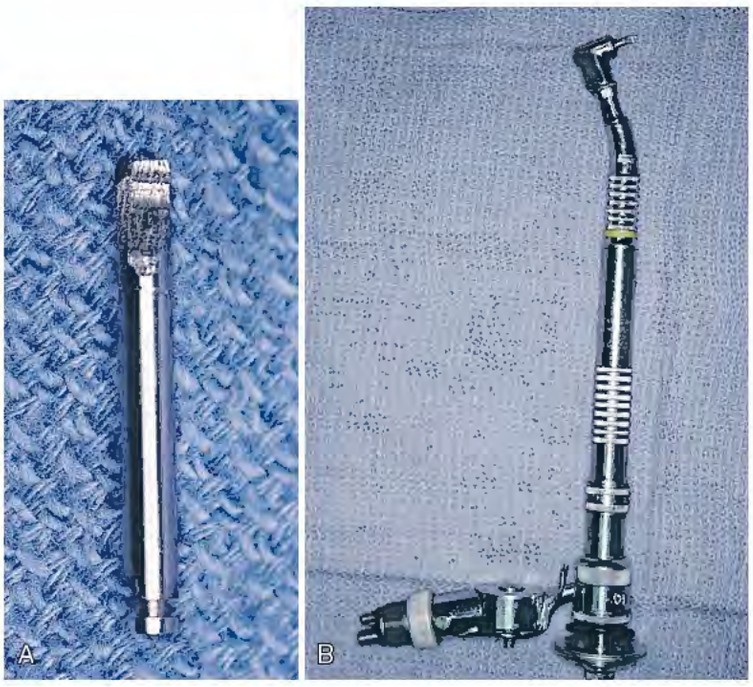


FIGURE 28-50. **A,** Some fixation screws emerge at angles that make them inaccessible to a straight screwdriver. A No. 8 latch-type contra-angle round bur is machined into an offset screwdriver tip. **B,** When placed in the handpiece or contra-angle, it is used to engage the screw slot. Rotation is achieved by turning the wheel manually in a counterclockwise direction. In cases of a fractured threaded abutment, a one-half round bur is used to cut a slot in the screw's superior surface. The machined screwdriver is effective for backing such posts out of their implants.

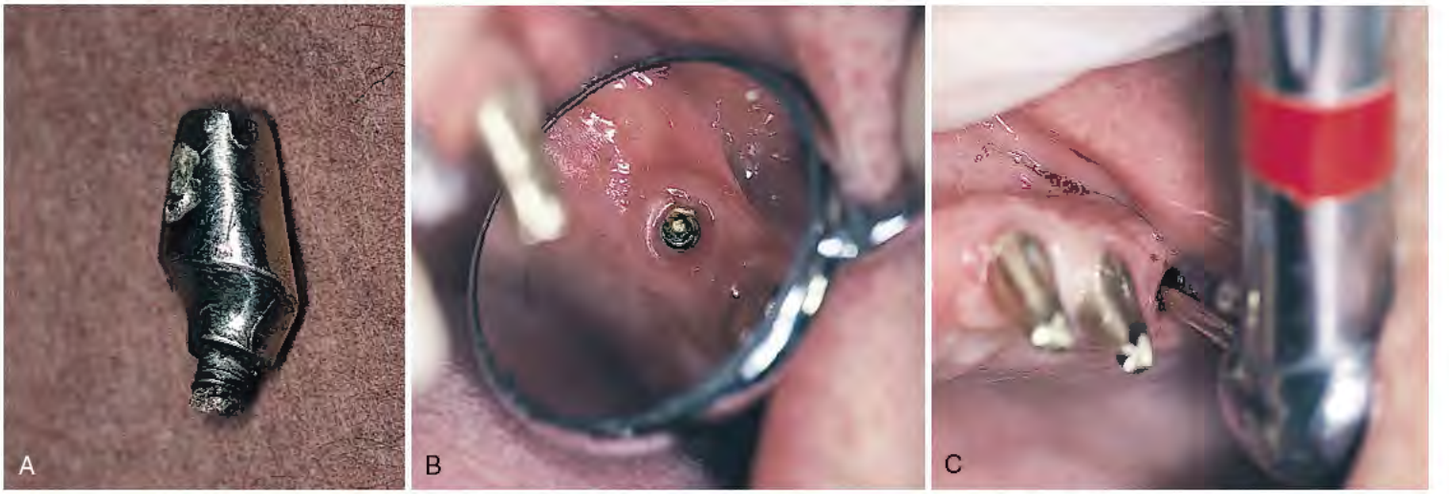


FIGURE 28-51. **A,** Threaded abutments can fail because of fatigue. **B,** If their remnants cannot be backed out with a screwdriver, they must be drilled out. **C,** Drilling can destroy the thread pattern; if it does, cementable castings must be made using classic impression techniques.

Broken Screws

If a screw fractures in the interior of an implant, the superstructure is removed, and without damaging the internal threads, a groove is cut into the top of the residual screw fragment. To retrieve the fragment, a ¼-inch round, high-speed, water-cooled bur in the Impactair is used to scribe a horizontal groove into the top of the residual shaft. Then a small, compatible screwdriver is used to back off the fractured segment (Fig. 28-52).

Stripped Implant Threads

Excessive manual effort sometimes results in stripping of a threaded interface. If this occurs, an attempt should be made to introduce a new screw. If this is successful, it indicates that the screw threads had failed. If the replacement screw fails to bite, the fault lies in the implant's core. Each company manufactures a screw threader for recutting the internal threads in an implant. These tapping tools, which are made of hard carbon steel, are used manually and work efficiently and predictably. Screws of the same diameter as the tap are supplied to return the retention mechanism to its preincident condition.

When all else fails, the final alternative is to treat the implant as if it were a natural tooth, prepare it for a post and core, and fabricate one of precious metal. However, casting cannot be done until the abutment is retrofitted into the lubricated original crown with GC Pattern. After it is completed, the new abutment is cemented into the implant, and the prosthesis resting over it is cemented as well.

Fabrication of an Implant-Borne Temporary Prostheses

Occasionally, a fixed-detachable bridge may need to be sent to the laboratory for repair after it has been in use. A composite facing may have fractured, occlusal wear may have occurred, or a metal junction may need to be soldered. The temporary prosthesis the patient wore during fabrication of the fixed-detachable bridge should have been retained. If it was not, a new one must be fabricated.

To do this, a well-extended alginate impression of the arch is made with the prosthesis in place, using a stock tray modified with periphery wax. The impression is poured with quick-setting stone. If sections of teeth are missing from the resultant model, they are restored with wax or denture teeth. A two-sheet thickness of pink base plate wax is placed on all the uncovered tissue surfaces of the model (e.g., palate, alveolar crest not covered by prosthesis), the model is soaked for 5 minutes in cold water, and an impression of it is made in alginate. The impression is poured in quick-setting stone.

When the stone has set, the model is trimmed, and an Omnivac form is made over it using a 0.016-inch thick, clear sheet. It is trimmed so that the plastic just grasps the art border. Next, a heatless stone is used on the first model to reduce the height of the teeth to 4 mm. In addition, 2 mm is trimmed from the facial surface of each tooth. The model is lubricated thoroughly with a separating medium.

The teeth in the Omnivac form are filled to three-fourths level with tooth-colored acrylic (or tooth-colored Triad material), and all other areas are covered with pink denture base acrylic or Triad polymer. The Omnivac is seated onto the altered, lubricated model until the shell moves fully into place. The acrylic is polymerized in a curing unit. The Omnivac form and newly fashioned denture are removed from the model, trimmed in the patient's mouth, and relined with Coe-Comfort or Viscogel for retention over the bar or implants (Fig. 28-53). As an alternative, it can be screwed into place by opening two or three holes corresponding to the locations of strategically placed implants. The occlusion is adjusted, and the patient is instructed to follow a meticulous oral hygiene regimen.

Fractured Mesostructure Bars

Preinsertion bending, poor structural integrity, overly long spans, insufficient implant support, loss of integration of an abutting implant, or excessive occlusal trauma can cause a mesostructure bar to fracture.

If the bar is the fixed-detachable type, the implant surgeon should remove it, take an index, and repair and reinforce the bar. If the etiology is known (i.e., long span, lost implant support, thin bar), steps must be taken to institute correction. The modified bar is then reinserted.

Cases of cemented coping bar fracture or partial loss of cementation can be managed using a unique, simplified, chair side procedure.

Intraoral welding produces virtually no heat and creates firm, reliable unions on titanium and its alloys. Such welds resist the most significant challenges. Ingenuity, a welding machine (Hruska/Rome),

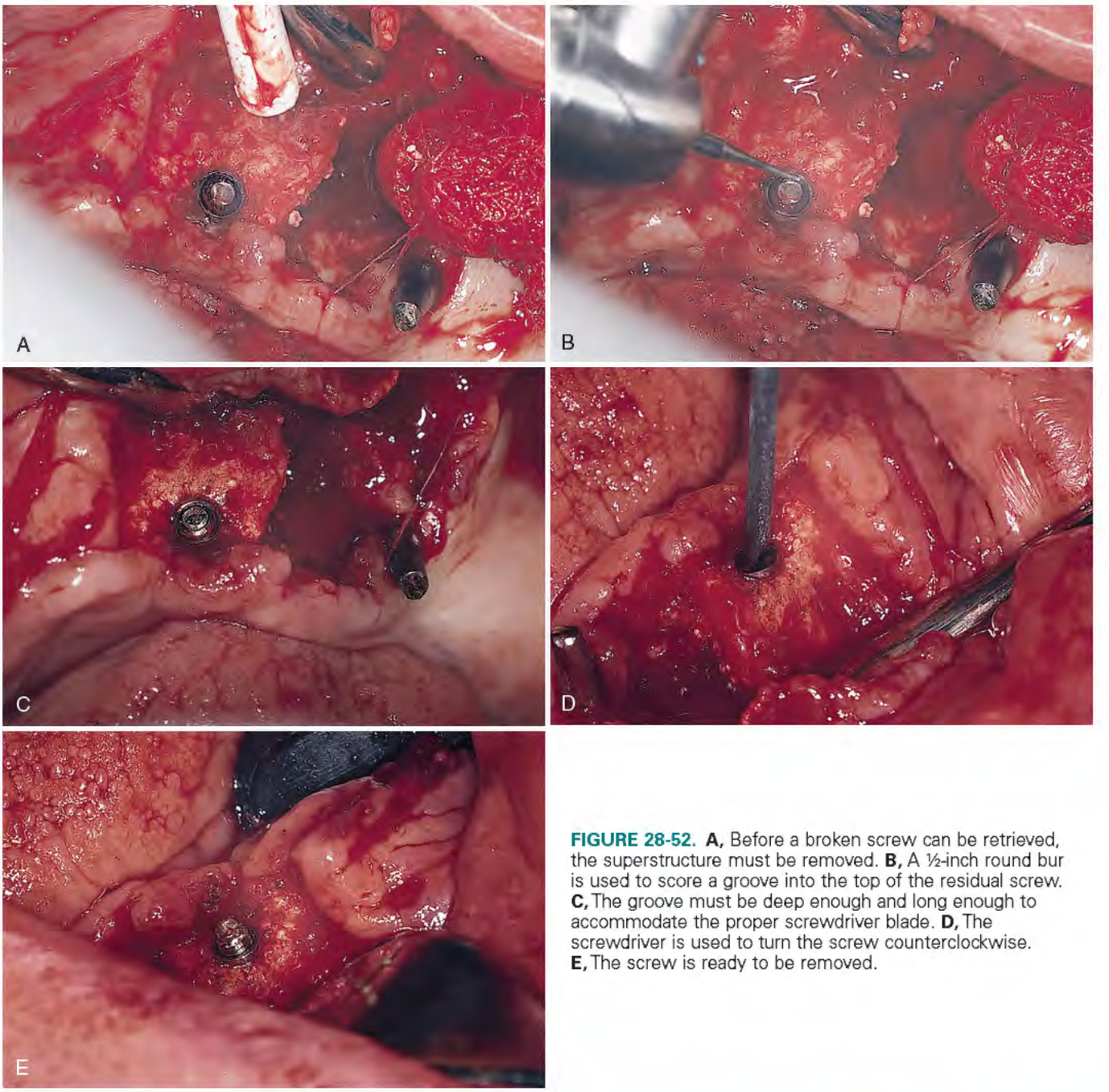


FIGURE 28-52. **A,** Before a broken screw can be retrieved, the superstructure must be removed. **B,** A ½-inch round bur is used to score a groove into the top of the residual screw. **C,** The groove must be deep enough and long enough to accommodate the proper screwdriver blade. **D,** The screwdriver is used to turn the screw counterclockwise. **E,** The screw is ready to be removed.

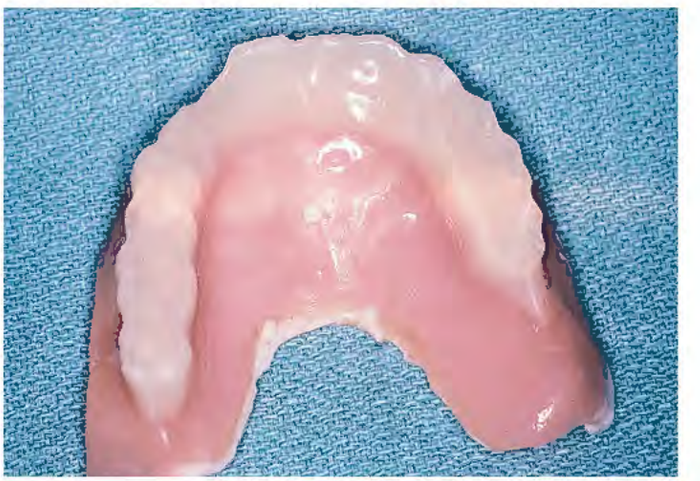


FIGURE 28-53. If removed for repair, a fixed prosthesis can be replicated with the Omnivac-Triad systems in white and pink acrylic, and the replica can be used as a temporary denture. After removal from the flask, it must be finished and polished, and screw holes must be placed for transitional fixed-detachable application.

and CP titanium half-round rods of varying dimensions are the armamentaria required.

The loosened or broken titanium copings are removed by cutting the bar, which releases the copings from the still-cemented section. A torque-free repair bar segment should be bent to the required contour of the fixed section. The Electrodex, which is handheld, serves as a clamp holding the bar to the titanium abutment. By the mere touch of a button on the console, a weld is achieved. The most successful welds are accomplished on broad, surface-to-surface relationships rather than by simple point contacts.

As the practitioner gains experience with intraoral welding, a wider variety of uses becomes apparent.

Partial Loosening of Cemented Bars or Prostheses

Although the benefits of cementation are many, its major disadvantage is the difficulty of retrieval. Bar removal must be possible in case porcelain or composite material fractures, a solder joint breaks, or a substructure problem arises (e.g., implant infection or bone loss).

Unswerving advocates of cementation argue that the bar strategy was the accepted technique for affixing prostheses to natural teeth and that it has served satisfactorily for decades. The worst solution to that scenario, if reverse hammer tapping failed, was to make bur cuts in the facial surfaces of the crowns and to use Weidelstadt chisels as levers to spring them off. Of course, a new prosthesis is then required.

Two possible remedies might be considered as substitutes for this draconian measure.

- The loosened segment is removed by sectioning with ultrathin Carborundum disks, and the crowns on either side of the removed segment are prepared with diamonds to receive new crowns. Impression making is routine, and the newly constructed segment with its telescoping abutments can be cemented. Before this is done, however, the cause of the original cement failure should be sought. If the etiology was poor occlusion or a destructive patient habit, these must be eliminated before the replacement segment is cemented.
- An effective, pneumatic reverse hammer attached to the handpiece coupling has been shown to remove even the most recalcitrant cemented prostheses. However, thought must be given to its use with regard to damage to support structures, fracturing of abutments or their screws, or splitting of implants. Once the practitioner becomes comfortable with the uses of the pneumatic reverse hammer, it presents an additional tool of great benefit for trouble-shooting.

Inaccurate Fit of Castings

The number of complicated steps in impression making that must be completed chair side, such as the fabrication of special trays, the dental floss/composite intraoral assembly of impression copings, the removal of implants by backing off screws followed by seating into an impression (further threatened by the pouring and separation processes), often results in inaccuracy of the fit of multiple unit castings. When these castings (whether hybrid bars or crowns) are designed to key into antirotational devices (spline or hex), the precision demanded to create flawless interfaces virtually defies first-round acceptance.

Consequently, passive fit is commonly achieved by subsequent verification strategies. The technique (see Chapter 22) involves separating the noncompliant units on the master cast, transferring them to the actual implants intraorally, and reassembling them with a stable polymer and a dental floss matrix. Achieving the demanding requirement of flawless fit requires patience and persistence.

Fractured Blade Abutments

One-piece blade implants usually are made of pure titanium and are designed to be bent (see Chapter 12). However, overstressing, coupled with chewing forces and the galvanism caused by the dissimilar metals of a fixed prosthesis, can cause cervical fractures. Another common cause of fracture is cement loss beneath the abutment of a natural tooth in a bridge that shares natural and implant abutments. Attempts to tap the bridge from the still firmly cemented implant abutment often cause this problem. This maneuver should be used only after great consideration. As a safe alternative, a slot can be cut in the cemented crown, allowing the bridge to be sprung free easily with a small operative chisel. If a cervical fracture of a blade implant occurs despite the most cautious approach, but the infrastructure is firm and well embedded in healthy bone (Fig. 28-54, *A* to *B*), the residual portion can be reconstructed.

To replace a fractured abutment, a crestal incision is made, and the bone overlying the buried shoulder is exposed. A No. 2L round bur with coolant is used to brush the bone away, exposing the shoulder for a distance of 4 mm mesial and 4 mm distal from the fracture site. That portion of the shoulder should be made accessible facially and lingually by removing bone from beneath it to a point 3 mm beneath its inferior border. A segment of shoulder 9 mm long with a 3-mm opening beneath it should now be visualized (Fig. 28-54, *C*). Complete hemostasis must be achieved. Raccord is effective (but must be used with care in a hypertensive or epinephrine-labile individual), but tamponade works well, using time and patience. When the area is dry, an Impregum impression of the site is made using a syringe and sectional tray technique. A wax bite and counterimpression also are necessary. Periodontal packing (e.g., Coe-Pak) is placed beneath the exposed shoulder and pressed into the bony cavity. The excess material is molded around the bar. The remainder of the incision is sutured mesially and distally.

The laboratory should be instructed to make a centrifuged epoxy model (for strength and accuracy) and to cast a double-leaved abutment in gold using the Whaledent SMS (Splint-Mate), nonparalling, horizontal pin system, which can rivet the two leaves together. The two leaves, when pressed together, embrace the exposed bar accurately, with each having a concave depression designed to fit over its half of the bar. The threaded leaf component must be the lingual one, and the rivet head side must be the buccal. Ideally, four threaded pins should be used, two above and two below the bar.

At the second or insertion procedure, the Coe-Pak is removed, revealing the segment of shoulder now exteriorized. Healed epithelium should be seen beneath it. The newly cast abutment's two halves are placed on each side of the bar, and with the assistant clamping them together with a heavy, curved Carmalt forceps, the accuracy of alignment of the four holes is tested using threaded SMS pins. Because the pins' handles are color coded, they should be aligned in the same order on the bracket table.

The field is isolated and dried, and the two components are joined with glass ionomer cement. Before the cement sets, all four pins are fully threaded into place and each is covered with a swipe of cement, locking and riveting the two leaves together. After setting, both protruding ends of each pin are trimmed and excess cement is removed. The result is a new abutment that can serve as a fixed bridge retainer (Fig. 28-54, *D* to *F*).

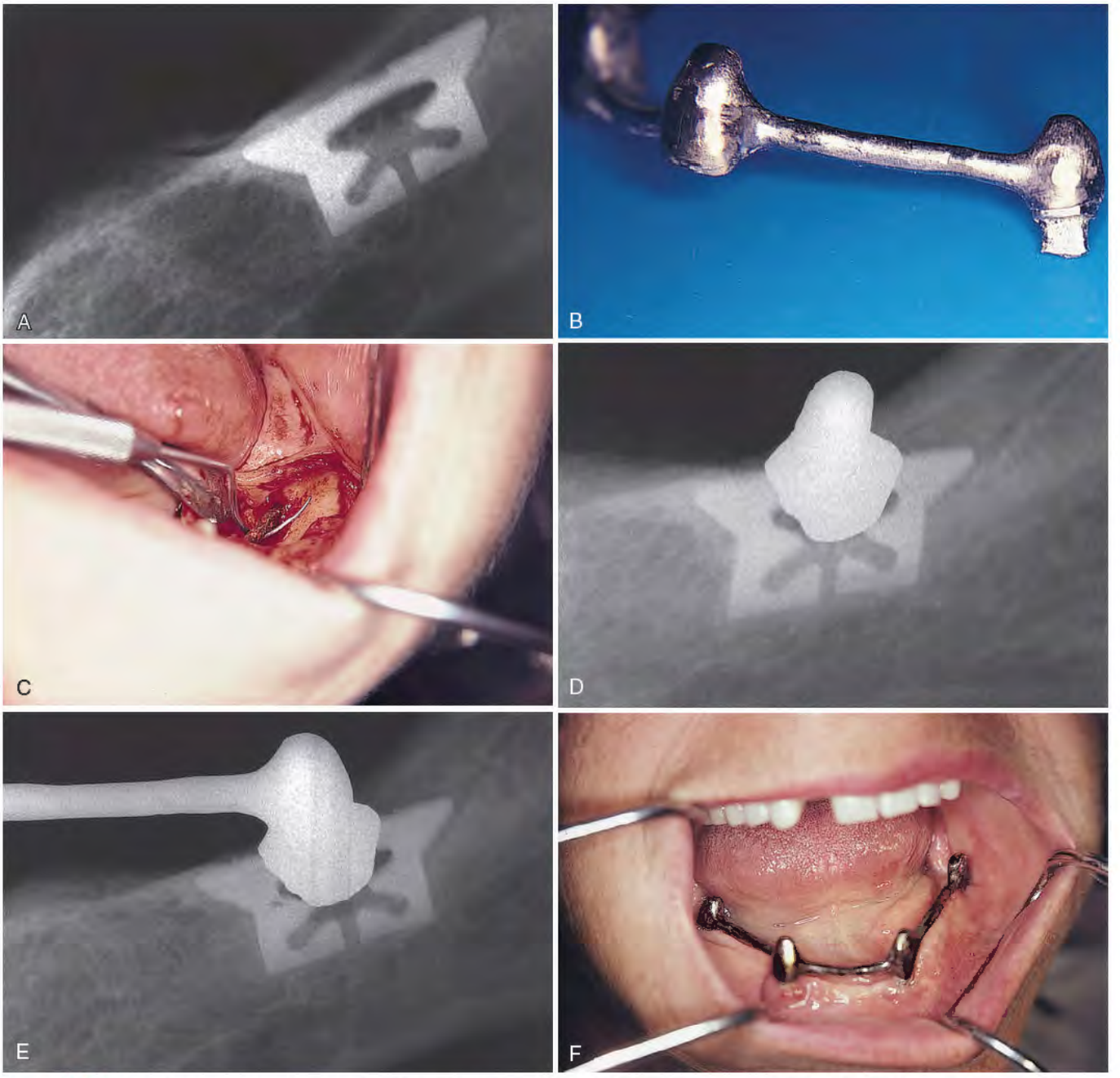


FIGURE 28-54. **A,** A 16-year-old blade implant fractured at the cervix. **B,** It had served as the distal abutment for a coping bar–overdenture reconstruction. The bar and fractured abutment are shown here. **C,** The shoulder of the integrated blade had to be exteriorized. After this was done, an explorer could be passed beneath it. **D,** The new abutment, consisting of twin, separately cast leaves, was affixed with SMS screws. This radiograph shows the reconstruction. **E** and **F,** Six-year postoperative radiograph and photograph of the repaired implant with a functioning bar and overdenture.

Subperiosteal Implant

Bone Resorption

Problems with subperiosteal implants most often occur after a considerable period of time. Generally, they are related to bone loss beneath the primary struts in the posterior components. However, in some cases (particularly in women), resorption can occur almost anywhere at almost any time, even as soon as 12 months (Fig. 28-55). If the involved areas are modest in size, the patient should be informed, and these areas should be tracked with standardized radiographs. If the areas do not change significantly and remain symptom free, they should be kept under observation. Progressively enlarging lesions or those that cause pain, granulomatosis, or swelling should be treated aggressively. They are managed by making crestal incisions and tissue reflections as if removal of the implant were planned.

The next step is arduous and requires great patience. Using a BP No. 12 blade on top of (or just alongside) the involved struts, the implant surgeon incises the enveloping fibrous tissue. It is tough and, fortunately, avascular. It often camouflages the struts, therefore gentle stroking with sharp No. 12 blades must continue as if following a road map of struts. As they are revealed, the position and depth of the connective tissue that must be removed can be clarified, and the radiographic components can be coordinated with those exposed surgically.

Using a combination of sharp periodontal curettes and knives, fresh No. 12 blades, and fine (mosquito or tonsil) curved hemostats,

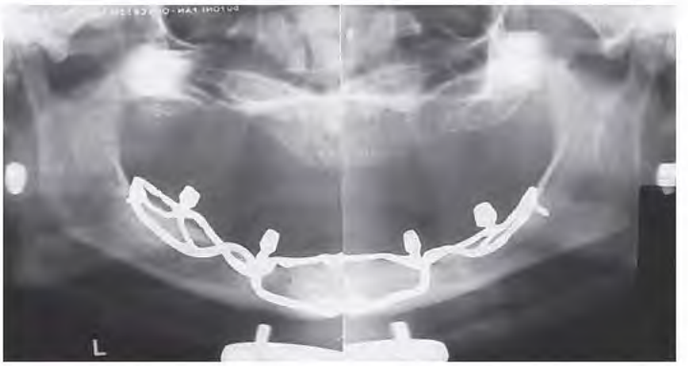


FIGURE 28-55. Radiograph showing bone loss beneath the posterior abutments of mandibular subperiosteal implants, a condition that occurs more frequently with designs that do not use a Brookdale bar.

the involved portions of the infrastructure eventually become completely stripped of the fibrous envelope. This is done to part of an implant or to an entire implant, one section at a time. After the infrastructure has been exposed, a syringe of 20-mesh DFDB or HA, moistened with the patient's blood or platelet-rich plasma (PRP), is used to place the particles under each strut, filling in the voids over the bone. The struts are covered with additional material. The operation is completed with a closure using 3-0 Polysorb or Biosyn in a continuous horizontal mattress suture configuration (Fig. 28-56).

Strut Dehiscence

Tissues sometimes shrink away from a strut after a considerable period of time. This occurs most often in the lingual posterior area of the mandible because of mylohyoid muscle activity and underlying bone resorption. The best cure is prevention; that is, by avoiding the placement of struts that lie in the mylohyoid region. When it does occur, if the patient has no symptoms, the patient should be taught to keep the strut clean with gentle abrasion using a firm wooden-stick, cotton-tipped applicator. In cases that do not respond to simple hygiene, strut resection is performed after determining that a major structural component will not be sacrificed. Local anesthesia can be used for resection of a strut. The mucosa is pushed several millimeters back along the strut. A new, tapered diamond stone and copious coolant are used to make gentle strokes, allowing sectioning through the exposed metal. Smoothing the cut ends causes beneficial abrasion of the adjacent mucosa and encourages healing. Sutures need not be placed, and after epithelization, the tissues cover the remaining metallic stumps.

Recurrent Pericervical Granulomas

Buds of friable hemorrhagic tissue sometimes protrude from the pericervical gingival crevices of subperiosteal implants (Fig. 28-57). This occurs most often in the areas of the posterior abutments. The presence of this tissue is merely a symptom, not a disease, therefore curetting does not make a valuable long-range contribution. The cause should be sought; in all probability,

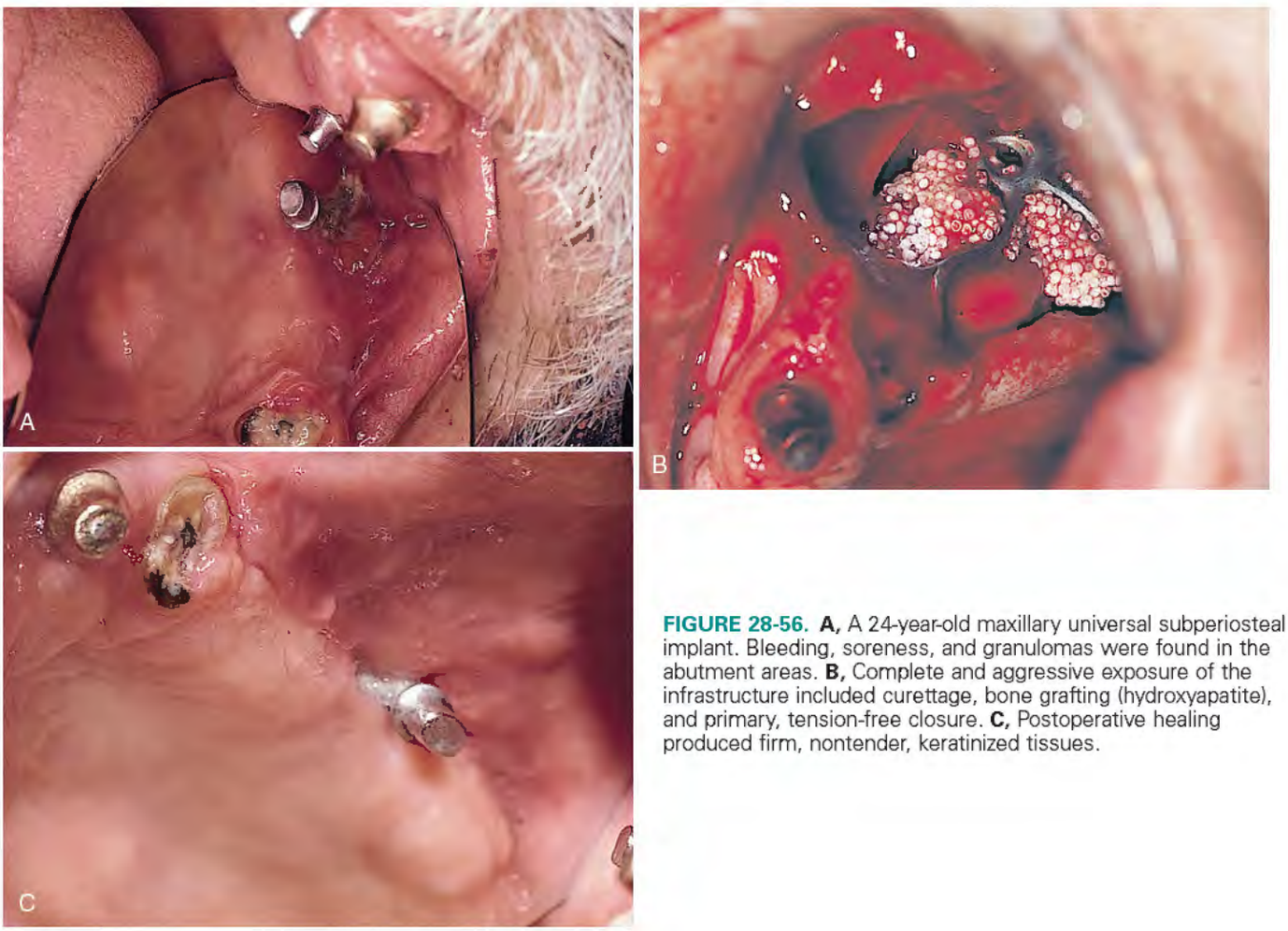


FIGURE 28-56. **A,** A 24-year-old maxillary universal subperiosteal implant. Bleeding, soreness, and granulomas were found in the abutment areas. **B,** Complete and aggressive exposure of the infrastructure included curettage, bone grafting (hydroxyapatite), and primary, tension-free closure. **C,** Postoperative healing produced firm, nontender, keratinized tissues.

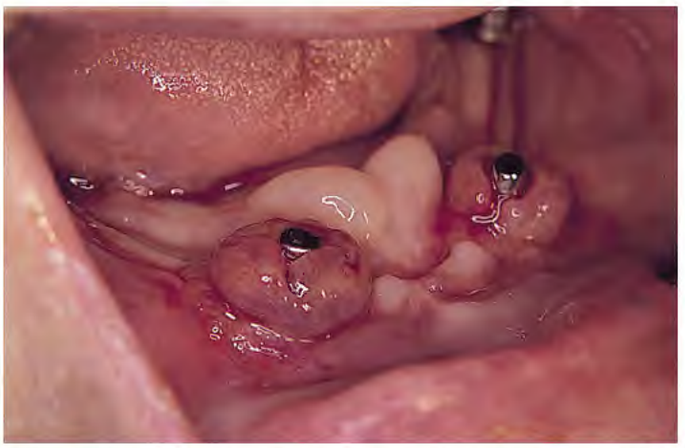


FIGURE 28-57. Granulomatous pericervical lesions are a symptom of peri-implantitis. Elimination of these granulomas without treating the underlying etiologic agent does not produce a cure.

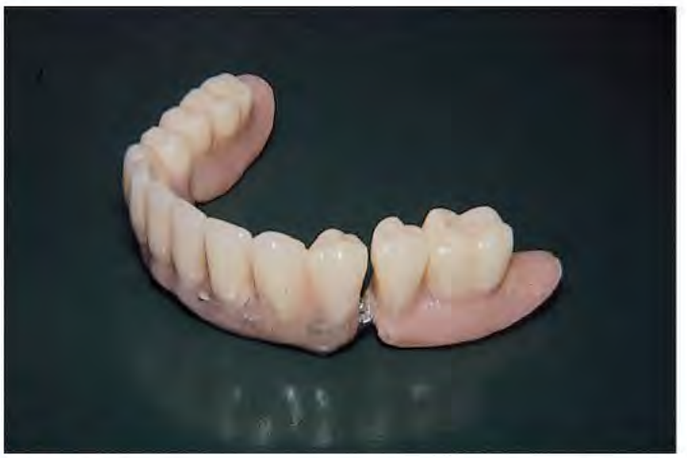


FIGURE 28-59. A superstructure that rests on an altered implant distributes stresses more evenly if it is readapted to its new environment. In this case, the tissue-borne distal end of the denture was transected and reattached with a DE hinge.

it is subabutment bone resorption. If so, the measures in the previous paragraphs regarding curettage and synthetic bone implantation should be followed.

If the problem fails to respond to such therapy, even though traumatic occlusion and bruxism (treated with a soft, protective occlusal appliance) have been eliminated, the involved portion of the implant may require resetting (Fig. 28-58). This is done in the same manner as described for strut resection. Instead of adding grafting material after exposure of the involved components, however, a few strategic connecting struts are transected with a fine diamond point so that the errant parts can be removed. If the implant is the one-piece type, the sectioning is done at the mental bow-tie configuration, with care taken not to injure the neurovascular bundle. If the implant is the tripodal design, the Brookdale bar is cut just distal to the anterior or canine abutment so that a 5-mm cantilevered segment remains. The posterior submandibular islet then is dissected free and removed. If any strut components are buried beneath bone, the preferred course often is to allow them to remain rather than to injure the cortex needlessly.

Immediate postsurgical alteration of the superstructure is important. At the point where the denture no longer is bar supported, the saddle is sectioned and a DE hinge (Howmedica) or similar stress-breaking device is inserted, allowing independent movement in a more physiologic fashion (Fig. 28-59). A tissue-conditioning liner (e.g., Coe-Soft) is placed beneath the newly hinged saddle. This can be changed to a permanent soft, silicone relining material after complete healing.

If acute infection and cellulitis precede the granulomas, the patient should be treated symptomatically before definitive surgery. Incision and drainage are used as indicated; drains are placed; and ice, saline rinses, and antibiotics are used as dictated by the clinical situation.

If continued maintenance of the subperiosteal implant is inimical to the patient's health because all efforts at repair have failed, the implant must be removed. Generally this applies only to subperiosteal implants that demonstrate mobility. This often is a difficult, complex, and time-consuming operation that can be performed using either local or general anesthesia.

A crestal incision is made from one posterior end of the infrastructure around to the other. A facial flap is developed using sharp dissection with a BP No. 12 blade. Care must be taken to maintain this as a full-thickness flap and to avoid injuring the vital mental neurovascular bundles.

When the most posterior peripheral strut is visualized, the assistant firmly retracts to make it accessible. A No. 12 blade is used to incise the dense fibrous envelope surrounding the metal. This process is continued with the scalpel, following the strut geometry. Inaccessible metal structure mandates more aggressive flap development and reflection. Finally, when all enveloping fibrous strands have been cut, completely exposing the entire infrastructure, an attempt should be made to lift it out. Osseous impediments may require removal with a cooled No. 6 round bur. Even after this, the implant usually requires sectioning to facilitate removal.

After removal and thorough debridement and irrigation, the procedure is completed with a primary 3-0 Vicryl mattress suture closure. The former superstructure is relined with Coe-Comfort and used as a stent and temporary denture during healing.

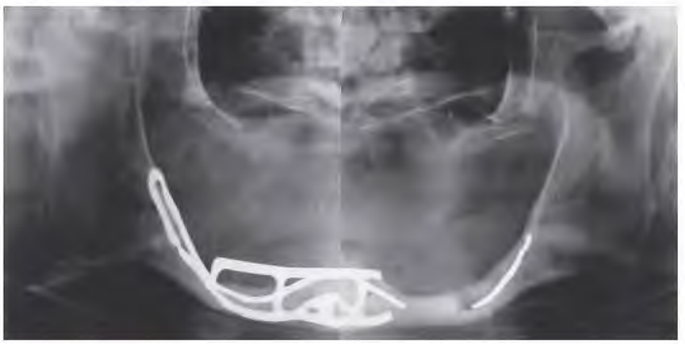


FIGURE 28-58. Posterior subperiosteal segments that are troublesome may be resected. In this case, the buccal peripheral strut had become integrated and was allowed to remain.

Broken Abutments

Although subperiosteal implants rarely fracture, this problem can be prevented (with either chrome alloys or titanium) by taking metallurgic x-ray films of all castings before surgical placement. Bubbles and casting defects show up easily with such views and indicate rejection of the casting (Fig. 28-60). If an abutment should break and enough cervix is left (which is unlikely), a casting can be made to telescope over it. If this is not possible, the

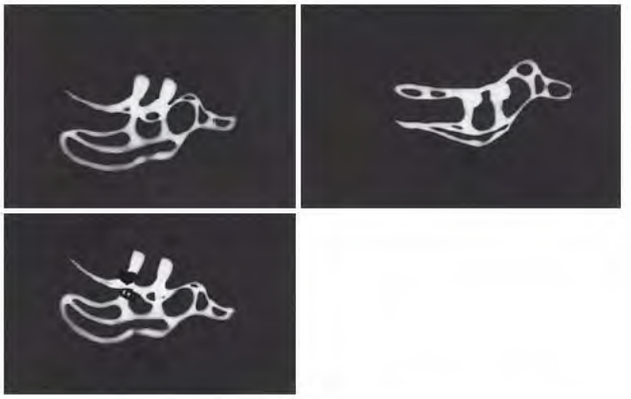


FIGURE 28-60. Sound manufacturing quality control should include the use of industrial metallurgic radiographs.

protruding cervix should be shaved down as much as possible, some bleeding should be created by abrasion with the diamond drill, and the epithelium should be allowed to cover the altered stump by secondary intention. This is particularly applicable if the affected site is a posterior one. In such cases, superstructural alterations are made by sectioning the saddle just distal to the anterior (canine) abutment and building in a DE hinge as a connector (see Fig. 28-59). This allows the posterior saddle to function on a stress-broken basis, as described earlier in the chapter.

Other, More Significant Symptoms

For dysesthesia of recent or sudden onset or the slightest mobility in a subperiosteal implant (usually as a result of settling), immediate removal is mandatory. Care must be taken not to further injure the neurovascular bundle or other vital structures during the removal procedure. This is facilitated by sectioning the infrastructure into small segments and allowing some of the components to slide out from beneath the tissues, thereby minimizing trauma.

Postsubperiosteal Sublingual Floor Elevation

Flap elevation and replacement over a mandibular subperiosteal implant or repairs to endosteal implants in the anterior mandible sometimes cause sublingual elevation and malposture that places the anterior portion of the plicae sublingualis and the orifices of Wharton's ducts over the crest of the ridge (Fig. 28-61, *A*). As a result, when the patient places the superstructure or overdenture, pain occurs, and often salivary obstruction.

This difficulty is corrected surgically by repositioning the floor of the mouth. With the patient under regional block anesthesia, an incision is made at the crest of the edentulous ridge from one molar area to the other. The mucosa outlined by this introductory maneuver is reflected from the lingual surface of the anterior mandible, allowing the periosteum to remain in position (Fig. 28-61, *B*).

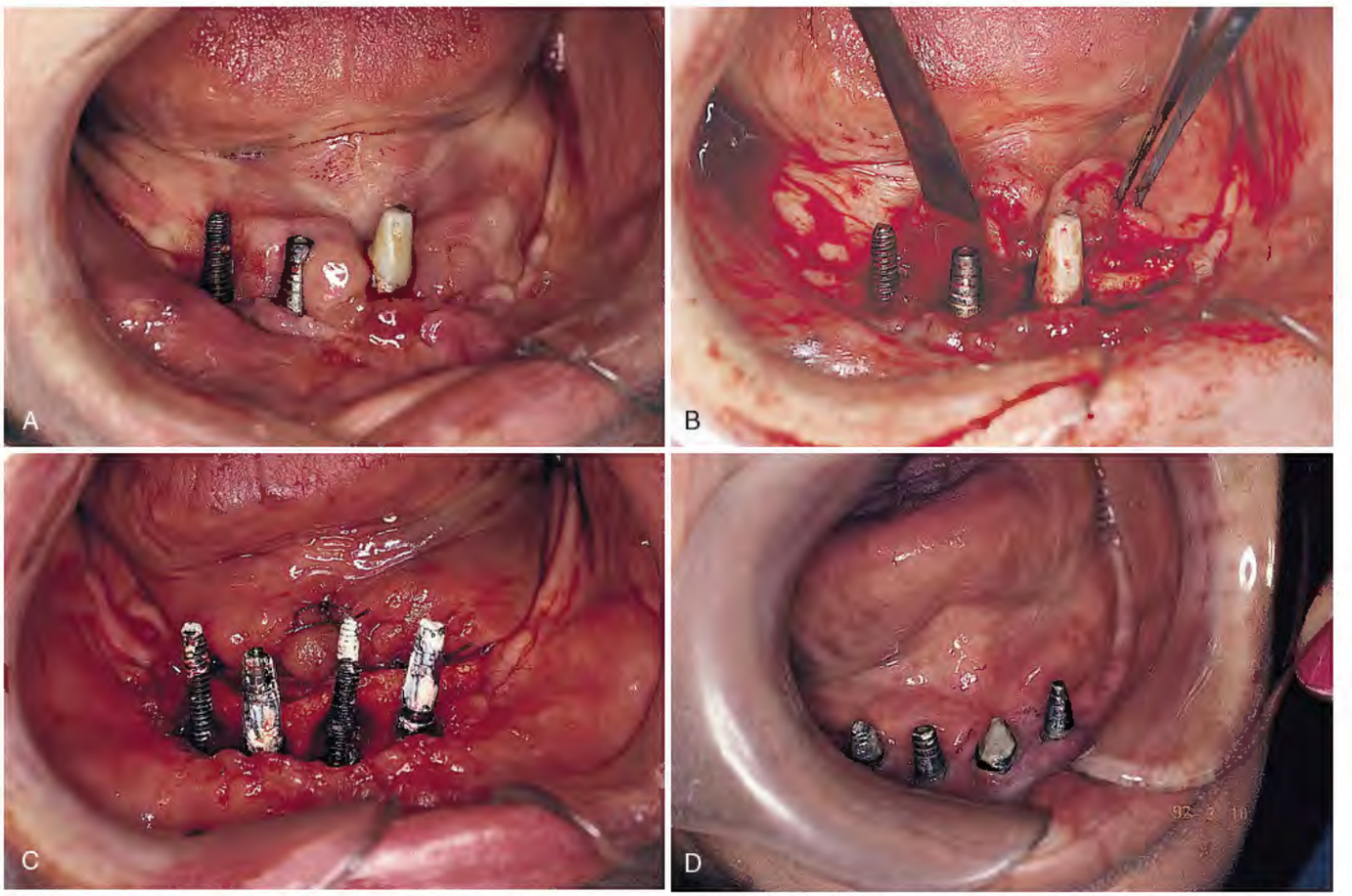


FIGURE 28-61. **A,** As a result of previous surgery, this patient has an anteriorly displaced sublingual floor. **B,** A crestal incision is made from one retromolar pad to the other, which allows the entire sublingual complex to be freed and elevated. **C,** The patency of Wharton's ducts is ensured before the wound margin is repositioned and sutured to the lingual periosteum at a point 5 mm below the ridge crest. **D,** One year after surgery, the sublingual anatomy is properly relocated, and the possibility of overdenture impingement has been eliminated.

The sublingual mucosa now can be dissected free of the Wharton's ducts, the sublingual glands, and the fibers of the mylohyoid muscles. The ducts, which had been cannulated with whalebone bougies, are brought through the mucosa at sites made lingual to the ridge crest, where they are not obstructed by the overdenture flange. The entire mucosal margin is sutured to the lingual periosteum 5 mm apical to the crest of the ridge (Fig. 28-61, *C*).

After the patency of the ducts is ensured, the lingual flange of the overdenture is lined with surgical cement, and the overdenture is inserted as a stent.

The postoperative course usually is uneventful. The stent is removed on the fourteenth postoperative day. A zone of fixed gingiva epithelizes secondarily beneath the surgical cement over the exposed lingual periosteum, and the structures of the floor of the mouth become stabilized in their newly placed, appropriate anatomic positions (Fig. 28-61, *D*).

IMPLANTATION IN THE IRRADIATED JAW

Many patients who have received tumoricidal doses of radiation need implants for improved comfort, mastication, and esthetics. Current thought encourages the placement of enough implants to allow insertion of totally implant-borne prostheses. A principal cause of osteoradionecrosis is the pressure of saddles on the overlying mucosa, therefore their use should be discouraged. Consensus favors the use of hyperbaric oxygen for preoperative and postoperative therapy.

Nine to 12 months should elapse after irradiation before implant surgery is performed. By that time, considerable revascularization has been reported. The patient should have had thorough oral prophylaxis, had all teeth with a poor prognosis extracted before irradiation, have given up smoking and the use of tobacco products, and be free of malignant disease. Before implant surgery, the patient should receive 20 hyperbaric oxygen treatments of 90 minutes each at 2 to 2.4 atmospheres. Three days before the surgery, an antibiotic regimen is started (i.e., Augmentin, 500 mg every 12 hours).

The implant surgery should follow the guidelines presented in Chapter 9, with special consideration given to small incisions; preservation of periosteal attachments; use of sharp, well-irrigated drills with small gradients of drill diameter change; and flawless soft tissue management and closure. Antibiotics are continued for 10 days after surgery, and the patient should have 10 more days of hyperbaric therapy. The time allowed for integration should be doubled to give the implants the best opportunity for success.

Maintenance and Hygiene

29 CHAPTER

All implant patients must carefully follow a regimen of postinsertion orders. Most patients who request implants lost their teeth because of decay or periodontal disease. By habit, they may be among the least conscientious of patients. Therefore, before implant surgery, the dental surgeon must impress upon them the importance of home care and maintenance. Implants undergo tissue breakdown and bone loss more quickly than natural teeth. Patients who receive implants must show a voluntary change in behavioral pattern. They must be followed carefully to ensure that they continue to maintain the implants and prostheses. They also should be instructed to report any problems to their dentist promptly.

After both implant surgery and insertion of the prosthesis, appointments should be made to see the patient at 1, 2, 4, 12, and 24 weeks. (These time periods may be altered in light of the patient's oral hygiene practices or other prevailing circumstances.) At recall appointments, the prostheses and their attachments are evaluated for function, esthetics, and stability, and they are removed and replaced if necessary. The implants should be examined radiographically for radiolucencies at least at 1-year intervals. Periapical and, when needed, panoramic films should be taken, following a standardized radiographic technique. The implants should be inspected for mobility at each recall appointment. If the prosthesis is the fixed-detachable type, the mesostructure bar or full superstructure prosthesis should be removed before the implants are assessed. An instrument handle can be used on the buccal and lingual surfaces of each implant abutment in a gentle attempt to rock the abutment back and forth.

PERIOTEST MOBILOMETER (PERIOTEST M)

Medizintechnik's electronic mobilometer, the Periotest M (Fig. 29-1), is available through Salvin Dental Specialists (Charlotte, North Carolina). This instrument detects the level of mobility of root form implants. Readings from −7 to +18 indicate movement that is too imperceptible to be detected clinically. When mobility readings are +9 or above, implants with even the best of radiographic findings must be evaluated and treated.

The Periotest M offers a more reliable method of diagnosing implant status, because it measures subclinical mobility in a reproducible manner. It uses an ultrasonically vibrating probe to assess micromobility. The device has been used in a number of applications since it was introduced in 1983 to determine the periodontal status of natural teeth. It has proved an effective tool for evaluating implant stability from second-stage surgery through all subsequent stages of management. Some dentists have even claimed to use it to balance and fine-tune the forces of occlusion. In vitro evaluations of the Periotest M revealed no statistically significant difference in measuring perio test values (PTVs) from operator to operator. High levels of repeatability between different Periotest M units also have been shown.

However, the Periotest M often fails to detect saucerization of bone. Radiographs show the bone levels of implants more accurately. The Periotest M also does not detect bone loss until it is quite advanced.

Based on these findings, the Periotest M can be seen as a reliable tool for diagnosis of the stability of implants, and it also can be used to evaluate the salvageability of an implant with advanced bone loss. However, it fails to diagnose an implant with progressive bone loss, because its values are unchanged until the bone loss is virtually complete. Therefore, the information gained from the Periotest M must be combined with other clinically acquired information (e.g., periapical radiographs) to determine the true status of an implant.

Mobility is recorded as for natural teeth on a follow-up record form (see Appendix J). Tissue color and tone are inspected and recorded using the Löe and Silness index. Muhlemann's index is satisfactory for recording any bleeding.

PST GENETIC TEST

The sulcular oral flora found in the mouths of patients with periodontal disease has been isolated from the peri-implant environment. If saucerization or other bone loss is suspected to have affected implant host sites and the problems of traumatic occlusion, bruxism, or inappropriately designed crown margins and pontic ridge laps have been eliminated, a genetic test may be valuable.

As with many other chronic inflammatory disorders, periodontal disease (gum disease) and peri-implantitis (disease of the supporting structures of the implant) vary from person to person in severity and progression, depending on the interaction of genetic and behavioral risk factors. The PST Genetic Test provides a reliable means of assessing an individual's genetic risk for periodontal disease, the most common cause of tooth loss and a leading cause of implant failure.

The PST Genetics Test (Interleukin Genetics, Waltham, Massachusetts) is the only genetics test that analyzes two interleukin 1 (IL-1) genes for variations that identify a person's predisposition to overexpression of inflammation and the risk of periodontal disease (Fig. 29-2). A sample is collected chair side by using a soft brush inside the cheek. The sample is sent to the DNA laboratory, where the specimen is processed and either a positive or a negative reaction occurs. Patients who are PST positive have been shown to produce as much as two to four times more IL-1 in response to the same bacterial challenge as patients who are genotype negative for these polymorphisms. IL-1 levels in gingival crevicular fluid and periodontal tissues have been found to be significantly higher in patients who are PST positive than in controls. Among heavy smokers who are also PST positive, the likelihood of losing teeth has been reported to be as much as 7.7 times higher. The test is valuable

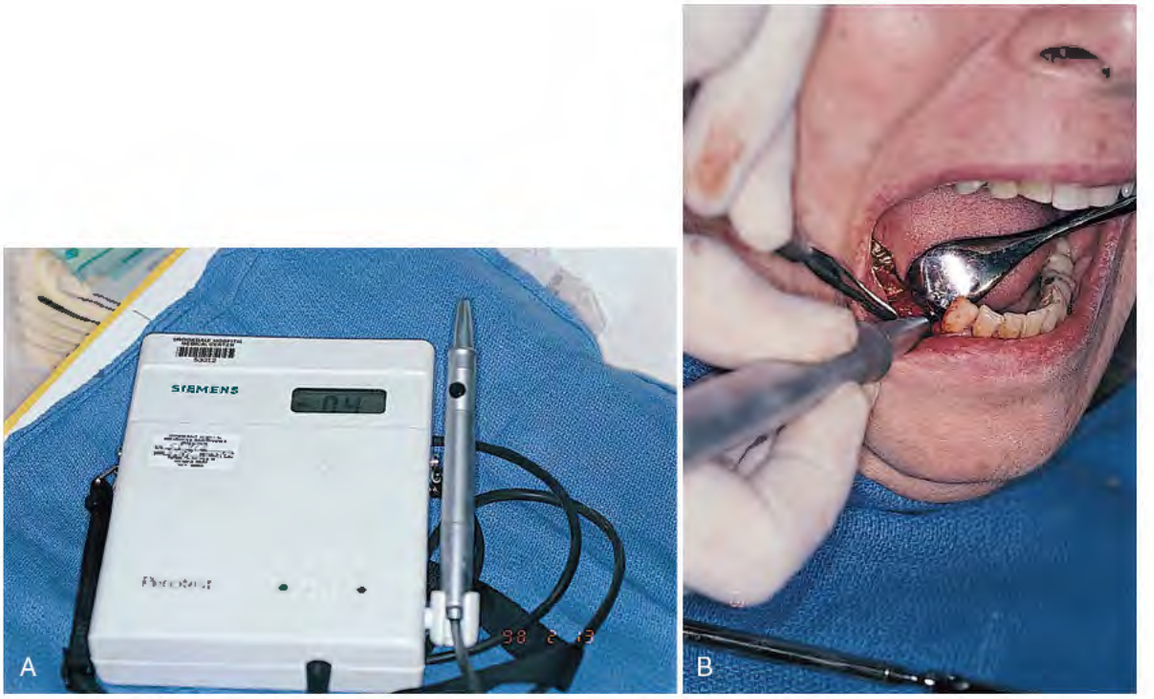


FIGURE 29-1. **A,** Medizintednik's Periotest mobilometer (Periotest M) consists of a wand that is used intraorally and a console that gives readings digitally and by electronic voice. **B,** For proper use, the wand must be parallel to the floor and placed at right angles to the implant or tooth in question.

FIGURE 29-2. The PST Genetic Test is a chair-side sample collection for which a soft brush is used inside the cheeks.

not only for the clinician, but also for the patient, because it presents tangible evidence of a need for improved oral hygiene.

MEASUREMENTS

Pocket depths are checked and charted in the normal manner. Because of the tentativeness of the cervical epithelial adhesion, probing is done gently with plastic instruments (Fig. 29-3). The peri-implant tissues are palpated to assess for exudate or pain. These findings are recorded on the follow-up form. If radiographs indicate saucerization phenomena or other signs of bone loss,

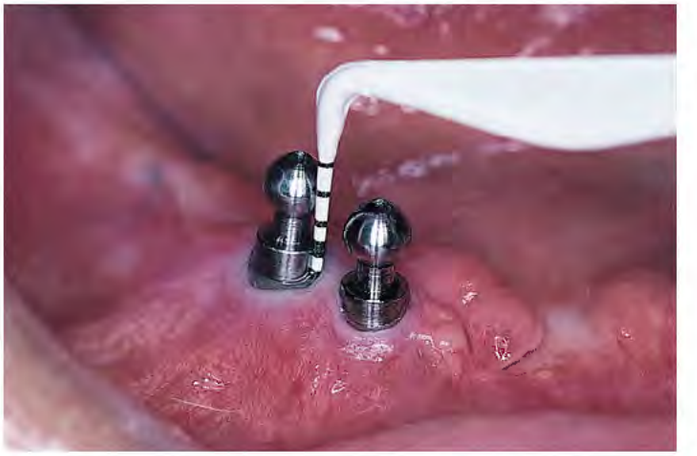


FIGURE 29-3. If pocket probing is to be done at all, it must be done gently and with a plastic probe.

decisions must be made with regard to bone substitute, guided tissue membrane repair, or even implant removal with subsequent prosthesis alteration.

PATIENT SKILLS

An important issue is the patient's home care skills. A disclosing agent should be used to detect the amount of plaque present. This is recorded on the follow-up chart for all surfaces of each implant, abutment, and areas of bars, mesostructures, or superstructures. When possible, the patient's natural teeth should be used as longitudinal parameters for comparisons. This information allows decisions to be made as to whether any corrective procedures are required. (Chapter 28 presents therapeutic approaches that may be required.)

RECALL VISIT

At recall appointments, the implant abutments are cleaned with plastic scalers, curettes, wooden-tipped porte polishers, or automated instruments (Figs. 29-4 and 29-5). Teflon-coated or gold-plated tips must be used to protect the highly polished transepithelial (cervical) surfaces of the abutments. Manual and mechanical scaler tips (Cavitron, Titan) can be obtained with Teflon coatings (available from E.A. Beck and Company of Costa Mesa, California). Biomet-3i (Palm Beach Gardens, Florida) makes handheld gold-plated and rigid plastic scalers (Fig. 29-6). Extreme care must be taken to protect epithelial adhesion at the cervices during cleaning.

HOME CARE

Patients are painstakingly instructed in home care procedures, which should be performed two or three times a day. Use of a toothbrush, plastic-coated Proxybrush (Fig. 29-7), rubber tips (Fig. 29-8), stimulators, rotary brush (Fig. 29-9), Rotadent, Sonicare, Interplak, or WaterPik (at ultralow settings) is recommended. In addition, depending on the size, shape, and location of the prosthesis, Super Floss (Fig. 29-10), G-Floss (Fig. 29-11), Post Care Floss (Fig. 29-12), pipe cleaners, and even 2 × 2-inch gauze sponges opened to full length and used in the same way as shoeshine cloths may be useful (Fig. 29-13).

If the prosthesis is an overdenture, the patient should be instructed to remove it three times a day so that the superstructure and abutments can be cleaned thoroughly. If possible, the patient should leave

FIGURE 29-4. A wooden porte polisher used with pumice is a gentle but effective method of professional plaque removal.

FIGURE 29-6. The gold-plated scaler (Implant Innovations) causes less injury to delicate implant cervices than steel instruments.

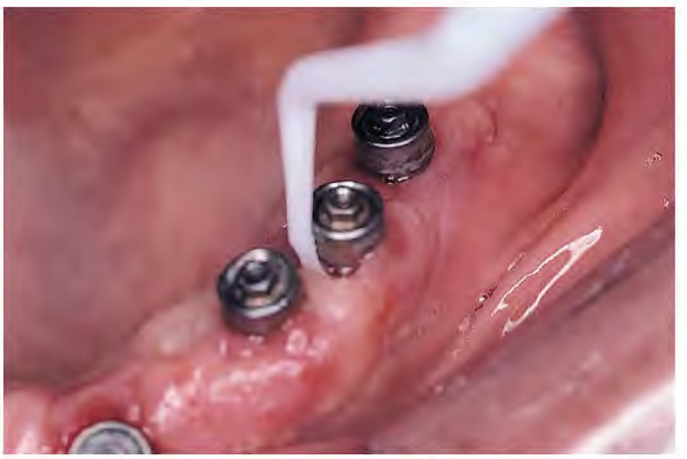


FIGURE 29-5. Plastic scalers are helpful for removing calculus with minimal abrasion to polished implant surfaces.

FIGURE 29-7. The plastic-coated Proxybrush is a simple but efficient interproximal hygienic device.

FIGURE 29-8. A requisite for all patients who want high-level hygiene is the tapered rubber tip, which can be used with toothpaste or chlorhexidine.

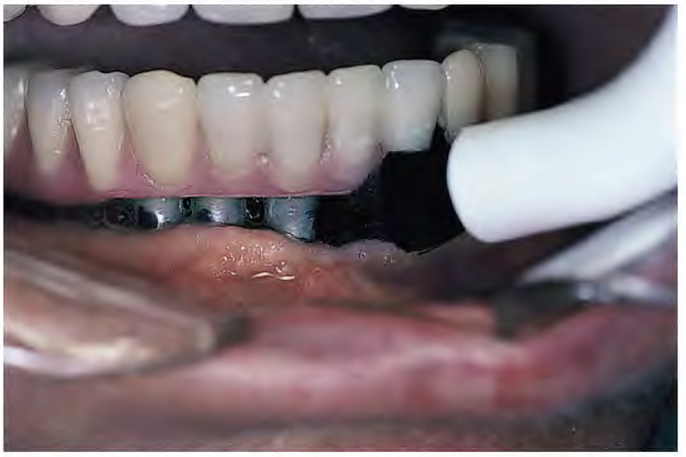


FIGURE 29-9. Rotadent, an electrically powered, handheld, rechargeable, home care product, is effective for reducing plaque. The angle of its handle encourages patient compliance.

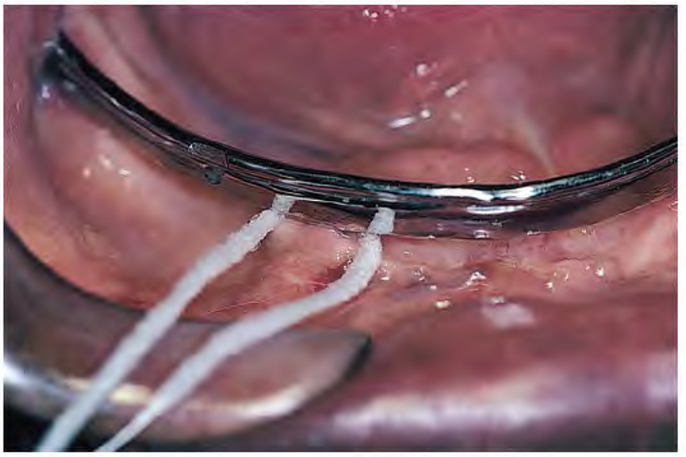


FIGURE 29-10. Super Floss, a fuzzy, gentle, but highly effective home care material may be difficult to introduce, but it is very efficient.

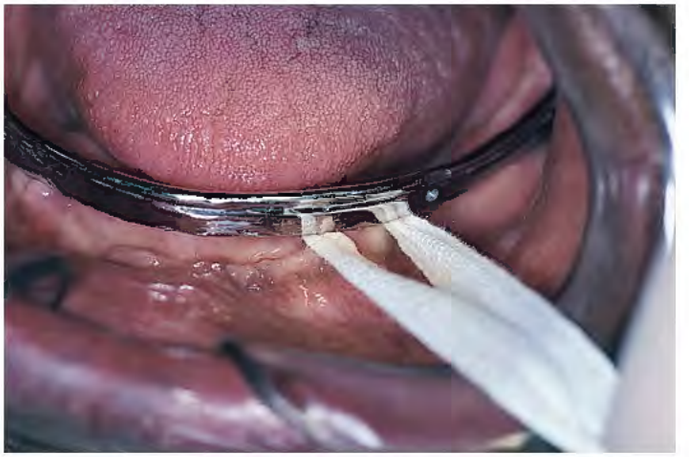


FIGURE 29-11. G-Floss, which is slightly larger in diameter than Super Floss, performs with predictive capability as a plaque remover.

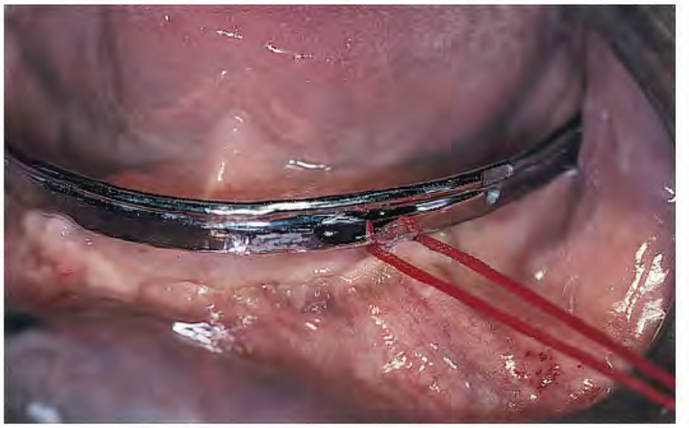


FIGURE 29-12. Post Care Floss is self-threading and somewhat less compliant than ordinary floss, but its pleasant color and ease of application make it a popular product. Patients require careful instruction in the proper manipulation of such materials.

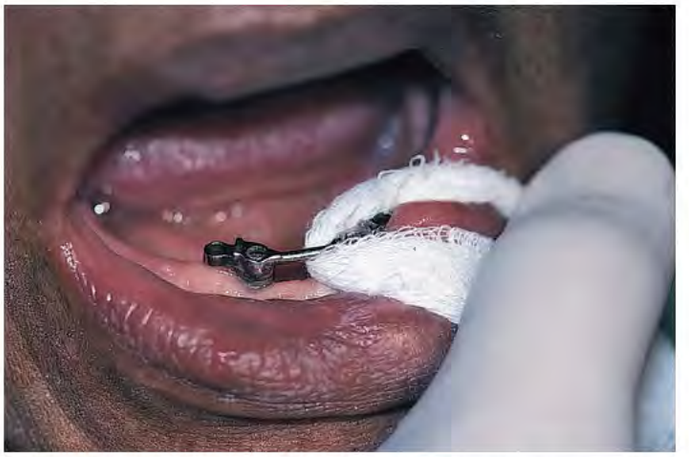


FIGURE 29-13. A simple but practical approach to hygiene involves the use of an opened 2 × 2-inch gauze pad. When passed successfully (which may be thwarted by small embrasures), it offers great benefit. It should be used in the same way as a shoeshine cloth.

the denture out of the mouth at night (kept in water) or at least for 4 hours or longer to allow the supporting tissues to recover.

The patient should practice the dentist's recommended home care regimen for 2 weeks, and the practitioner then should evaluate the patient's efficiency and make any necessary corrections. The patient should use a chlorhexidine mouth rinse (Peridex or PerioGard) twice a day if peri-implant inflammation occurs or fails to resolve despite oral hygiene practices or because of other, undetermined causes.

The hygiene measures recommended should be noted on the patient's chart, and if problems with manual dexterity or some other inability prevents the patient from performing them with good results, changes should be made that simplify the procedures. If an effective home care program cannot be introduced, more frequent hygiene maintenance appointments should be scheduled.

Careful evaluation at the indicated time intervals is mandatory. This allows the practitioner to detect any departures from acceptable form and function and to make corrections before irreversible damage occurs. If an implant's status indicates removal, this must be done promptly to spare bone loss or injury to adjacent implant host sites. Proper maintenance by both the patient and the practitioner helps ensure the health and longevity of the implants and the prostheses they support.

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Chapter 3

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Chapter 4

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Glossary

Abscess A localized collection of purulence in a cavity formed by disintegration of tissues.
Abutment The part of an implant above the neck that provides support for a fixed, fixed-detachable, or removable dental prosthesis.
Adhesion The sticking together of dissimilar materials.
Adnexa (sing., adnexus) Adjunct parts or structures adjacent to a tooth or other structure.
Allograft See Alloplast.
Alloplast A relatively inert, synthetic biomaterial, generally metal, ceramic, or a polymeric material.
Alloys Strong, relatively ductile substances that provide electropositive ions to a corrosive environment and can be polished to a high luster; characterized by metallic atomic bonding; most often used for surgical implants because of a combination of favorable properties and long-term use in the construction of surgical implants, primarily titanium-, cobalt-, or iron-based systems.
Alterable blade implant A blade type of implant that can be changed and reshaped to meet clinical requirements.
Aluminum oxide (alpha single crystal) An inert, highly biocompatible, strong ceramic material used in the fabrication of endosseous implants.
Aluminum oxide (polycrystal) A fused aluminum oxide (Al_2O_3) biocompatible material.
Alveolar Pertaining to an alveolus.
Alveolar crest The most coronal part of the alveolar bone.
Alveolar process The part of the maxillae or mandible that forms the dental arch and serves as a bony investment for the teeth.
Alveolar ridge The bony ridge of the maxillae or mandible that contains the alveoli (sockets of the teeth); the remainder of the alveolar process after the teeth have been removed.
Alveolar mucosa The mucous membrane covering the basal part of the alveolar process and continuing without demarcation into the vestibular fornix and the floor of the mouth. It is loosely attached to the periosteum and is movable.
Alveoloplasty Conservative contouring of the alveolar process to achieve an acceptable contour.
Ambulate To move about, walk.
Anastomosis Communication between vessels by collateral channels.
Anchor An endosteal metal implant in the shape of a ship's anchor.
Anesthesia Absence of sensation to stimuli.
Anneal To heat and then cool slowly to prevent brittleness.
Anterior nasal spine See Nasal spine.
Anteromedially Forward and toward the midline.
Antrum A cavity or chamber within the maxillary bone.
Arc A bowlike, curved line.
Areolar Pertaining to the areolae; any minute space or interstice in a tissue; loose mucosa adjacent to alveolar mucosa.
Armamentarium The total store of available resources; the equipment, such as instruments, drugs, and other items, used in a technique.
Articulation (artificial) The use of a mechanical device that simulates the movements of the temporomandibular joint, allowing orientation of casts in a manner duplicating or simulating various positions or movements of the patient.
Asepsis Prevention of contact with microorganisms; the state of the surgical field for implant surgery.
Atrophy A reduction in the size of the ridge because of resorption of the bone.
Attached gingiva The portion of the gingiva extending from the marginal gingiva to the alveolar mucosa; the attached gingiva is fairly dense and tightly bound down to the underlying periosteum, tooth, and bone.
Attachment A mechanical device for the fixation, retention, and stabilization of a dental prosthesis.
Auger A tool for boring a hole.
Augmentation The placement of autogenous or alloplastic materials to correct bony insufficiencies.
Autogenous Self-generated.
Autograft A graft taken from one part of the patient's body and transplanted to another part.
Available bone The amount and quality of residual bone accessible for implantation.
Avascular Without blood.
Bacteremia The presence of bacteria in the blood.
Bacteriostatic The ability to inhibit or retard the growth or multiplication of bacteria without actually destroying them.
Biodegradable Susceptible to degradation by biologic processes.
Biointegration Establishment of a contact without interposition of nonbony tissue between an implant's surface coating and host-remodeled bone, forming a biochemical bond at the light microscopic level.
Biomaterial A relatively inert, naturally occurring or manufactured material that can be implanted in or used to interface with living tissues or biologic fluids without causing untoward reactions in those tissues or fluids; it can be used to fabricate devices designed to replace body parts or functions.
Blade (implant) A thin, wedge-shaped metal implant that is placed in bone to provide an abutment (see Metal plate implants.)
Blanching To become white or pale.
Block form Any large, solid piece; bulk.
Bone The material comprising the skeleton of most vertebrate animals; the tissue that makes up bones.
Bone, alveolar The specialized bone structure that contains the alveoli or sockets of the teeth and supports the teeth.
Bone, basal The part of the mandible and maxillae from which the alveolar process develops.
Bone, bundle The bone that forms the immediate attachment of the numerous bundles of collagen fibers incorporated into bone.

Bone, cancellous (also called spongiosa, spongy bone, supporting bone, medullary bone, trabecular bone) The bone that forms a trabecular network, surrounds marrow spaces that may contain either fatty or hematopoietic tissue, lies subjacent to the cortical bone, and makes up the main portion (bulk) of a bone.

Bone, compact Hard, dense bone that constitutes the outer, cortical layer and consists of an infinite variety of periosteal bone, endosteal bone, and haversian systems.

Bone curettage The use of hand instruments to move medullary bone gently to create an implant receptor site or to remove diseased intraosseous tissue.

Bovine Of or like an ox or a cow.

Brookdale bar A one-piece, continuous mesostructure bar design for use with subperiosteal implants.

Buried An implant that has been placed below the soft tissue and is not in function.

Buttressed Supported or reinforced.

CAD/CAM Computer-aided design/computer-aided manufacturing; milled by computer control.

Calibrate To correct the gradations of an instrument.

Cancellous bone See Bone, cancellous.

Carbons Vitreous (polycrystalline or glassy) or pyrolytic graphitic structures of relatively hard, inert, and stable compounds that conduct thermal and electrical energy; characterized by ionic and van der Waals–type atomic bonding; primarily carbon or carbon-silicon compounds; once used in endosseous dental implant systems and as an implant coating.

Caveat A warning.

Cellulitis Purulent inflammation of loose connective tissue.

Centric Pertaining to or situated at the center.

Centric occlusion Maximum intercuspation of the teeth.

Centric relationship The most posterior relationship of the mandible to the maxilla when the condyles are in their most posterior positions in the glenoid fossa.

Ceramics Compounds of a metal and oxygen that form chemically and biochemically stable substances that are strong, hard, brittle, and inert nonconductors of thermal and electrical energy; characterized by ionic bonding.

Cervix The neck of the implant; connects the infrastructure to the abutment.

Cessation A ceasing; stop; pause.

Circummandibular Around the mandible.

Circumosseous Around the bone.

Circumzygomatic Around the zygoma.

Coagulate To cause to clot.

Coagulum The clot that closes the gap made in a vessel or between the wound margins.

Coaptation To approximate the edges of a wound.

Coated An outer covering; a layer of some substance over a surface.

Coherent Sticking together of the same material; having cohesion.

Cold-weld A frictional fit or press-fit.

Collate To put into proper order.

Compliant Yielding, submissive.

Connecting bar A fixed bar that connects two or more permucosal extensions; in the case of the ramus frame or subperiosteal implant, it can be an integral part of the substructure.

Connective tissue The binding and supportive tissue of the body; it is composed of fibroblasts, primitive mesenchymal cells, collagen fibers, and elastic fibers, with associated blood and lymphatic vessels, nerve fibers, and other components.

Contralateral The opposite side.

Conventional blade implant A one-stage implant design that does not involve buried healing.

Conversion appliance A temporary, fixed-detachable prosthesis.

Cornua A horn.

Corrosion (biomaterials) The loss of the elemental constituents of metals to the adjacent environment. Polymers undergo biodegradation as a result of preferential leaching of lower molecular weight fractions and polymeric chain breakdown by enzymatic cleavage and/or hydration and/or oxidation-reduction processes. The same types of processes affect carbons (conductors) and ceramics (nonconductors), although to a lesser degree.

Cortical bone A peripheral layer of compact osseous tissue; the average thickness of the cortex of alveolar bone is 2 mm (also see Bone, compact.)

Counterbore The slight enlargement at the superior aspect of the osteotomy that allows the next gradual enlargement to take place.

Countersink To enlarge the top part so that it can accept the head or cervix.

Countertorque The force used to act against or in the opposite direction from the rotating motion being produced.

Crevicular Referring to the gingival crevice.

Crossbite Malocclusion in which the mandibular teeth are in buccal version to the maxillary teeth.

Cross-sectional slice A vertical computed tomography (CT) scan slice.

Cruciform Shaped like a cross.

Custom-cast blade implant An implant designed and made to the unique specifications of the patient's available bone.

Cyst Any closed, epithelial-lined cavity or sac, usually containing liquid or semisolid material.

Debridement The removal of foreign material and contaminated or devitalized tissue from or adjacent to a traumatic or infected lesion until surrounding healthy tissue is exposed.

Defatting To remove the fat from the surface of a metal.

Deglove To expose the bone by dissecting and reflecting all soft tissue.

Degreaser A chemical used to remove organic contaminants from the surfaces of an implant.

Dehiscence A splitting open of or break in the epithelium covering an implant, leaving an isolated area of the implant or of bone exposed to the oral cavity. Mandibular dehiscence is exposure of the inferior alveolar nerve as a result of extreme resorption of the mandible, to the point that the roof of the mandibular canal is no longer covered with bone, leaving only soft tissue separating the contents of the canal from the oral cavity.

Dehydration Removal of water from a substance; excessive loss of water.

Delaminate To remove a layer.

Demarcated Limits or boundaries that are separate and well marked.

Demineralize To remove the mineral content.

Dental implant A biocompatible, biofunctional permucosal device that is placed on or within the bone associated with the oral cavity to provide support for fixed or removable prostheses.

Dentoalveolar Pertaining to a tooth and its alveolus.

Depassivation The breaking down of metallic oxide when local conditions produce an acidic environment at the metallic interface.

Disclosing agent (or solution) A dye that allows visualization of dental plaque through staining with a selective medium.

Dissection The act of cutting apart and disclosing the individual tissues; the separation of tissues in surgical procedures.
Dorsum The posterior or superior surface of a body part.
Dysesthesia A disturbance in or impairment of sensory nerve transmission.
Ecchymosis A hemorrhagic area of the skin or a mucous membrane that forms a flat, rounded, blue, or purplish patch.
Edema An abnormal accumulation of fluid in intercellular spaces of the body.
Elastomeric Rubberlike.
Electrocoagulation The use of an electrical current to coagulate tissue.
Endodontic endosteal implant A smooth and/or threaded pin implant that extends through the root canal of a tooth into periapical bone, to stabilize a mobile tooth.
Endodontic stabilizer implant See Endodontic endosteal implant.
Endosteal (endosseous) Occurring or located within a bone.
Endosteal (endosseous) implant A device placed within alveolar and/or basal bone.
Epithelial attachment The continuation of the sulcular epithelium that is joined to the tooth or implant structure and is located at the base of the sulcus, or pocket.
Epithelial cuff, implant The band of tissue that is constricted around an implant's cervix.
Epithelium The outer layer covering the underlying connective tissue stroma.
Epithelium, gingival A stratified squamous epithelium consisting of a basal layer; when it comprises the attached gingiva, it is keratinized or parakeratinized.
Epithelium, sulcular The stratified squamous epithelium that forms the covering of the soft tissue wall of the gingival sulcus, or crevice.
Evert To turn inside out; to turn outward.
Exploratory surgery Surgery performed for the purpose of examination, study, or diagnosis.
Exteriorization To cause to be on the outside.
External oblique ridge A smooth ridge on the buccal surface of the body of the mandible that extends from the anterior border of the ramus, with diminishing prominence, downward and forward to the region of the mental foramen. This ridge changes very little in size and direction throughout life and is an important landmark in the design of a subperiosteal implant.
Exudate A fluid with a high protein content that has escaped from blood vessels and has been deposited in tissues as a result of inflammation; pus.
Fenestrations Any windowlike openings.
Fibro-osteal (fibro-osseous) integration See Fibrous integration.
Fibrosis The formation of fibrous tissue.
Fibrous Composed of or containing fibers.
Fibrous integration Interposition of healthy, dense, collagenous ligament tissue between implant and bone that transmits loads from the implant to the bone.
First-stage surgery The preparatory stage for an implant procedure. For subperiosteal implants, the surgical bone impression and bone bite, which are done to construct the implant. For endosteal implants, the placement of the implant, which is to be submerged for a healing period before it is put into function.
Fistula An abnormal tract connecting two body cavities or organs or leading from a pathologic or natural internal cavity to the surface.
Fixed bridge A prosthetic dental appliance that replaces lost teeth; it is supported and held in position by attachments to natural teeth and/or implants in a nonremovable manner.
Fixed-detachable A fixed bridge that can be removed by the practitioner but not by the patient.
Follicle A sac or pouchlike depression or cavity.
Foramen A natural opening or passage out of or through bone containing a neurovascular bundle or nerve.
Freestanding implant An implant that can withstand functional forces without being splinted to any adjacent abutments.
Freeze-dried Damaged or attenuated by exposure to cold and dehydration.
Frenulum A small fold of integument or mucous membrane that checks, limits, or curbs the movements of an organ or part.
Friable Easily crumbled, pulverized.
Functional occlusion The contact of the teeth that provides the highest efficiency in the centric position and during all excursive movements of the jaw that are essential to mastication without producing trauma.
Galvanism The electropotential difference of dissimilar metals that can occur in dental implant metallurgy.
General anesthesia A state of unconsciousness and lack of susceptibility to pain produced by administration of anesthetic agents through inhalation or intravenously, intramuscularly, rectally, or via the gastrointestinal tract.
Generic Referring to a kind, a class, or a group; general, as opposed to specific.
Genial tubercles Mental spines, small round elevations (usually two pairs) clustered around the midline on the lingual surface of the lower portion of the mandibular symphysis. These tubercles serve as attachments for the genioglossus and geniohyoid muscles and are critical landmarks for the subperiosteal implant.
Graft A material used to replace a defect in the body; anything that is inserted into something else to become an integral part of the latter; in the case of bone, either artificial or synthetic bone, usually used to increase strength or dimension, or both.
Granuloma A tumorlike mass or nodule of granulation tissue caused by a chronic inflammatory process.
Guarded Cautious, questionable, needing supervision.
Habituate To become used to, accustomed, familiar with.
Harvest The gathering or collecting of material (bone).
Head See Abutment.
Healing abutment A temporary cuff used after implants are uncovered so that the soft tissues can heal in the permucosal areas.
Hemisection The process of dividing or cutting a tooth or structure into two parts.
Hemostasis The arrest of bleeding; interruption of blood flow.
Heterograft A graft taken from one species and placed in another.
Hollow grind To tunnel or make concave; producing a cavity within the appliance or substance used.
Homograft A graft taken from one human subject and transplanted to another.
Host site See Receptor site.
Hydrophilic Capable of absorbing water.
Hydroxyapatite (HA) A mineral compound that is the principal inorganic component of bone, teeth, and dental calculus.
Hydroxyapatite ceramic A dense, nonresorbable ceramic. When implanted in bone, it displays a highly attractive generic profile, including a lack of local or systemic toxicity.
Hyperesthesia Abnormally increased sensitivity of the skin, mucosa, or other organ of special sense.

Hyperostotic Hypertrophy of the bone.
Hyperplasia The abnormal multiplication or increase in the number of normal cells in normal arrangement in a tissue.
Hypertrophy An increase in the bulk of a tissue beyond normal limits, caused by an increase in the size but not the number of cellular elements.
Hypoplasia Defective or incomplete development.
Iatrogenic Resulting from the activity of the physician or dentist.
Impaction A condition in which a tooth or other structure or material is blocked by a physical barrier.
Implant See Oral implant.
Implant dentist, surgeon A professional who practices the art and science of implant dentistry.
Implant dentistry The area of dentistry concerned with the diagnosis, design, and insertion of implant devices and implant restorations that provide adequate function, comfort, and aesthetics for edentulous or partially edentulous patients.
Implant denture A denture that receives its stability and retention from a dental implant.
Implant integration Tissue-to-implant contact.
Implant interstices The small spaces or pores within and on the surface of the implant's infrastructure.
Implantologist A professional who practices the art and science of implant dentistry.
Implantology The art and science of the surgical insertion and restoration of materials and devices to restore function to a partially or totally edentulous patient.
Implant prosthodontics The part of implant dentistry concerned with the construction and placement of a fixed or removable prosthesis on any implant device.
Implant prosthodontist A professional who practices the art and science of diagnosis, surgical placement of implants, construction of superstructure-restoring occlusion, and postoperative maintenance of oral implants.
Implant surgery The part of implant dentistry concerned with the placement, surgical repair, and removal of implant devices.
Incision A cut or wound produced by cutting with a sharp instrument, laser, or electrosurgical scalpel.
Incisive foramen A foramen located in the midline on the anterior extreme of the hard palate; it transmits the left (more anterior) and right (more posterior) nasopalatine (Scarpa's) (long sphenopalatine) nerves and vessels; a critical landmark for implant surgery.
Infection Invasion and multiplication of microorganisms in body tissues, especially microorganisms that cause local cell injury.
Inflammation A protective tissue response to injury or destruction of tissues that walls off both the injurious agent and the injured tissues.
Infraosseous Below the bone.
Infrastructure The implant substructure below the soft tissue.
Insert The part that goes into the opening in the implant; abutment, cervix.
Integration period The interval during which the bone grows to and surrounds the implant's surface and makes it a part of the whole.
Interdental implant An implant used between natural tooth abutments (pier abutment).
Internally threaded Having a thread pattern within the housing of the implant.
Interocclusal distance The distance between the occlusal surfaces of opposing teeth of the mandibular and maxillary arches.
Interposed In between.
Intramucosal insert (subdermal implant) An alloplastic device placed in the tissue-bearing surface of a removable prosthesis to maintain the mucostatic seal mechanically; generally made of titanium, surgical stainless steel, or aluminum oxide and shaped with a narrow permucosal neck, a wider retentive head, and a broad, flat, denture-attaching base; it generally is used for a maxillary complete denture or mandibular and maxillary removable partial dentures.
Intraosseous Within bone.
Involuted Rolled or turned inward.
Ischemia Loss of blood supply to a tissue as a result of mechanical obstruction that may cause cell death.
Islet A very small island.
Isometric Maintaining the same length; of equal dimensions.
Isthmus A narrow strip.
Keratinized gingiva The part of the mucosa covered by keratinized epithelium.
Knife edged Having a very sharp, very narrow morphology (ridge).
Ligate To tie or bind with a ligature.
Ligature A wire or suture used to bind, tie, secure, stabilize, or immobilize.
Linea alba A white line or narrow white scar, as at the crest of the residual ridge after tooth loss.
Locking taper See Cold-weld.
Lumen The cavity or channel within a tube or needle.
Mandibular basal bone The part of the body of the mandible that supports and underlies the alveolar bone; the part of the mandible that remains after resorption of the alveolar process.
Mandibular nerve The third division of the trigeminal nerve. This nerve leaves the skull through the foramen ovale and provides motor innervation to the muscles of mastication, to the tensor palati, the tensor tympani, the anterior belly of the digastric, and the mylohyoid muscles. It provides general sensory innervation to the teeth and gingivae, the mucosa of the cheek and floor of the mouth, the epithelium of the anterior two thirds of the tongue, the meninges, and the skin of the lower portion of the face.
Mandibular staple (bone plate) A form of a transosseous implant in which a plate is placed at the inferior border, and a series of retentive pins is placed partially into the inferior border with two continuous screws inserted transcortically and penetrating the mouth in the canine areas to be used as abutments.
Master cast The final model that represents the exact positioning of the abutments, on which the prosthesis is fabricated.
Matte finish A nonglossy or dull surface finish.
Maxillary sinus The anatomic space superior to the posterior maxillary alveolus that limits the volume of alveolar bone in this area; a landmark in maxillary implant surgery.
Medullary Pertaining to the bone marrow.
Mental foramen The opening in the lateral surface of the mandible that allows the exit of the third division of the trigeminal nerve and vessels; considered one of the five anatomic landmarks for subperiosteal implants.
Mesostructure The part that couples the implant complex (infrastructure) to the superstructure.
Metal plate implants Flat, blade-shaped implants of various thicknesses that derive their support from a horizontal length of bone. They may be perforated, smooth, fluted, textured, coated, vented, multiheaded, and submerged or nonsubmerged in a variety of biocompatible materials.

Monomer The liquid portion of acrylic (polymethylmethacrylate) resin.
Morbidity The condition of being diseased, unhealthy.
Mucobuccal fold The cul-de-sac formed by the mucous membrane as it turns from the upper or lower gingivae to the cheek.
Mucogingival junction The scalloped linear area denoting the approximation or separation of the gingiva and the areolar mucosa.
Mucoperiosteum A layer of mucosa, connective tissue, and periosteum that covers bone in the oral cavity; it sometimes gives rise to muscle attachments.
Mucosa (mucous membrane) A membrane, composed of epithelium and lamina propria, that lines the oral cavity and other organs and cavities of the body.
Muscle mold, border mold The shaping of a material by the manipulation or action of the tissues adjacent to the borders of an impression.
Mylohyoid ridge An oblique ridge on the lingual surface of the mandible that extends from the level of the roots of the last molar as a bony attachment for the mylohyoid muscles, which form the floor of the mouth; it determines the lingual boundary of the mandibular subperiosteal implant.
Nasal spine A median, sharp process formed by the forward prolongation of two maxillae at the lower margin of the anterior aperture of the nose; used to support a maxillary subperiosteal implant.
Necrosis The death of tissue.
Neoplastic Pertaining to new or abnormal growth.
Neuropathy Any functional disturbance or change in a nerve.
Neurovascular Pertaining to blood vessels and nerves.
Noninvasive Does not actively destroy surrounding tissue.
Nonresorbable Substances that show relatively limited in vivo degradation.
Obtundant A material used to obturate.
Obturate The act of closing or occluding.
Occlusal equilibration Achievement of a balance between opposing elements of the masticatory apparatus.
One-piece implant An abutment and an implant infrastructure that are constructed of the same continuous piece of metal.
Oral implant A biomaterial or device made of one or more biomaterials, biologic or alloplastic, that is surgically inserted into soft or hard tissues for functional or cosmetic purposes.
Oroantral An opening between the maxillary sinus and the oral cavity.
Oronasal An opening between the nasal cavity and the oral cavity.
Osseointegration The establishment of contact, without interposition of nonbony tissue, between normal remodeled bone and an implant at the light microscopic level, entailing a sustained transfer and distribution of load from the implant to and within the bone tissue.
Osseous Of the nature or quality of bone.
Osteoconduction A process in which bone is stimulated to grow from a host bone surface in a predictable fashion.
Osteoconductive A material that supports but does not stimulate bone growth.
Osteogenesis The development of bony tissue; ossification; the histogenesis of bone.
Osteoinduction A process that involves cellular change or cellular interaction. The cells are made to differentiate and do something they normally would not do. This technique is used when large bone grafts are performed.
Osteoinductive A material that stimulates new bone growth that would not be expected in routine healing.
Osteointegration See Osseointegration.
Osteo-odontotomy (odonto-osteotomy) A single osteotomy made through both a tooth and its supporting bone for placement of an endodontic implant.
Osteophilic response A condition that favors bone growth on the surface of a biomaterial.
Osteosynthesis See Osteogenesis.
Osteotomy Cutting of a bone.
Ostium An opening in the bone from the sinus to the nasal cavity.
Overdenture, overlay denture A removable partial or complete denture with built-in secondary copings that overlie or telescope over the primary copings fitting over the prepared natural crowns, posts, or studs.
Parafrenular Around the frenulum.
Parallel pin A directional guide used to assess the line of implant placement.
Parasymphyseal Around, associated with, or pertaining to the symphysis.
Paresthesia The onset of dysesthesia during the immediate postoperative period.
Parietal Of or pertaining to the walls of a cavity; a bone of the skull.
Particulate A process in which metals are treated to eliminate or reduce local surface areas of positive and negative ionic charges; a process in which the thickness of the oxide layer of a metal is increased.
Passive Without resistance, inert.
Patent Open, unobstructed, not closed.
Pedicle graft A full thickness of the skin or periodontal tissue attached to the donor site by a stalk with a nutrient blood supply.
Pedunculated Having a stemlike connecting part.
Penultimate Next to the last.
Perforate To pierce or make a hole.
Periapical Around or about the apex of the tooth.
Pericervical About or around the cervix.
Peri-implant Around the implant.
Peri-implantitis A general term defining an inflammatory disease process surrounding or involving implanted foreign materials; can be traumatic, ulcerative, resorptive, or exfoliative (e.g., periodontitis).
Periodontoplasty The surgical repair and reconstruction of the periodontium (e.g., peri-implantoplasty).
Periosteum Specialized connective tissue that covers all bones of the body except the cartilaginous extremities.
Peripheral struts The supports of a subperiosteal implant casting that are at the outermost area or farthest extent of the implant.
Permucosal Through the mucosa.
Permucosal pin implants Endosseous dental implants with smooth or threaded shafts that are used in bipodal or tripodal configurations as abutments.
Phlebotomy Incision of or entry into a vein.
Pier abutment An intermediate abutment (see Interdental implant).
Plaque A soft, thin film of food debris, materia alba, and dead epithelial cells that is deposited on a surface (teeth, prosthesis), providing a medium for the growth of various microorganisms.
Polyhema, polyhydroxylethylmethacrylate A synthetic, hydrophilic, polymeric material used in the body alone or in combination with other materials (contact lenses).

Polymer A naturally occurring or synthetic substance consisting of giant molecules formed from smaller molecules of the same substance.
Polymer tooth replica Polymethylmethacrylate (PMMA), used alone or in combination with other polymers (e.g., pHema), to form an implant, shaped like a tooth root recently extracted, and immediately placed into the tooth's alveolus.
Porosity The condition of having minute openings or pores.
Posterior palatal seal, postdam Postpalatal seal, the seal at the posterior border of a denture.
Postoperative Occurring after the operation.
Press-fit Retention of an implant by the proximity of bone, without the use of threads or tapping.
Primary healing A process of cure; the restoration of wounded parts by first intention union.
Primary retention The fixation in the initial period after implant placement, before integration occurs.
Primary struts The supports of a subperiosteal implant casting that cross the ridge crest and to which the abutments are affixed.
Procumbent Excessive labioaxial inclination of the incisors; protruding.
Prolapse To slip out of place.
Prosthetic Serving as a substitute.
Protocol The established methods.
Provisional restorations A prosthesis made for temporary use.
Pterygoid notch A groove at the pyramidal process of the palatine bone between the pterygoid plates and the maxillary tuberosity.
Pterygomandibular space A part of the infratemporal space that lies between the medial pterygoid muscle and the ramus of the mandible.
Pulley A small wheel with a groove in which a rope runs, allowing weights to be raised by pulling on the rope; the hamulus for the levator veli; palatinus tendon.
Punctate Resembling or marked with points or dots.
Purulence The formation or presence of pus.
Pus A protein-rich, liquid inflammation product made up of cells.
Pyriform aperture The pear-shaped anterior nasal cavity opening.
Radiopaque The quality of appearing light or white on exposed x-ray film; capable of blocking x-rays.
Ramus frame A full arch implant of tripodal design that consists of a horizontal supragingival connecting bar with endosteal segments placed into the two rami and symphyseal areas.
Ramus implant A type of endosteal blade implant placed in the ramus.
Reamer A sharp-edged tool for enlarging or shaping holes.
Receptor site former A duplicate form of a root-shaped or blade-shaped body of an implant; designed to form an osseous implant receptor site for implant shapes that cannot be prepared with rotating instruments; used for compression of intramedullary trabeculation or expansion of intramedullary space; a "try-in."
Receptor site An area in bone or soft tissue that is prepared to receive an implant or intramucosal insert.
Re-epithelization The process by which connective or osseous tissue recovers its epithelial surface.
Reflection The elevation or folding back of the mucoperiosteum to expose the underlying bone.
Rehabilitate To restore, to put back into good condition.
Reimplantation Reinsertion of a tooth into the alveolar socket from which it had been avulsed.
Resect To excise part or all of a structure surgically.
Residual ridge A remnant of the alveolar process and soft tissue covering after the teeth have been removed.
Resilient Having the ability to spring back into shape or position.
Resorbable Capable of assimilation or dissolution of a substance or material after it has been implanted into the body.
Resorption (of bone) The loss of bone substance by physiologic or pathologic means associated with the natural aging process, metabolic disturbances, or trauma.
Retainer Any type of clasp, attachment, or device used for the fixation or stabilization of a prosthesis.
Retraction The holding back of tissue to maintain operative site exposure and protect the tissues from trauma.
Retromolar pad A mass of tissue, frequently pear shaped, at the distal termination of the mandibular residual ridge, made up of the retromolar papilla and the retromolar glandular prominence.
Rhytidectomy The excision of skin to eliminate wrinkles.
Ridge (alveolar) The alveolar process and its soft tissue covering that remain after teeth are removed.
Ridge augmentation Increasing the dimensions of the existing ridge morphology.
Ridge crest The highest continuous surface of the alveolar ridge.
Ridge maintenance The process of keeping the ridge in existence.
Root form endosteal implant A root-shaped implant that derive its support from a vertical expanse of bone. These implants are available in the form of spirals, cones, rhomboids, and cylinders. They can be smooth, fluted, finned, threaded, perforated, solid, hollow, or vented. They can be coated or textured and are available in submergible and nonsubmergible forms in a variety of biocompatible materials.
Rudiment An incompletely developed or vestigial part.
Saddle The part of a complete or partial denture that rests on the ridge and to which the teeth are attached.
Salutary Conducive to health.
Saucerization (pericervical) The circular bone resorption that occurs about the necks of endosteal implants shortly after their insertion and continues slowly during the time of the implant's biologic presence.
Schneiderian membrane The membrane that lines the antrum.
Scout film The primary film in a computed tomography (CT) scan series; the film that dictates the scan parameters.
Screw implant See Root form endosteal implant.
Secondary epithelization Healing by the growth of epithelium over a denuded area.
Secondary struts The supports of a subperiosteal implant casting that build in strength and rigidity.
Second-stage surgery With subperiosteal implants, the reopening of the tissue and placement of the infrastructure that was constructed after the first-stage surgery. For endosteal submerged implants, the re-exposure of the part of the implant that receives the attachment or abutment.
Semiadjustable articulator A device that simulates jaw movements and that can be adjusted so that it conforms with the patient's mandibular functions.
Semilunar Resembling a crescent or half-moon.
Sequela The result of something; that which follows as a result.
Serosanguineous Composed of serum and blood.
Sessile Attached by a broad base.
Settling To sink, to move downward; caused by bone resorption under primary struts.
Shoulder The flat, horizontal projection connecting the infrastructure to the cervix.
Single-crystal sapphire A material for implantation composed of a single crystalline alpha aluminum oxide that is identical in crystalline structure to a gem sapphire.

Sinusitis Inflammation of a sinus.
Sinus lift Augmentation of the antral floor with bone substitutes to create a host site for implant placement; antroplasty.
Site former See Receptor site former.
Speculum An instrument for opening or extending an orifice or cavity to allow visual inspection and entry for manipulation.
Spinous Pertaining to or like a spine.
Spiral implant See Root form endosteal implant.
Splint A prosthetic device used to stabilize hard tissues (bone and teeth) during periods of healing.
Splinting The joining of two or more abutments into a unit.
Staple See Transosteal implant.
Stent A prosthetic device used to influence and guide the healing of soft tissues.
Sterile technique A standard technique in which an aseptic area is established and maintained to a specific conclusion (e.g., the proper sterilization of instruments, drapes, gowns, gloves, and surgical area); and the systematic maintenance of asepsis throughout an implant insertion procedure.
Sterilization Complete elimination of microbial viability. Caution must be exercised to ensure the preservation or the integrity and properties of an implant.
Stress Normally defined in terms of mechanical tensile stress, which is the form divided by perpendicular cross-sectional area over which the force is applied.
Stress break To relieve the abutment teeth of all or part of the occlusal forces.
Strip To break or jam the threads.
Stylus A pointed, needlelike marking device.
Subapical Below the apex of the tooth.
Subcuticular Situated or occurring beneath the skin.
Submandibular Below the mandible.
Submental Below the chin.
Submerged implant An endosseous implant with a removable head and neck that allow healing and maturation of the osteotomy and intraimplant trabeculation isolated from the oral cavity without a permucosal opening; a buried endosteal implant.
Subperiosteal implant A framework specifically fabricated to fit the supporting areas of the mandible or maxilla with permucosal extensions for support and attachments of a prosthesis; the framework consists of: permucosal extensions with or without connecting bars and struts. Struts are classified as peripheral, primary, and secondary. A subperiosteal implant can be the complete arch, unilateral, or universal type.
Superstructure The prosthesis that attaches to the mesostructure.
Surgery Treatment by manual or operative methods.
Surgical jaw relationship (subperiosteal) A registration of the vertical dimension in centric relationship of the exposed superior surface of the mandibular or maxillary bone with the opposing arch to provide intermaxillary registration for determination of abutment height of a subperiosteal implant framework.
Surgical occlusion rim (subperiosteal) A conventional occlusion rim with a base that has been adapted to provide an accurate recording of the surgical vertical-centric relations.
Surgical template A device designed to guide the location and direction of osteotomies preparatory to implant placement.
Suspensory ligament The ligament arising from a bone surface that surrounds and supports an endosseous or subperiosteal implant.
Suture The act of joining together, as by sewing.
Symphysis The immovable dense midline articulation of the right and left halves of the adult mandible.
Tamponade The use of compression to control hemorrhage.
Tapping The cutting of threads into medullary bone for a screw-type implant.
Telescopic coping A thin metal covering or cap that is fitted over the prepared tooth or implant abutment to accept a secondary or overlay crown or prosthesis.
Template A guide.
Tendinous Like or having the characteristics of a tendon; inelastic cords of tough, fibrous connective tissue by which muscles are attached to bones.
Threaded A spiral or helical surface of an implant.
Three-dimensional implant An endosteal implant that is placed from the lateral aspect of the alveolar ridge and supplies support in both the horizontal and vertical dimension.
Tissue-borne overdenture A prosthesis supported by the tissue and retained by the implant.
Torque A force or combination of forces that produce a twisting or rotating motion.
Toxicity The adverse reactions of tissues (dose-response time relationships) to selected foreign substances, resulting in unacceptable in vivo interactions. The toxicity can be at the local or systemic level, depending on the amount, rate of release, and specific type of substance available to the tissues.
Transaxial slice A computed tomography (CT) horizontal scan slice.
Transcortical Across the cortex of the bone.
Transect To divide by cutting across.
Transepithelial Going through or across the epithelium.
Transepithelial abutment The part of an implant that attaches directly to the infrastructure and passes through the soft issues into the oral cavity (permucosal); it acts as a platform for either a mesostructure bar or a prosthetic superstructure.
Transillumination The passage of light through an object to allow examination of its internal structures.
Transitional Temporary.
Transosteal The penetration of both the internal and external cortical plate by a dental implant.
Transosteal implant A type of implant designed to penetrate the mandible from the inferior border to the alveolar crest and to protrude sufficiently into the oral cavity through mucous membrane to provide retention and stability for a dental prosthesis.
Trephine Surgical method of creating a circular opening.
Trial inserts Implant replica to test a receptor site; modified intramucosal inserts worn during the healing phase at "try-in."
Tricalcium phosphate (TCP) An inorganic, particulate or solid form of relatively biodegradable ceramic, which is used as a scaffold for bone regeneration; it can act as a matrix for new bone growth.
Tripodal Three legged.
Trismus Motor disturbance of the trigeminal nerve, especially spasm of the masticatory muscles; limited opening of the mouth.
Truncated Having a square or broad end (e.g., truncated bone).
Try-in implant A replica, usually made of stainless steel, of the actual implant, which is used to check the shape and size of the osteotomy before the actual implant is placed.

Tuberosity, maxillary The most distal portal of the maxillary alveolar ridge that can be used for implant support.

Uncovering To unroof; after healing of a buried two-stage implant, the act of going through the soft tissue to relocate the implant.

Undermine To incise beneath; to form as a tunnel to separate mucosa or skin from underlying stroma.

Unaesthetic Without improvement of appearance, without beauty.

Unilateral subperiosteal implant A partial subperiosteal implant that usually is located in the posterior area of the mandible or maxilla.

Unit-built pontic A hollow, coping-shaped casting designed to allow placement of individual telescopic porcelain jacket crowns.

Universal subperiosteal implant A full arch subperiosteal implant that circumvents the remaining natural teeth.

Vertical dimension The superoinferior dimension of facial height; it can be altered by depressing or elevating the occlusal plane.

Vestibuloplasty Surgical modification of the gingival mucous membrane relationships in the vestibule of the mouth, including deepening of the vestibular trough.

Wolff's Law Every change in the use of static relationships of a bone leads not only to a change in its internal structure and architecture, but also to a change in its external form and function.

Xenograft See Heterograft.

Zygoma The area formed by the union of the zygomatic bone and the zygomatic process of the temporal and maxillary bones; used to support subperiosteal implants.

Sources for Glossary

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3. Cranin AN: *Oral implantology*, Springfield, Ill, 1970, Charles C Thomas.
4. *Dorland's Medical Dictionary*, ed 27, Philadelphia, 1988, WB Saunders.
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7. Dr. A. Norman Cranin.

Past Medical and Dental History

APPENDIX A

Name _____ Gender _____ Age _____ Date of Birth _____

Address _____

Telephone (Res.) _____ (Bus.) _____ Height _____ Weight _____

Directions

Please circle Yes or No and answer all questions.

1. Are you in good health? _____ YES NO
   a. Has there been any change in your general health within the past year? _____ YES NO
   _____
   b. If so, please explain _____
   _____
2. My last physical examination was on _____
   My last dental examination was on _____
3. Are you now under the care of a physician? _____ YES NO
   If so, what is the condition being treated? _____
   _____
4. My physician's name and address are _____
   _____
5. Have you had any serious illness or operations? _____ YES NO
   If so, what was the illness or operation? _____
6. Have you been hospitalized or had a serious illness within the past five (5) years _____ YES NO
   _____
   If so, what was the problem? _____
7. Do you have, or have you had, any of the following diseases or problems?
   a. Rheumatic fever or rheumatic heart disease YES NO
   b. Congenital heart lesions YES NO
   c. Cardiovascular disease (heart trouble, heart attack, coronary insufficiency, coronary occlusion, high blood pressure, arteriosclerosis, stroke) _____ YES NO
      (1) Do you have pain in your chest upon exertion? YES NO
      (2) Are you ever short of breath after mild exercise? YES NO
      (3) Do your ankles swell? YES NO
      (4) Do you get short of breath when you lie down, or do you require extra pillows when you sleep? YES NO
   d. Allergy YES NO
   e. Asthma or hay fever YES NO
   f. Hives or skin rash YES NO
   g. Fainting spells or seizures YES NO
   h. Diabetes YES NO

(1) Do you have to urinate (pass water) more than six times a day? _____	YES	NO
(2) Are you thirsty much of the time? _____	YES	NO
(3) Does your mouth frequently become dry? _____	YES	NO
i. Hepatitis, jaundice, or liver disease	YES	NO
j. Arthritis (painful, swollen joints)	YES	NO
k. Stomach ulcers	YES	NO
l. Kidney trouble	YES	NO
m. Tuberculosis	YES	NO
n. A persistent cough or a cough that brings up blood	YES	NO
o. Low blood pressure	YES	NO
p. Venereal disease	YES	NO
q. Other		
8. Have you had abnormal bleeding associated with previous extractions, surgery or trauma? _____	YES	NO
a. Do you bruise easily?	YES	NO
b. Have you ever required a blood transfusion?	YES	NO
If so, explain the circumstances _____		
9. Do you have any blood disorder, such as anemia?	YES	NO
10. Have you had surgery or x-ray treatment for a tumor, growth, or other condition? _____	YES	NO
11. Are you taking any drugs or medicine (not limited to the ones listed below)? _____	YES	NO
a. Antibiotics or sulfa drugs	YES	NO
b. Anticoagulants (blood thinner)	YES	NO
c. Medicine for high blood pressure	YES	NO
d. Cortisone (steroids)	YES	NO
e. Tranquilizers	YES	NO
f. Aspirin	YES	NO
g. Insulin, tolbutamide (Orinase), or a similar drug	YES	NO
h. Digitalis or drugs for heart trouble	YES	NO
i. Nitroglycerin	YES	NO
j. Medicine for osteoporosis _____		
k. Other	YES	NO
12. Are you allergic to or have you reacted adversely to any of the following?		
a. Local anesthetics	YES	NO
b. Penicillin or other antibiotics	YES	NO
c. Sulfa drugs	YES	NO
d. Barbiturates, sedatives, or sleeping pills	YES	NO
e. Aspirin	YES	NO
f. Other		

13. Have you had any serious trouble associated with any previous dental treatment? _____	YES	NO
a. Are you having dental pain?	YES	NO
b. Does food pack between your teeth?	YES	NO
c. Do your gums bleed when you brush your teeth?	YES	NO
d. Do you grind your teeth during the night?	YES	NO
e. Do you have any pain in or near your ears?	YES	NO
f. Have you ever had periodontal (pyorrhea) treatment?	YES	NO
g. Have you ever been instructed on proper home care of your teeth?	YES	NO
h. Do you have any sores or lumps in your mouth?	YES	NO
i. Do you want to keep your teeth?	YES	NO
14. Do you have any disease, condition, or problem not listed above that you think I should know about?	YES	NO

If so, please explain _____

Questions for Women

15. Are you pregnant? _____	YES	NO
16. Do you have any problems associated with your menstrual period? _____	YES	NO
17. Date of onset of your last menstrual period _____		

Remarks:

Signature of Patient:

Date:

Laboratory Values

APPENDIX B

NORMAL COMPLETE BLOOD COUNT

WBCs (cells/μL): 4.800-10.800		
RBC (cells/μL)	Male: 4.7-6.1 × 10^6	
	Female: 4.2-5.4 × 10^6	
Hemoglobin (g/dL)	Male: 14-18	
	Female: 12-16	
Hematocrit (%)	Male: 40-54	
	Female: 37-47	
MCH (pg)	27-31	
MCHC (%)	33-37	
MCV (fl)	Male: 80-94	
	Female: 81-99	
RDW	11.5-14.5	
Platelets (μL)	150-450	
Differential	Segmented neutrophils	41%–71%
	Stab neutrophils	5%–10%
	Eosinophils	1%–3%
	Basophils	0–1%
	Lymphocytes	24%–44%
	Monocytes	3%–7%

WBC, White blood cells; *RBC,* red blood cells; *RDW,* red blood cell distribution width; *MCV,* mean corpuscular volume; *MCH,* mean corpuscular hemoglobin; *MCHC,* mean corpuscular hemoglobin concentration. (See the section on differential diagnosis to calculate the values of the MCV, MCH, and MCHC.)

NORMAL URINE VALUES

Appearance: Yellow, clear, straw colored, clear
Specific gravity:
Neonate: 1.012
Infant: 1.002-1.006
Child and adult: 1.001-1.035
pH:
Newborn/neonate: 5-7
Child and adult: 4.6-8.0
Negative for: Bilirubin, blood, acetone, glucose, protein, nitrite, leukocyte esterase
RBC: 0-3 per high-power field (HPF)
WBC: 0-4 per HPF
Epithelial cells: Occasional
Hyaline casts: Occasional
Bacteria: None

CHEMISTRY VALUES (μg/dL)

Glucose	75-110
Urea	7-24
Creatinine	0.6-1.6
Sodium	133-145
Potassium	3.5-5.5
Chloride	94-108
Carbon dioxide	22-28
Uric acid	2.0-7.0
Calcium	8.5-10.5
Phosphorus	2.5-4.5
Total protein	5.7-8.0
Albumin	3.67-5.0
Alkaline phosphatase	28-120
Total bilirubin	0.2-1.0
Cholesterol	150-250

PROTHROMBIN TIME (PT)

11.5-13.5 seconds (within 4 seconds of control)

PARTIAL THROMBOPLASTIN TIME (PTT)

27-38 seconds (within 5 seconds of control)

CAD/CAM Computed Tomography

C
APPENDIX

CD-ROM HANDLING REQUIREMENTS

The following are the CD-ROM handling requirements for all bone modeling exams sent to Techmedica.

The image data from the exam can be stored using any archiving program and copied onto a new, unused CD-ROM. The raw or scan data should be saved as backup. If the scan is performed on the cone beam volumetric tomography (CBVT) scanner, the formatted image can be copied onto a CD-ROM using an archiving program included with the software native to the scanner.

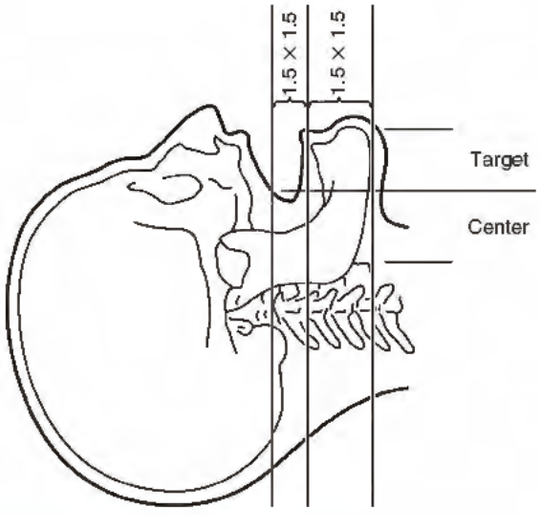
The CD-ROM must be clearly labeled as follows:

- Imaging center's name, and address
- Telephone number
- Scan technician's name
- Scanner type
- Volume (full or partial)
- Patient's name
- Patient's side (left or right)
- Run number
- Scan protocol number
- Referring physician's name

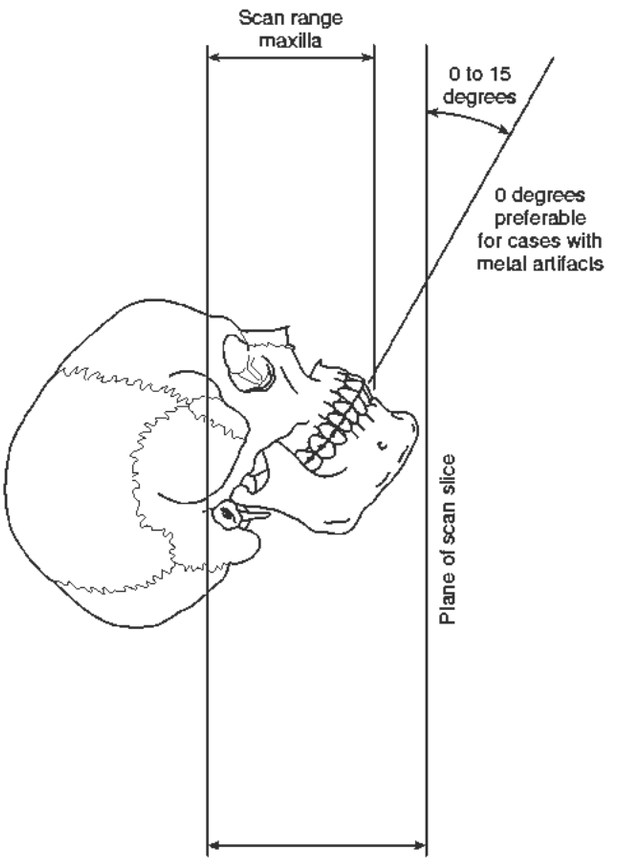
The scout view is filmed with the slice locations posted (every other or every third slice location is posted if the scan interval is small) and the sagittal and coronal arrange cuts through the plastic rod.

Mandible Modeling for a Subperiosteal Implant

CT Scan Protocols	Data Transmission	Procedure
Patient movement	Scanner maintenance check	Remove all metal from patient's head and neck (e.g., jewelry, hairpins).
Anatomic feature	Mandible	Position the patient with the head as far into the head holder as possible. Wear gloves.
Patient positioning	With the patient lying supine, place the head as far as possible into the coronal head holder so that the mandible is behind the metal in the forward part of the head holder. Place a pillow under the patient's knees for comfort. Wedge sponges between the head and head holder, if space is available, to prevent patient movement. Strap the chin and forehead.	Wet the intraoral jig and shake off excess moisture. Sprinkle the gum areas of the jig with Rigident powder and shake off excess. Insert the jig into the patient's mouth. Lubrication of the lips with lubricating jelly may be necessary. Attach the vacuum line to the jib tube and set on the lowest possible setting that still evacuates saliva. If the vacuum "grabs" the tongue, reduce vacuum. Palpate the inferior border of the anterior body of the mandible and position it parallel to the scan plane. Secure patient's head in head holder.
Plastic rod location	Tape the ⅜ -inch diameter plastic rod to the patient's face, down the midline, from the end of the nose to past the end of the chin, so that the rod is approximately perpendicular to the scan plane.	
Scout view	Lateral	
Scan thickness	1.5 mm	
Scan interval	1 mm (entire body of mandible) 1.5 mm (rami of mandible)	
Prospective target	Center target half the distance between the mentum and the anterior aspect of the body of the vertebra	
Calibration file	Head	
Target factor (GE 8800 scanner)	1.25 (key in all three digits)	
Field of view (GE 9800 scanner)	20 cm	
Algorithm (mA)	0 (bone)	
(GE 8800 scanner)	320 mA at 2 pulse width, KV = 120 (NOTE: If fast tube cooling is available, use dynamic scan at 320 mA, 2 pulse width with interscan delay of 7 sec for first 20 slices.)	
(GE 9800 scanner)	200 mA at 2 sec scan time, KV =120	
Raw/scan data save	Yes (save for 3 months at your facility. Do not send raw/scan data to Techmedica)	
First slice location	1.5 mm below inferior border of the body of the mandible.	



1. Take a lateral scout film. Center target half the distance between the mentum and the anterior aspect of the body of the vertebra.
2. Locate the first slice position and scan at 1-mm intervals until just past the crest of the ridge of the body of the mandible anteriorly. Continue the scan at 1.5-mm intervals until 5 mm below the sigmoid notch.
   NOTE: Check the first slice to make sure you are below bone and within the target area. If adjustment is necessary, make it before starting the run.
3. Under no circumstances should the gantry be angled.
4. After the exam is complete and the images have been reformatted, hold the patient and perform both a sagittal and coronal reconstruction of the plastic rod using the Arrange program. These reconstructed images of the rod should appear straight, with no jogs or bends. Perform a screen save of the reconstructed images of the rod. Only after this movement check is complete may the patient leave.



PATIENT POSITIONING AND SCANNING RANGE: ANATOMIC MODELING OF MANDIBLE AND MAXILLA

Scanner Settings for Maxillofacial and Mandibular Regions

GE 9800 Quick
120kV, 100mA, dynamic scan (6-sec delay)
512 × 512 matrix
1- to 2-mm thickness/1 mm spacing
(13- or 14-cm field of view) 0.4-mm pixel
Gantry angle: zero
Bone algorithm

GE 8800
120 kV, 200 mA, 9 or 3 sec
Dynamic scan
320 × 320 matrix, 576 views
1- to 2-mm thickness/1-mm spacing
Target 2 (0.4-mm pixel size)
Gantry angle: zero
Bone algorithm

Philips (310, 350, T60, TX60)
120 kV, 100 mA, dynamic scan (4.5 to 7 sec)
512 × 512 matrix
1.5-mm thickness/1-mm spacing
Zoom factor
320 matrix = 13 cm
512 matrix = 14 cm
Gantry angle: zero
Bone algorithm, filter 4C

Delta 200 Series
120 kV, 100 mA, dynamic scan (2-sec scan)
512 × 512 Matrix
1- to 2-mm thickness/1-mm spacing
≤0.4-mm pixel size (mag 2)
Gantry angle: zero
Normal head filter

Siemens—DR Series
120 kV, 200-280 MAS, dynamic scan
480, 720, or 960 projection
1.5-mm thickness/1-mm spacing
Zoom factor
Average head 3.7 = 0.29-mm pixel (13.78 cm)
Small head 4.5 = 0.24-mm pixel (11.3 cm)
Large head 2.7 = 0.4-mm pixel (18.9 cm)
Archive images *in view from below* form
Gantry angle: zero
Bone detail, kernel 8

Picker 1200
120 kV, 200 MAS, dynamic scan (2 to 3.4 sec)
512 × 512 Matrix
1- to 2-mm thickness/1-mm spacing
14-cm field of view = 0.4-mm pixel
Gantry angle: zero
Bone algorithm no. 4

1. Metal braces, piercings, dentures, reading glasses, and jewelry should be removed from the head and neck region, if possible, before scanning.
2. The area of interest must completely fill the screen using the smallest field of view, which allows for a smaller pixel size.
3. Placement of a cold-cure bite jig in the mouth is highly recommended. If one is not available, a nonopaque article, such as a tongue depressor wrapped in gauze, should be placed between the teeth.
4. Absence of motion artifacts is essential. The patient's head should be taped securely, and dynamic scanning should be used to eliminate motion.
5. To help detect patient motion, an acrylic rod or ball point pen (with the insides taken out) should be taped vertically on the lateral portion of the patient's face.
6. Archive the *image* data to a CD-ROM in the *uncompressed* (800 or 1600 bpi) form. (GE 9800 compressed data is the only exception.) No gantry tilt.
7. Only one case should be loaded on each new magnetic tape. Label the tape with the patient's name, the scanner type, and the physician's name.
8. An interscan delay of 7 to 10 seconds is recommended to keep tube cooling time to a minimum.

Modeling for a Subperiosteal Implant Using Data from a CBVT Scanner

CT Scan Protocols	Data Transmission	Procedure
Patient movement	Scanner maintenance check	Remove all metal from the patient's head and neck (e.g., jewelry, hairpins).
Anatomic feature	Mandible or maxilla	Position the patient with the head as far into the head holder as possible. Wear gloves.
Patient positioning	With the patient standing or sitting upright in the machine, place the head as far as possible into the head holder so that the mandible is behind the metal in the forward part of the head holder. To prevent patient movement, strap the forehead.	Palpate the inferior border of the anterior body of the mandible and position it perpendicular to the scan plane. Secure the patient's head in the head holder.
Scout view	Panorama	
Scan thickness	0.3/0.15 mm	
Scan time	14 sec/2-6 sec entire volume (15 × 15 × 15) cm^3	
Reconstruction time	2.5 to 4.5 min	
Prospective target	The head should be perpendicular to the tube head and the plate.	
Calibration file	Head positioner, chin rest, and support	
Target factor (Sirona Galileos scanner)	Full color touch screen	
Field of view (Sirona Galileos scanner)	15 × 15 × 15 cm^3	
	12 × 15 × 15 cm^3	
Algorithm (mA) (Sirona Galileos scanner)	0 (bone)	
	5 to 7 mA at 2 pulse width, KV = 85	
Effective dosage (Sirona Galileos scanner)	29 µSv/68 µSv	
	21 mAs, 85 kV	
Raw/scan data save	Yes	

1. Metal braces, piercings, dentures, reading glasses, and jewelry should be removed from the head and neck region, if possible, before scanning.
2. The area of interest must completely fill the screen using the smallest field of view, which allows for a smaller voxel size.
3. Absence of motion artifacts is essential. The patient's head should be braced securely to eliminate motion.
4. An interscan delay of 4 to 7 minutes is recommended to keep tube cooling time to a minimum.
5. Archive the *image* data to a CD-ROM in the *uncompressed* form.
6. Only one case should be loaded onto each new CD-ROM. Label the CD with the patient's name, the scanner type, and the physician's name.
7. After the exam is complete and the images have been reformatted, hold the patient and perform both a sagittal and a coronal reconstruction. These reconstructed images should appear straight, with no jogs or bends. Save the reconstructed images. Only after this is complete may the patient leave.

After the exam is completed and the images have been reformatted, hold the patient and perform both a sagittal and a coronal reconstruction. These reconstructed images should appear straight with no "jogs" or bends. Save the reconstructed images and only after this is complete may the patient leave.

- Archive the *image* data to a CD-ROM in the *uncompressed* form.
- Only one case should be loaded on each new CD-ROM. Please label the CD with patient name, scanner type, and physician's name.
- Area of interest must completely fill the screen using the smallest field of view, which provides for a smaller voxel size.
- Absence of motion artifacts is essential. The patient's head should be braced securely to eliminate motion.
- An interscan delay of 4 to 7 minutes is recommended to keep tube cooling time to a minimum.
- Removable metal braces, piercings, dentures, reading glasses, and jewelry in the head and neck region should be removed before scanning.

Stereolithographic Reproduction of Anatomic Structures Using a CT or CBVT Scan

ORDERING AN ANATOMIC MODEL

1. Call the scanning facility for appointment, or if you have a cone beam volumetric tomography (CBVT) scanner in your facility, schedule the patient according to the usual procedure.
2. Determine whether the facility has ever used the scanning protocol required for anatomic model generation.
3. Fill out the patient information sheet.
4. Send a scan protocol to the scanning facility. More important, send it to the technologist doing the scan. To prevent any mistakes, send a copy of the scan protocol with the patient.
5. It is important to fill out the patient information sheet and fax it directly to the facility generating the anatomic model, or it can be sent with the electronic computed tomography (CT) data. Because necessary scanner data are included on the patient information sheet, ask the scanning technologist to fill out that portion.
6. To prevent any misunderstanding about the anatomy to be scanned, mark the area to be scanned on the skeletal worksheet and send it with the patient to the scan facility.
7. Whether the data are being sent from the hospital or the implantologist's office, include the necessary patient information sheet and skeletal worksheet.
8. Send the data overnight delivery; this helps prevent any delays or damage to the electronic data.
9. If you are concerned about the scan facility or with the scan quality, call your model-generating facility, which will call the scan facility immediately before the scan. The scan facility should proceed step by step through the protocol to obtain a quality scan.
10. Inform your office staff of modeling activities so that the modeling facility can contact them in case of your absence.

SCAN PROTOCOL FOR THE SCANNING TECHNOLOGIST

1. *Always use a zero-degree gantry tilt when using a flatbed scanner.*
2. When scanning the patient, proceed three slices above and three slices below the area of interest.
3. Choose the appropriate field of view for the area of interest.
4. The field of view, patient position, and table height must not be changed during the scan.
5. Scan the patient with appropriate technical factors for the anatomy.
6. Monitor the patient closely for any motion during the scan. If motion is detected during the scan, rescan the patient.
7. Bone algorithm or edge enhancement need not be used. Simply use a combination of bone and soft tissue, if possible.
8. Send the files to the modeling facility on a CD-ROM (one study per CD-ROM). The modeling facility may be able to have the data uploaded to an FTP site, from which the data can be retrieved (contact the modeling facility to confirm the data delivery mode).
9. *For a CT scan:* Place the patient supine on the table. Position the head so that the nasomeatal line is perpendicular to the table. The recommended slice interval is 1 mm by 1 mm for individual bony facial anatomy, including the mandible. For the complete skull, an interval of 2 mm by 2 mm is acceptable. A wise course is to use radiopaque positioning rods during the scan. A three-dimensional reconstruction of the rod can be done on the scanner to check for motion.
10. *For a CBVT scan:* Have the patient in a sitting or standing position. Place the head straight, with the inferior border of the mandible parallel to the floor and perpendicular to the imaging plate.

ANATOMIC MODELING FACILITIES

Innova International
850 S. Greenville Ave. Suite 114
Richardson, TX 75081
Tel: 972-761-0491
Fax: 972-761-0495
Innova@dallas.net

3D Systems Corporation
333 Three D Systems Circle
Rock Hill, SC 29730
Tel: (803) 326-3900
Technical support: (803) 326-4080
www.3dsystems.com

Medical Modeling Corp.
17301 West Colfax Ave. Suite 300
Golden, CO 80401
Tel: 303-273-5344 or 1-888-273-5344
Fax: 303-277-9472
www.medicalmodeling.com

QUESTIONNAIRE*

Patient Name _____ Date of Scan _____ Time _____

Check all that apply:

Patient-specific bone model _____
Patient-specific soft tissue model _____
Selectively colored model _____
3-Dimensional .stl file only _____
Custom implant design _____
Computer-aided design for custom instruments _____

Circle One:
CT scan
or
MRI

Patient History/Diagnosis

Physician Information

Dr. _____
Add: _____
_____
City/St: _____
Zip: _____
Tel: (_____) _____-_____
Fax: (_____) _____-_____

Scan Information

Hospital/clinic: _____
_____
Technologist: _____
Phone: _____
Scanner model: _____
Technical factors: KV _____MA_____S_____
Slice/slice spacing: _____
Gantry tilt:

Physician's signature required:
Dr._____
If billing other than to physician, please contact modeling facility for assistance.
Modified from Innova patient information sheet
*Anatomic models are not for direct implantation.

Treatment of Metals

APPENDIX E

Metals that require special treatment are nontitanium castings (e.g., Vitallium subperiosteal or blade implants). By following these instructions, the practitioner is assured of having passivated (oxide-coated), fat-free, clean, and wettable surfaces. The casting requires autoclaving after the treatment is complete. Autoclaving is best done in a nonmetallic container, such as a porcelain coffee cup.

ARMAMENTARIUM

Six glass laboratory beakers
Two porcelain coffee cups
Arm and Hammer bicarbonate of soda
Triple-distilled water (that can be released from a spout, spigot, or petcock for rinsing)
Special filter for compressed air systems to eliminate oil and other lubricants
10% phosphoric acid
30% nitric acid
Acetone
Autoclave and autoclaving bags

CAVEATS

Respect and follow this seemingly complicated series of steps. They may make the difference between success and failure of your implant.
Do not handle castings with bare fingers. Use new, talc-free rubber gloves. Talcum powder can cause serious tissue reactions.

STEPS OF THE PROCESS

1. Degrease the casting in an organic solvent (acetone is an excellent choice). Use a porcelain cup for these solutions, and immerse the casting for 10 minutes.
2. Dry the casting with an air syringe. The compressor must be equipped with a filter to eliminate oil and other contaminants.
3. Place the casting in a beaker filled with 1 heaping tablespoon of bicarbonate of soda in distilled water and boil it for 5 minutes.
4. Rinse the casting in cold, triple-distilled water, using a gloved finger to scour every exposed part.
5. Dip the casting in 10% phosphoric acid, which should be placed in a second cup or beaker.
6. Thoroughly rinse the casting in cold, triple-distilled water using a gloved finger.
7. Passivation is achieved by immersing the casting in 30% nitric acid at 130° F for 30 minutes. A third porcelain or glass vessel is required.
8. Rinse the casting in cold, triple-distilled water.
9. Rinse the casting in hot, triple-distilled water.
10. Dry the casting using clean air.
11. Autoclave the casting at 270° F for 15 minutes in a porcelain or glass beaker. If immediate implantation is not planned, the casting should be bagged for dating and storage.

RADIOFREQUENCY AND PLASMA GLOW DISCHARGE: CLEANING, TREATING, AND STERILIZATION

A radiofrequency glow discharge (RFGD) unit prepares an implant for insertion without subjecting it to the steps just listed.

The goal in placing implants is to achieve the greatest adhesive strength in conjunction with host tissues by promoting excellent tissue bonding to the implant's surfaces. In addition, the part of each implant that protrudes into the oral cavity must resist bacterial colonization and discourage the formation of plaque and the production of endotoxins; this encourages primary healing around the abutments and contributes to good oral hygiene.

Useful tools for reaching these goals are the Picotron plasma glow discharge system (Surgical Innovators of America, Park Dental Research Implant Center) and a RFGD unit designed by Dr. Robert Baier (Herricks, Inc., Ossining, New York). With these units, the surfaces of an implant can be cleaned, sterilized, and conditioned. These techniques increase the wettability of an implant and thereby enhance its surface energy, which promotes bioadhesion. The cycle time of these units is approximately 5 minutes, and their use requires no technical skills. The practitioner simply inserts the implant, closes the door, creates a vacuum in the chamber, releases the argon gas, and sets the timer. On removal, the casting is placed in a sterile beaker or sealable vessel containing triple-distilled water until it is ready for use.

Consent Form for Implant Surgery

The implant surgery procedure has been explained to me, and I understand what is necessary to accomplish the placement of the implant under the gum or in the bone. The Dr./s have carefully examined me. To my knowledge, I have given an accurate report of my health history. Any prior allergic or unusual reactions to drugs, foods, insect bites, anesthetics, pollen, dusts, blood or body disease, gum or skin reactions, abnormal bleeding, or any other conditions concerning my health are included.

I was informed of other methods that would replace missing teeth. I have tried or considered these methods, and I prefer an implant(s) to help secure the replaced missing teeth. I understand that any of the following may occur: bone disease, loss of bone and/or gum tissue, inflammation, swelling, infection, sensitivity, looseness of teeth, followed by necessity of extraction. Also possible are temporomandibular joint problems, headaches, referred pains to the back of the neck and facial muscles, and tired muscles when chewing. I also understand that if conventional removable dentures are used, I may suffer injury to and/or loss of teeth and bone as well.

The Dr./s have explained to me that there is no method of predicting accurately the gum and bone healing capabilities of each patient after placement of an implant. I understand that smoking, alcohol, or departures from acceptable dietary practices may affect gum healing and may limit the success of the implant(s). I agree to follow home care and dietary recommendations per the Dr./s' instructions. I agree to report for checkups as instructed. A reasonable fee will be charged for these examinations after the first year of implant placement. If, for any reason, at the discretion of the Dr./s, it is deemed that the implant is not serving properly, it is agreed that the implant will be removed. It will be replaced with conventional prosthesis or another implant, depending on the decision of the Dr./s.

I have been informed and understand that occasionally complications of surgery, drugs, and/or anesthesia occur. Pain, bleeding, swelling, infection, discoloration, and numbness of the lip, chin, face, tongue, cheek, or teeth may occur, the exact duration of which may not be determined. The numbness may be irreversible. Also possible are inflammation of a vein, injury to teeth if present, bone fractures, nasal or sinus penetration, delayed healing, and allergic reactions. It has been explained to me that implant therapy may fail, and in such case the implant must be removed.

With full understanding, I authorize the Dr./s to perform dental services for me, including implants and other surgery. I agree to the type of anesthesia chosen. I agree not to operate a motor vehicle or other hazardous devices for 24 hours or until fully recovered from the effects of the anesthesia or drugs given for my care, whichever is longer.

I authorize photographs, slides, videos, x-ray films, or any other viewing of my care and treatment during its progress to be used for the advancement of dentistry. I approve any modification in designs, materials, or care if, in the professional judgment of the Dr./s, it is in my best interest.

I understand that there is no warranty or guarantee as to any result. I am further advised that I can get additional explanations of risks before or during the progress of my treatment merely by asking.

The procedure and its risks have been explained to me by

_____

_____

Date Patient Witness

Postoperative Guidelines for the Implant Surgeon

APPENDIX G

ROUTINE

Antibiotics

Use preoperative antibiotics routinely at double the therapeutic level or greater, or the prophylaxis dose recommended by the American Heart Association (AHA). Administration should provide maximum blood levels at the time of incision.

Analgesics

Depending on the severity of the procedure and an assessment of the patient's level of pain tolerance:

- Ibuprofen (Motrin), 400 to 600 mg, four times daily, or a comparable non steroidal anti-inflammatory drug (NSAID), such as Advil (two tablets four times daily) or Aleve (two tablets twice a day after meals) for the first five days after surgery is effective.
- More potent are the codeine drugs (with aspirin or Tylenol), 30 to 60 mg. In further ascending order of effectiveness are hydrocodone (Vicodin) or Vicodin ES (Extra Strength) or oxycodone (Percodan [with aspirin] or Percocet [with acetaminophen]). The last two drugs may be quite habituating. All pain medications are taken every 4 to 6 hours.
- For patients sensitive to codeines, Demerol, 100 mg, is effective.

If gastritis occurs, it can be handled with an antacid (e.g., Maalox) or by administrating the analgesic with yogurt.

Edema

Generally, nature should be allowed to take its course. If the patient or physician is concerned, and if it has been established that the edema is not related to infection, use steroids both intraoperatively and postoperatively. During the procedure, 20 mg of dexamethasone may be given intravenously. This can be followed postoperatively for several days with 5-mg tablets four times daily or a Medrol dose pack. (Consider not prescribing medications every 6 hours, because it often confuses patients, who forget to take the fourth pill because of the hours of sleep). When anti-inflammatory drugs are used, the wise course is to keep patients covered with antibiotics. The use of ice is important only for the first 48 hours. It should be wrapped in a towel and applied over the facial tissues apposing the operative site, 20 minutes on and 20 minutes off.

Local Care

1. Chlorhexidine rinses (Peridex, Perioguard) should be used gently three to four times daily for 2 weeks.
2. Brushing at the operative site should be discouraged for the first 3 to 4 days. Then, a very soft brush (e.g., Oral B-20 or -30) can be used carefully for cleansing. Any dentifrice is satisfactory.

Diet

For the first 2 days, only a liquid or blender-produced pureed diet is acceptable. Mastication of food of challenging texture that might injure the operative site should be avoided. Plan a reasonable, nutritionally balanced diet for each patient. It should not cause physical or local injury, and it should be high in protein and moderate in texture. A sample diet, day by day, for the immediate postoperative period can be found in Appendix I.

Postoperative Problems

Instruct patients to call immediately if any difficulty arises about which they may have a question. If, some unanticipated complication is noted after an examination, refer to Chapter 28 for guidance.

SPECIAL POSTOPERATIVE REGIMEN—ANTRAL PROCEDURE

Place an implant into the sinus after cortical penetration (the treatment of such complications should be reviewed in Chapters 18 and 23). Hard tissue replacement (HTR) and hydroxyapatite (HA) repairs are always beneficial, and routine antibiotic regimens should accompany their use. In these conditions, initiate a special plan. Instruct the patient as follows:

1. Do not blow your nose.
2. Try not to sneeze.
3. Take a decongestant for 10 days, such as Ornade spansules, one every 12 hours; or for hypertensives, pseudoephedrine (Sudafed), 60 mg, one every 6 hours.
4. Recommended oral antibiotics:
   - Ampicillin 500 mg four times daily
     or
   - Augmentin 875 mg twice daily
     or
   - Amoxicillin 500 mg three times daily
     or
   - Ceftin or cefazolin 500 mg twice daily
   - If the patient is allergic to penicillin:
     - Biaxin, 500 mg twice daily
       or
     - Zithromax, 500 mg the first day, then 250 mg once daily to complete 5 days
5. Afrin 12-hour nasal spray (oxymetazoline), or a steroid, such as Beconase, Flonase, or Vancenase, two puffs in each nostril twice daily for 3 days to dry up the sinuses and reduce inflammation after surgery.

Postoperative Instructions for the Patient

1. Fill the prescription(s) and follow the instructions on the label(s).
   (Consider handing the patient the prescriptions or calling in the prescriptions to the patient's pharmacy a few days before the surgery date and recommend that the patient pick up the medications a few days before surgery. The patient thus has the medications on hand and after surgery does not have to wait to take the medications or need not be inconvenienced by waiting at the pharmacy to have the prescriptions filled. Another reason to have the prescriptions filled before the date of surgery is to give the pharmacy time to order the drug if it is not in stock, so that the patient will not have to wait for it after surgery.)
2. Apply ice wrapped in a cloth to your face, 10 minutes on, 20 minutes off, for 48 hours.
3. Make the following solution: To 1 quart of tap water, add 1 level teaspoon of table salt. Mix. Bring to a boil. Store in a covered container. Use as a gentle irrigant, 8 ounces each hour. Do not use vigorously. Start tomorrow and continue until your sutures are removed.
4. Eat very soft foods as tolerated. They should be high in protein. Good choices are soft boiled eggs, milk, ice cream, malts, boiled chicken and soup, cheeses, and junior foods.
5. For the first 24 postoperative hours, drink plenty of fluids: juice, soda, water, or milk.
6. Take 2 tablespoons of milk of magnesia tonight.
7. Expect a good amount of swelling and some discoloration. These are common and do not indicate infection or other problems. Sleep with your head well elevated; even so, you will find swelling to be most marked on arising tomorrow morning. It is not uncommon to have bleeding from the nostril for a day or two after surgery in the upper jaw, especially after a sinus lift or antral elevation procedure. Do not blow your nose.
8. If severe bleeding occurs, elevate your head, apply ice to the back of your neck, and bite on a piece of gauze for 25 minutes. If the bleeding persists, bite on a wet teabag.
9. Do not hesitate to telephone if any questions arise about your condition or the operation. In an emergency, you should call us at (telephone number).

Recommended Diet After Implant Surgery

NOTE: Until all sutures have been removed or have dissolved or for 2 weeks after surgery, no foods with small seeds should be eaten, and for at least the first week, neither should foods with sharp corners or edges.

Day 1: Liquid diet: soups, Jell-O, high-protein drinks (e.g., Sustacal, Ensure). The patient should not wear prostheses for eating and should wear them only for esthetics for the first 2 weeks after surgery.

Day 2: Same as day 1.

Day 3: Pureed diet, any food that can be well blenderized; applesauce; mashed potatoes; soft boiled or scrambled eggs; pasta.

Day 4: Same as day 3.

Day 5: Same as day 4.

Days 6 to 14: Soft, high-protein diet (e.g., Salisbury steak, tuna fish, boiled chicken, soup, cheeses).

After day 14: Return to normal diet.

Implant Patient Follow-Up Form

Patient Name _____ Follow-up Date _____

Address _____

Age _____ Gender _____ Telephone _____

Dentist _____ Surgical Implantation Date _____

Prosthetic Loading Date _____

1. Check mobility (at each abutment/implant junction) Periotest M

   Less than 0.5 mm laterally

   More than 0.5 mm laterally

   Depressable with finger pressure Yes

   No

2. Intraoral color photograph taken _____

3. Condition of gingival tissue (at each abutment/implant junction)
   Normal _____ Hyperplastic _____ Suppuration _____ Gingivitis _____ Inflamed _____

4. Intraoral radiograph taken _____

   Appearance: Normal _____

   Bone resorption 0.5-1 mm _____

   1-2 mm _____

   2-3 mm _____

   3-4 mm _____

5. Pain:
   None _____ Nocturnal _____ Upon Function _____ Intermittent _____ Constant _____

6. Prosthesis:

   Mobility: Yes _____ No _____

   Plaque: Yes _____ No _____

   Occlusion: Normal _____

   Needed adjustment _____

7. Treatment needs:

   Soft tissue procedure _____

   Osseous graft _____

   Replacement of prosthetic components _____

   Tightening of prosthetic screws _____

Examiner's Signature _____

Date _____

A separate form is used for each implant.

Manufacturers and Suppliers of Equipment and Materials

ACE Surgical Supply
1034 Pearl St.
P.O. Box 1710
Brockton, MA 02301
Ph: 1-508-588-3100
1-800-441-3100
Web: infor@acesurgical.com
www.acesurgical.com
AlloDerm Acellular Dermal Graft

Lifecore Biomedical
3515 Lyman Blvd
Chaska, MN 55318

Anchor Implant
Vancouver Implant Resources Inc.
2370 Maple St.
Vancouver, BC, V6J 3T6 Canada
Web: AnchorSimpler@MSN.com
Arestin

OraPharma
Ph: 1-866-273-7846

Aseptico
P. O. Box 1548
Woodinville, WA 98072
Ph: 1-800-426-5913
Astra Tech Implants

Astra Tech
890 Winter St.
Waltham, MA 02451
Atridox

Tolmar
701 Centre Ave.
Fort Collins, CO 80526
Ph: 1-970-212-4500
Web: info@tolmar.com

Attachments International
824 Cowan Road
Burlingame, CA 94010
Atwood 347 Diamond Bur

Atwood Industries
1708 Rubenstein Drive
Cardiff by the Sea, CA 92007
Autostaple Skin Closure

U. S. Surgical Corporation
150 Glover Ave.
Norwalk, CT 06856
Avetine

Alcon Laboratories
6201 S. Freeway
Fort Worth, TX 76134
Bard-Parker

Becton & Dickinson
1 Becton Drive
Franklin Lakes, NJ 07417
Basic Implant
Bicon Implants
Dental Implant Systems, Inc.

Bicon Dental Implants
501 Arborway
Boston, MA 02130
Web: support@bicon.com

BioHorizons Implant System
2300 Riverchase Center
Birmingham, AL 35244

Bosker TMI Implant
Walter Lorenz Surgical Instruments
1520 Tradeport Drive
Jacksonville, FL 32229
Brånemark Implant

Nobel Biocare USA
22715 Savi Ranch Parkway
Yorba Linda, CA 92887

Brasseler USA
One Brasseler Blvd.
Savannah, GA 31419
Brasseler Burs
Internally Irrigated
Pilot and Spade

C-R Syringe
Centrix
770 River Road
Shelton, CT 06484
Capset

Lifecore Biomedical
3515 Lyman Blvd
Chaska, MN 55318

Cendres & Metaux S. A. Ors Dentaires
Biel Bienne, Switzerland
Coe-Comfort
Coe-Pak
Coe-Soft
Colla-Cote
Colla-Plug
Sulzer-Calcitek

Zimmer Dental
1900 Aston Ave.
Carlsbad, CA 92008
Ph: 1-800-854-7019 (U. S.)
1-760-929-4300 (international)
Fax: 1-760-431-7811

Biomet-3i
4555 Riverside Drive
Palm Beach Gardens, FL 33410
Ph: 561-776-6700

Crête Mince Pins
Bauer (Chercheve)
14 Elleonorehring
6350 Bad Nauheim, Germany
or Megeve, France
Cytoplast Regenetex
GBR200

Innova
Dalbo
Dalla Bona Abutment
Dolder, ERA, Hader,
Octolink, Rothermann
O-Ring Abutment
Snap Abutment
Tube-lock, Tube & Screw,
UCLA Gold/Plastic combo
Zest, ZAAG

Sterngold Dental
23 Frank Mossberg Dr.
Attleboro, MA 02703
Demineralized Bone
Irradiated Bone
See Appendix L.
Dental Eye II/III

Yashica
Canon D20
Canon USA, Inc.
Disposaboots

Cabot Medical
2021 Cabot Blvd. West
Langhorn, PA 19047

Duo-Dent Implant Systems
340 W. Butterfield Road
Elmhurst, IL 60126
Dura Base
Duralay

Relliance Dental Manufacturing
P. O. Box 38
5805 W. 117th Place
Worth, IL 60482
Durapatite

Cook Waite
DVA Abutment

Dental Ventures of America
217 Lewis Court
Corona, CA 92882
Dentsply Caulk
Dycal

L. D. Caulk Company
38 W. Clarke Ave.
Milford, DE 19963-0359

Dynadent
151 E. Columbine Ave.
Santa Ana, CA 92707
DynaSurg

Lifecore Biomedical
3515 Lyman Blvd.
Chaska, MN 55318
Blade Implants
Intramucosal Insert Implants

Park Dental Research
19 W. 34th St., Suite 301
New York, NY 10001
Ph: 1-212-736-3765
Fax: 1-212-268-6845
Endopore Implant

Innova–Sybron Implant Solutions
1717 W. Collins Ave.
Orange, CA 92867
Ph: 1-714-516-7800
1-800-898-6261
Fibermesh

Pulpdent
80 Oakland St.
Watertown, MA 02172
Flexiroot

Dr. Andras Haris
101 Bala Ave.
Bala Cynwyd, PA
Dentsply Friadent
Frialit-2 Implant

Friadent Gmbh
SteinzeugstraBe 50
68229 Mannheim
Germany
Web: info@friadent.de
GC Pattern Resin

G.C.
156 Burns Ave.
Atherton, CA 94027
GoreTex Augmentation Material

W. L. Gore & Associates
Medical Products Division
P. O. Box 2400
Flagstaff, AZ 86003
HTR Sciences

U. S. Surgical Corporation
150 Glover Ave.
Norwalk, CT 06856

Park Dental Research
19 W. 34th St., Suite 301
New York, NY 10001
Ph: 1-212-736-3765
Fax: 1-212-268-6845
Hydroxyapatite (HA) Coating for Subperiosteal Implants

Artech
14554 Lee Road
Chantilly, VA 22021
Quintron, Inc.

Driskell Bioengineering
5229 Cheshirine Road
Glena, OH 43201
Vitallium

Howmedica
359 Veterans Blvd.
Rutherford, NJ 07070

Hygiene and Maintenance Instruments

Biomet-3i Implant Innovations
4555 Riverside Drive
Palm Beach Gardens, FL 33410

Johnson & Johnson Professional Care
10040 N. 25th Ave. Suite 110
Phoenix, AZ 85021

Oral-B Laboratories
Redwood City, CA 94065
Imcor Implant

Imcor
74 Northeastern Blvd., Building 19
Nashua, NH 03062
Impac Abutment

Vident
3150 E. Birch St.
Brea, CA 92821
Impactair Handpiece

Pallisades Dental
111 Cedar Lane
Englewood, NJ 07631
Impla-Med Implant

Impla-Med
13794 N. W. 4th St., Suite 207
Saw Grass International Corporate Park
Sunrise, FL 33325
Implant Support Systems

Lifecore Biomedical
3515 Lyman Blvd.
Chaska, MN 55318
Implaseal

Lifecore Biomedical
3515 Lyman Blvd.
Chaska, MN 55318
Impregum

ESPE Premier Sales
Norristown, PA 19401

Imtec
2401 N. Commerce
Ardmore, OK 73401
ITI Implant

Straumann USA
60 Minuteman Road
Andover, MA 01810
Lambone

Pacific Coast Tissue Bank
2519 S. Flower St., 2519
Los Angeles, CA 90007
LaminOss Implant

Impladent
Foothill Ave. 198-45
Holliswood, NY 11423
Lew Attachment

Park Dental Research
19 W. 34th St., Suite 301
New York, NY 10001
Ph: 1-212-736-3765
Fax: 1-212-268-6845
Linkow Blades

Ultimatics
P. O. Box 400
Springdale, AK 72765
Medidenta

Medidenta International
39-23 62nd St., Suite 1
Woodside, NY 11377
Minidriver

Hall International
3M Surgical Products Division
P. O. Box 4307
Santa Barbara, CA 93103
Monitoring Equipment

Criticare Systems
20925 Crossroads Circle
Waukesha, WI 53186
Nobel Biocare Implants

Nobel Biocare
22715 Savi Ranch Parkway
Yorba Linda, CA 92887
Omniloc Implant

Sulzer-Calcitek
Optosil C

Columbus Dental Miles
Orangewood Sticks
Any local dental supply house
Blade Implants
Oratronics
Orthomatrix HA
Spiral

Orthomatrix
9609 Mourning Dove Drive
Germantown, TN 38139
Orthomatrix HA

Lifecore Biomedical
3515 Lyman Blvd.
Chaska, MN 55318
Osada Consoles

Osada
3000 S. Robertson Blvd., Suite 130
Los Angeles, CA 90034
OsseoTite, NanoTite Implants

Biomet-3i Implant Innovations
4555 Riverside Drive
Palm Beach Gardens, FL 33410
Osteo Implant

Osteo-Implant
318 Highland Ave.
New Castle, PA 16101
Osteogen
Linkow Blades

Ultimatics
P. O. Box 400
Springdale, AR 72765
Osteogen (HA resorb)
Osteograft
Impladent

CeraMed
12860 W. Cedar Drive, Suite 110
Lakewood, CO 80228
Osteomed Implant

Osteomed
3885 Arapaho Road
Addison, TX 75001
Panavia

J. Morita USA
Irvine, CA 92618

Sulzer Dental
15821 Ventura Blvd., Suite 420
Encino, CA 91436
Peridex

Proctor & Gamble
Two Proctor & Gamble Plaza
Cincinnati, OH 45202
Periograf

Cook Waite
Periotest M

Salvin Dental Supply
Permaridge
Physiotron
Picotron
PocketWatch M
Polygel

Park Dental Research
19 W. 34th St., Suite 301
New York, NY 10001
Ph: 1-212-736-3765
Fax: 1-212-268-6845
Steri-Oss

L. D. Caulk Company
RA1-RA2
Ramus Frame

Pacific Implant
920 Rio Dell Ave.
Rio Dell, CA 95562
Racord

Pascal Company
P. O. Box 1478
Bellevue, WA 98009
Radiofrequency Glow Discharge Unit

Park Dental Research
19 W. 34th St., Suite 301
New York, NY 10001
Ph: 1-212-736-3765
Fax: 1-212-268-6845
Replace Implants
Reprosil

Dentsply-Caulk
Restore Implants

Lifecore Biomedical
3515 Lyman Blvd.
Chaska, MN 55318
Ross TR Implant

Dr. Stanley Ross
240 W. Palmetto Park Road, Suite 120
Boca Raton, FL 33432
Rotary Brushes
Braun Oral-B Plaque Remover

Braun
66 Broadway, Route 1
Lynnfield, MA 01940
Sargon Dental Implants

Sargon Enterprises
16101 Ventura Blvd., Suite 350
Encino, CA 91436
Sendex (Imtec) Abutments

Preat
P. O. Box 1030
Santa Ynez, CA 93460
Simpler Implant

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American Red Cross Tissue Services
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Ph: 1-512-206-1272

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1-800-905-2556

Community Tissue Services/Northwest Ohio
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Toledo, OH 43615
Ph: 1-419-536-4924
Fax: 1-419-536-4973

Community Tissue Services/Pennsylvania
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Bemsalem, PA 19020
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Fax: 1-215-245-4358

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Pensacola, FL 32503
Ph: 1-850-471-1672

Gift of Life Michigan
3861 Research Park Drive
Ann Arbor, MI 48108
Ph: 1-800-482-4881

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(Eye and tissue bank)
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Indianapolis, IN 46204
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Fax: 1-317-685-1687

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615 Arapeen Drive, Suite 105
Salt Lake City, UT 84108
Ph: 1-801-583-0907

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1864 Concert Drive
Virginia Beach, VA 23453
Ph: 1-757-464-4761
1-757-301-6582
1-800-847-7831

LifeLink Tissue Bank
8510 Sunstate St.
Tampa, FL 33634
Ph: 1-813-886-8111
1-800-683-2400
Fax: 1-813-886-1851
Mr. Dana L. Shires III

LifeShare of the Carolinas
5000 D Airport Center Parkway
Charlotte, NC 28208
Ph: 1-704-512-3303

Lions Doheny Eye and Tissue Bank
1127 Wilshire Blvd., Suite 602
Los Angeles, CA 90017
Ph: 1-213-482-9353

Mid-America Transplant Services
1110 Highlands Plaza Drive East
St. Louis, MO 63110
Ph: 1-314-435-8200

Musculoskeletal Transplant Foundation
Edison Corporate Center
125 May St., Suite 300
Edison, NJ 08837
Ph: 1-732-661-0202
Fax: 1-732-661-2297
(800-433-6576)

New England Organ Bank
Tissue Banking Services
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Northern California Transplant Bank
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Ph: 1-530-242-9123

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921 Terry Ave.
Seattle, WA 98104
Ph: 1-206-292-6500

Pacific Coast Tissue Bank
2500-19 S. Flower St.
Los Angeles, CA 90007
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1-800-745-0034
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2993 South Peoria St., Suite 390
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Fax: 1-303-337-9383

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Mount Sinai Hospital, Room 607
600 University Ave.
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Fax: 1-416-586-4458

Sierra Regional Eye and Tissue Bank
1700 Alhambra Blvd., Suite 112
Sacramento, CA 95816
Ph: 1-916-456-1450

South Texas Blood and Tissue Center
6211 I-H 10 West
San Antonio, TX 78201
Ph: 1-210-731-5555

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Nashville, TN 37203
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1-888-234-4440

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Fax: 1-214-648-2086

UCSF Tissue Bank
3924 Williams Road, Suite 201
San Jose, CA 95117
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Mr. Jason Tufts
Ph: 1-330-830-0628

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University of Miami
Dept. of Ortho Rehab, Tissue Bank
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1600 N. W. 10th Ave.
Miami, FL 33101
Ph: 1-305-243-6786
Fax: 1-305-243-4622

University of Pennsylvania Medical Center
Bone and Tissue Bank
3508 Market St., Suite 490
Philadelphia, PA 19104
Ph: 1-215-662-7488
Fax: 1-215-349-5083
Mr. Darren Ebesutani CTBS

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770 Welch Road, Suite 107
Palo Alto, CA 94304
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1-650-324-1946

California Cryobank
950 Massachusetts Ave.
Cambridge, MA 02139
Ph: 1-617-497-8646
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Idant Laboratories
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1-212-330-8536

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Metairie, LA 70001
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1-800-227-4561
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1-580-223-4561 (international)
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1-877-336-8643
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Antibiotic Prophylactic Regimens

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APPENDIX

These prophylactic regimens are adapted from *Prevention of Bacterial Endocarditis: Recommendations by the American Heart Association* by the Committee on Rheumatic Fever, Endocarditis, and Kawasaki Disease and are endorsed by the American Dental Association.

PROPHYLACTIC REGIMEN FOR DENTAL AND ORAL SURGICAL PROCEDURES

The Endocarditis Committee of the American Heart Association (AHA), together with national and international experts on bacterial endocarditis (BE), extensively reviewed published studies to determine whether dental, gastrointestinal (GI), or genitourinary (GU) tract procedures are possible causes of BE. These experts determined that no conclusive evidence links dental, GI, or GU tract procedures with the development of BE.

The current practice of giving patients antibiotics before a dental procedure is no longer recommended *except* for patients at the highest risk of adverse outcomes from BE. The Endocarditis Committee could not exclude the possibility that an exceedingly small number of cases of BE, if any, might be prevented by antibiotic prophylaxis before a dental procedure. If such a benefit from prophylaxis exists, it should be reserved for certain patients (see following list). The committee recognized the importance of good oral and dental health and regular visits to the dentist for patients at risk of BE.

The administration of antibiotics solely to prevent BE in patients who undergo a dental procedure is no longer recommended.

Changes in these guidelines do not change the fact that a patient's cardiac condition can put him or her at increased risk for developing endocarditis. If a patient develops signs or symptoms of endocarditis (e.g., an unexplained fever), the individual must see the physician right away. If blood cultures are necessary (to determine whether endocarditis is present), it is important that the physician obtain these cultures and other relevant tests *before* antibiotics are started.

Antibiotic prophylaxis for dental procedures is recommended only for patients with cardiac conditions associated with the highest risk of adverse outcomes from endocarditis. These include patients who have one or more of the following:

- Prosthetic cardiac valve
- Previous endocarditis
- Congenital heart disease (only in the following categories):
  - Unrepaired cyanotic congenital heart disease, including patients with palliative shunts and conduits
  - Congenital heart disease completely repaired with a prosthetic material or device, whether placed by surgery or catheter intervention, during the first 6 months after the procedure (prophylaxis is recommended because endothelialization of prosthetic material occurs within 6 months after the procedure)
  - Repaired congenital heart disease with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibits endothelialization)
  - Cardiac transplant recipients with cardiac valvular disease

Dental procedures for which prophylaxis is recommended in patients with the cardiac conditions listed above include all dental procedures that involve manipulation of gingival tissue or the periapical region of the teeth, or perforation of the oral mucosa.

Antibiotic prophylaxis is *not* recommended for the following dental procedures or events: routine anesthetic injections through uninfected tissue, dental radiographs, placement of removable prosthodontic or orthodontic appliances, adjustment of orthodontic appliances, placement of orthodontic brackets, shedding of deciduous teeth, and bleeding from trauma to the lips or oral mucosa.

Antibiotic Prophylactic Regimens Recommended for Dental Procedures

Situation	Agent	REGIMEN: SINGLE DOSE GIVEN 30-60 MINUTES BEFORE PROCEDURE	
		Adults	Children
Oral medication	Amoxicillin	2 g	50 mg/kg
Unable to take oral medication	Ampicillin	2 g IM or IV	50 mg/kg IM or IV
	or		
	Cefazolin or ceftriaxone	1 g IM or IV	50 mg/kg IM or IV
Allergic to penicillins or ampicillin—oral regimen	Cephalexin*†*or*	2 g	50 mg/kg
	Clindamycin	600 mg	20 mg/kg
	or		
	Azithromycin or clarithromycin	500 mg	15 mg/kg
Allergic to penicillins or ampicillin and unable to take oral medications	Cefazolin or ceftriaxone†	1 g IM or IV	50 mg/kg IM or IV
	or		
	Clindamycin	600 mg IM or IV	20 mg/kg IM or IV

Modified from the American Heart Association, Committee on Rheumatic Fever, Endocarditis, and Kawasaki Disease: Prevention of infective endocarditis: guidelines from the American Heart Association. *Circulation*, published online, April 19, 2007. Available at www.americanheart.org.

IM, intramuscular; *IV*, intravenous.

*Another first- or second-generation oral cephalosporin may be given in equivalent adult or pediatric dosage.

†Cephalosporins should not be given to a patient with a history of anaphylaxis, angioedema, or urticaria from penicillins or ampicillin.

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