OTTO ZUHR MARC HÜRZELER

PLASTIC-ESTHETIC PERIODONTAL AND IMPLANT SURGERY

A Microsurgical Approach

QUINTESSENCE PUBLISHING

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مرکز تخصصی پروتزهای دندانی

های دنت

طراحی و ساخت انواع پروتزهای دندانی بویژه ایمپلنت

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OTTO ZUHR MARC HÜRZELER

PLASTIC-ESTHETIC PERIODONTAL AND IMPLANT SURGERY

A Microsurgical Approach

With the support of Bärbel Hürzeler and Stephan Rebele

QUINTESSENCE PUBLISHING

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Preface

One of the really significant stories relating to the creation of this book happened at the beginning of 2005, in our old apartment in Munich, Germany. Like so often, my little daughter Emma was sitting beside me at my desk chatting while I was working at the computer, desperately trying to make some progress on the book manuscript. I can still remember the exact moment when she suddenly changed the subject and more or less asked me pointblank what color the book would be. Taken by surprise, I tried to explain to her that I had just started working on the book and that the last thing on my mind at that moment was the color of the book. However, she did not let up. To make a long story short, I finally had no other choice but to actually swear on my "great princess's honor" that the cover of the book, should it one day ever get finished, would be printed up in her favorite color. So it happened that I had to insist on having the book bound in pink despite the serious concerns raised by the publisher. In the end, the responsible parties at Quintessence accepted under protest. My reason for choosing that color, therefore, was not to attract more attention or to make allusions to "pink esthetics" but solely to honor my reckless promise to my daughter Emma, whose favorite color is pink...

At this point, I would like to extend my sincere gratitude and appreciation to the senior management of Quintessence Publishing—Horst-Wolfgang Haase, Alexander Ammann, Christian Haase, and Johannes Wolters—not only for bearing with my color choice but also for the great confidence and trust they have placed in me, for their enduring patience throughout this book project, which was indubitably trying at times, and, not least, for their tremendous support, cooperation, and partnership over the last few years. Many thanks also to Janina Kuhn, Ina Steinbrück, Valeri Ivankov, and Peter Rudolf for turning the manuscript into an actual book. In particular, I am deeply indebted to Peter Rudolf, who gave me the reassurance and peace of mind straight from the beginning that he was doing everything possible to make this book the best it could be. Thanks also to Christine Rose, Florian Curtius, Andreas Dollinger, and Jens Hoepfner for processing the clinical photographs for print and to the Quintessence TV team of Gerd Basting, Martin Jakovljevic, Fabian Pietsch, and Ireneusz Watola for producing the videos for the accompanying video compendium. Credit also goes to Angelika Kramer for her dedication and commitment in preparing the drawings and to Stefan Bogner, Annette Bauer, and Stephen Wittmann for their assistance in developing the layout for this book. My thanks also go to Suzyon O'Neal Wandrey for the English translation and to Chee Wan Ang for the enormous effort he undertook in proofreading the English version of this manuscript.

Furthermore, I would like to take this opportunity to thank all of my teachers, even if it is not possible to mention every single one of them by name here and now. In my years as a dentist and periodontist, I have had the extraordinary luck to work with a lot of great personalities in our field. I was not only able to see them in action and learn from these great teachers but also had the chance to engage in intense discussion, discourse, and debate with some of them on a large number of topics. In particular, I would like to thank Wolfgang Bolz and Hannes Wachtel for their long-standing support of my professional development and for many inspiring years of common ground...

Looking back, I can hardly put into words how much time and energy have actually gone into work on this book. This inevitably led to gaps in coverage of the daily needs and requirements for quality-oriented practice management and treatment, which had to be compensated for and closed by others. In this context, my most profound thanks to my dental practice team, Bärbel Hürzeler, Marc Hürzeler, Wolf Richter, and all our hard-working dental assistants, dental hygienists, and administrative staff: Thank you for your open-minded and sincere teamwork and for your ceaseless and unswerving pursuit of our ultimate goal of making patient care at our dental practice a little bit better each day, year after year. To Stefan Fickl, who stepped in to help us when we had just started and were short-handed, many thanks indeed. In addition, I owe my respect to the ar-

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tist and sculptor Gerd Bischur, who was instrumental in the creation of object images and provided support in all aspects relating to digital photography. I am also deeply indebted to the dental laboratory technicians who performed all the prosthetic work in the scope of this book project and who have basically been a part of my team ever since I started my professional life: Rainer Janousch, Uli Schoberer, and Uli Werder. My special thanks go to Uli Schoberer for his exceptional analytical, creative, and technical skills, for his fundamental belief that a treatment outcome that is inferior to that which is technically feasible is never acceptable, and for his spirit of brotherhood.

The idea of having the book manuscript critically reviewed from the student perspective prior to its final completion proved to be a correct and rewarding decision: I would like to thank Stephan Rebele not only for drafting the rough sketches of the illustrations in this book but also for critically reading and creatively evaluating the manuscript. His input ultimately led to didactically valuable changes and additions in different parts of the book. I am also deeply indebted to Bärbel Hürzeler for the enormous amount of time she spent proofreading our manuscripts without complaint at various stages of development of this book, for the razor-sharp intellect with which she consistently enriched and constructively supported the book's development, and for her big heart.

Last but not least, I would like to thank Marc Hürzeler for his unparalleled way of practicing dentistry with a passion that is irresistibly motivating and contagious, for always being a model of partnership and team spirit for me, for standing by me all these years, and for helping whenever I needed him, without exception, without question, and without having to be asked: I feel extremely grateful and fortunate that our paths crossed. Without you, this book would never have become reality—my colleague, partner, very best friend...

With the deepest respect, I would like to thank my parents, Marianne and Otto, and my sisters, Marianne and Barbara, for showing and setting the example for me of what a home and family should be, for always allowing me to be who I really am, and for giving me their unconditional love.

From the bottom of my heart, I would most like to thank my children, Emma, Paula, and Oscar, for opening my eyes and, especially, my wife, Kira, for her enduring strength, serenity, and wisdom and for the continuous flow of energy, warmth, and love with which she has supported and motivated me over the years—I could not imagine living without you for one second. I love you, to the moon and back...

Uffing (Germany), September 2011 Otto Zuhr





1 Uli S. 2 Stefan 3 Stephan 4 Wolf 5 Rainer 6 Gerd 7 Otto 8 Bärbel 9 Marc 10 Uli W.

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It is our deepest conviction that the surgical potentials of the present can only be achieved by consistently following a surgical approach in which minimal soft tissue trauma and maximally perfect wound closure are key elements.

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SECTION A

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CHAPTER 1

BASIC PRINCIPLES OF PERIODONTAL ANATOMY AND STRUCTURAL BIOLOGY

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A sound knowledge of the macroanatomical and microanatomical structures of periodontal and peri-implant tissues is key to understanding the principles of plastic-esthetic periodontal and implant surgery. Therefore, anatomical structures relevant to the diagnostic and therapeutic procedures presented in later chapters of this book will be defined and described here (Fig 1-1). Because the scope of this chapter is limited to the information relevant to performance of these procedures, the reader should refer to more specific publications in the literature for a more detailed description of the anatomical and structural biology of periodontal and peri-implant tissues.[1]

1.1 Anatomy of Periodontal Structures

1.1.1 Gingiva

The oral mucosa, or mucous membrane epithelium of the mouth, can be divided into three types: *masticatory mucosa* (gingiva and hard palate), *lining mucosa* (lips, cheeks, vestibule, floor of the mouth, base of the tongue, and soft palate), and *specialized sensory mucosa* (taste buds on dorsum of the tongue).[2] The gingiva consists of gingival connective tissue and an epithelial covering. The surface of the gingiva is keratinized except in the interdental col region. The gingiva extends from the gingival margin to the mucogingival junction.

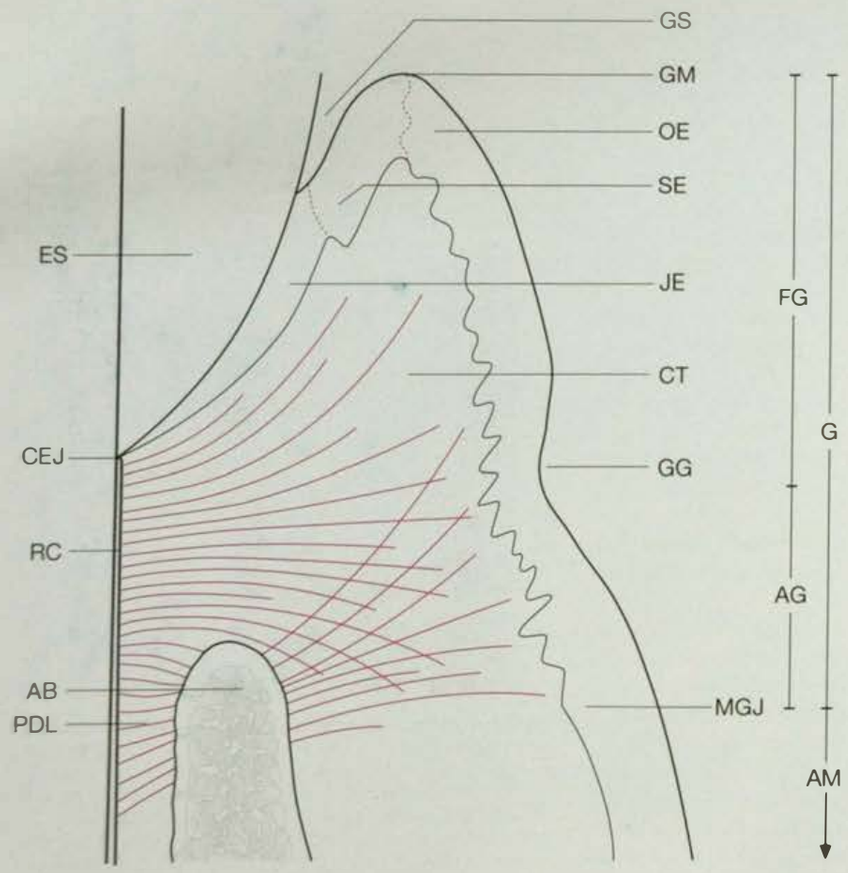


Fig 1-1 Anatomical structure of the marginal periodontium. ES: enamel space; CEJ: cementoenamel junction; RC: root cementum; AB: alveolar bone; PDL: periodontal ligament; GS: gingival sulcus; GM: gingival margin; OE: oral epithelium; SE: sulcular epithelium; JE: junctional epithelium; CT: gingival connective tissue; GG: gingival groove; MGJ: mucogingival junction; FG: free gingiva; AG: attached gingiva; G: gingiva; AM: alveolar mucosa.

The average thickness of the gingival tissue is around 1 mm.[3] Its vertical dimension is subject to great variation and can range from 1 to 9 mm but is generally greatest buccal to the maxillary anterior teeth and smallest lingual to the mandibular anterior teeth.[4,5] The width of the gingiva is basically determined by the position in which a tooth emerges through the alveolar ridge. The more buccal the tooth position, the narrower the gingiva on the buccal aspect of the tooth. Conversely, the more lingual the tooth position, the broader the gingiva on the buccal aspect of the tooth.[6]

The width of the gingiva increases during jaw growth in childhood.[7,8] Spontaneous buccolingual changes in tooth position during growth affect the dimensions of the gingiva, as does orthodontic movement in the buccolingual direction.[9,10] Buccal movement of a tooth results in narrowing of the gingiva on the buccal aspect of the tooth, whereas lingual movement results in widening of the gingiva.[10] The width of the gingiva also increases after orthodontic extrusion of teeth or coronal distraction of alveolar bone segments, including the respective tooth roots (see chapter 12).

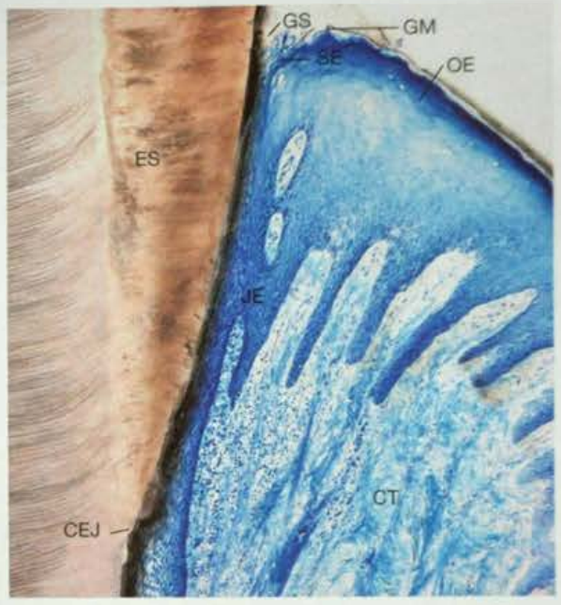


Fig 1-2 Histologic view of the free gingiva. ES: enamel space; CEJ: cementoenamel junction; GS: gingival sulcus; GM: gingival margin; OE: oral gingival epithelium; SE: oral sulcular epithelium; JE: junctional epithelium; CT: gingival connective tissue. (Courtesy of *Peter Schüpbach*, Zurich, Switzerland.)

Free gingiva

The free gingiva has a smooth appearance and extends along the buccal and lingual surfaces of the teeth from the *gingival margin* to the apical border of the epithelial attachment (Fig 1-2). This border, located at the level of the cementoenamel junction, can be identified clinically as the *gingival groove* in 30% to 40% of all patients.[5] Toward the oral cavity, the free gingiva is covered by stratified squamous keratinized epithelium.

Toward the tooth surface, it retracts slightly to form a shallow *sulcus* that, under healthy conditions, has a depth of approximately 0.5 mm. The sulcus is lined by oral sulcular epithelium, which extends coronally to merge with the oral gingival epithelium. Histologically, the overall structure of the oral sulcular epithelium resembles that of the oral gingival epithelium except for the outermost layers of cells. In the oral sulcular epithelium, they are thinner and, in part, incompletely keratinized. This pattern of incomplete keratinization is referred to as *parakeratinization* (Fig 1-3).

At the bottom of the gingival sulcus, the oral sulcular epithelium merges with the *junctional epithelium*, which forms a 1- to 2-mm-wide *epithelial attachment* on the enamel surface. The junctional epithelium is a stratified

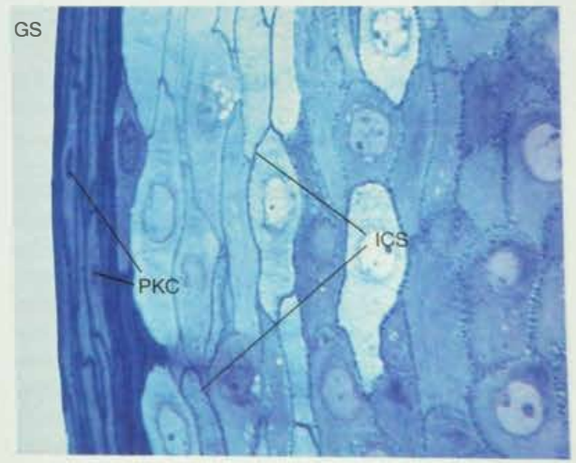


Fig 1-3 Histologic view of the oral sulcular epithelium. Parakeratinization is characterized by the presence of incompletely keratinized epithelial cells with cell nuclei in the outermost layer (stratum corneum). These are referred to as *parakeratinized epithelial cells* (PKC). Because of its narrow intercellular spaces (ICS), the oral sulcular epithelium has a low permeability to microorganisms. GS: gingival sulcus. (Courtesy of *Max Listgarten*, Philadelphia, Pennsylvania.)

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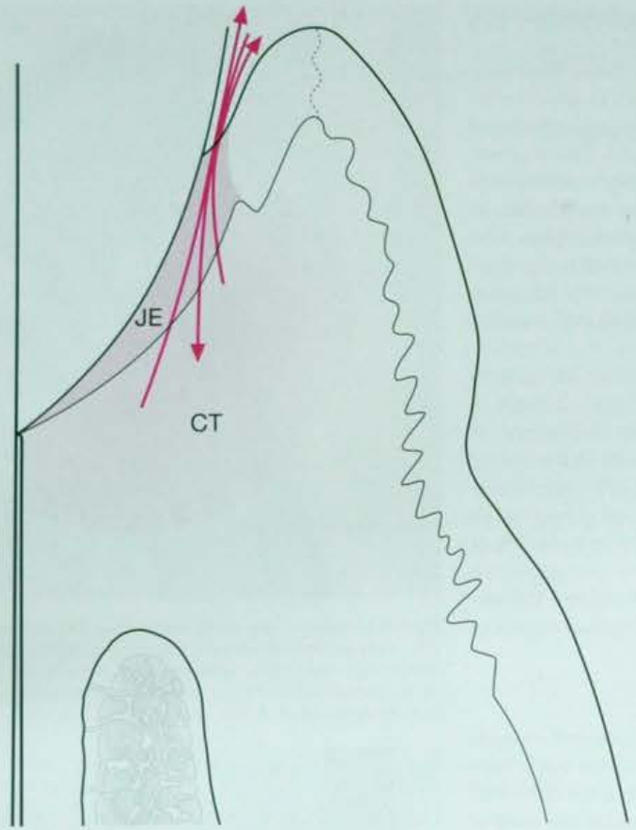


Fig 1-4 The junctional epithelium (JE) can be regarded as a reaction zone that enables the body to stage immunologic conflicts with oral microorganisms distant from the bone. The nonkeratinized structure of the junctional epithelium facilitates the immigration of immune cells from the subepithelial connective tissue (CT).

nonkeratinized epithelium that surrounds the tooth like a collar and resembles a thin wedge in cross section. Interdentally, the junctional epithelia of adjacent teeth touch, forming the nonkeratinized interdental col.

The junctional epithelium is demarcated by two basal laminae, one facing the tooth and the other facing the gingival connective tissue on the opposite side. Contrary to the widespread belief that the junctional epithelium attaches directly to the tooth surface by means of hemidesmosomes and integrins, hemidesmosomal attachment actually occurs at the internal basal lamina on the enamel surface. Compared to the conventional structure of the external basal lamina facing the gingival connective tissue, that of the internal basal lamina is very specialized.[11] The question of the exact mechanism of attachment of the internal basal lamina to the tooth surface cannot be answered adequately from a scientific perspective at this time.

The basic task of the junctional epithelium is to maintain the continuity of the epithelial lining of the oral cavity toward the tooth surface and thus to protect the underlying bone from microbial invasion. It allows bacteria and their toxic by-products to pass through the epithelium in the apical direction and allows components of cellular and humoral immunity that are chemotactically drawn from the connective tissue during a peripheral immune response to pass coronally in the direction of the sulcus. Therefore, the junctional epithelium can be regarded as a contact and reaction zone that enables the body to stage this immunologic conflict distant from the bone (Fig 1-4).

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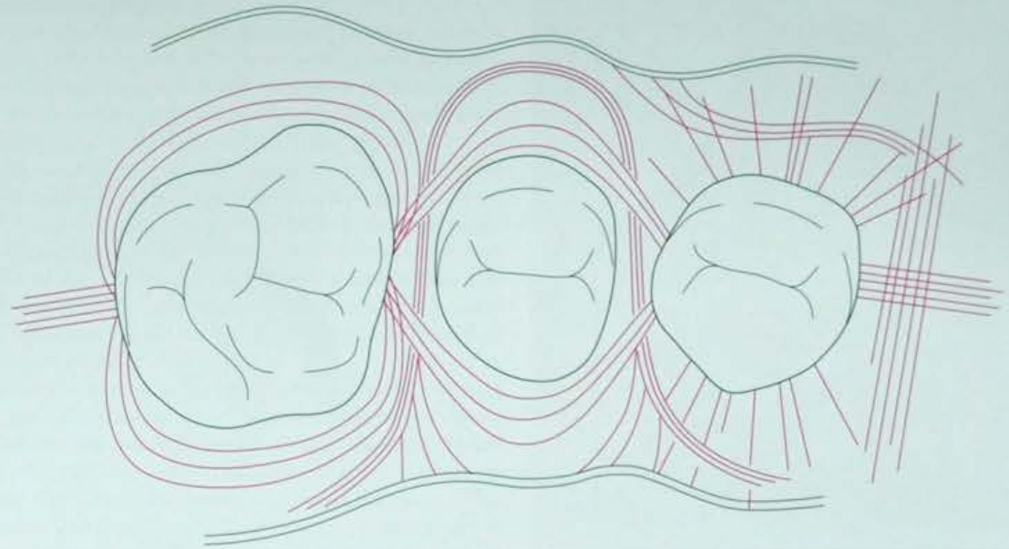


Fig 1-5 Arrangement of collagen fibers in gingival connective tissue.

The junctional epithelium undergoes continuous renewal, which is reflected by a very high rate of cell division. The turnover rate is only 4 to 6 days. During this time, epithelial cells from the basal layers of proliferative cells overlying the external basal lamina migrate coronally and are ultimately shed at the bottom of the sulcus. If the junctional epithelium is injured or removed, complete regeneration occurs within a few days by this mechanism.[12]

Attached gingiva

Buccal and lingual to the rows of teeth, the free gingiva becomes continuous with the attached gingiva, which is firmly connected to the cementum and alveolar bone. At the *mucogingival junction*, it merges with the mobile mucosa lining the alveolar bone. Palatally, the attached gingiva makes a smooth transition into the masticatory mucosa covering the hard palate.

When healthy, the surface of the attached gingiva has a pink color and a stippled appearance. Strong keratinization of the gingival epithelium is not an adaptive response to functional requirements but rather a result of genetic factors affecting the underlying connective tissue.[13,14]

The matrix of the gingival connective tissue contains fibers, cells, blood vessels, and nerves. Roughly 60% of its volume is occupied by collagen fibers, which are functionally arranged in bundles that form the supraalveolar fiber apparatus of the periodontium between the cementoenamel junction and the alveolar bone crest. The height of epithelial attachment is subject to strong individual variation, whereas the height of *connective tissue attachment* remains very constant at around 1 mm.[15,16] By virtue of the fact that they insert into the cementum and alveolar bone, the collagen fibers are able to attach the gingival tissues to the supraalveolar cementum and the alveolar bone crest. Due to their three-dimensional architecture, they stabilize the positions of the teeth and unite them into one closed row of dentition (Fig 1-5).

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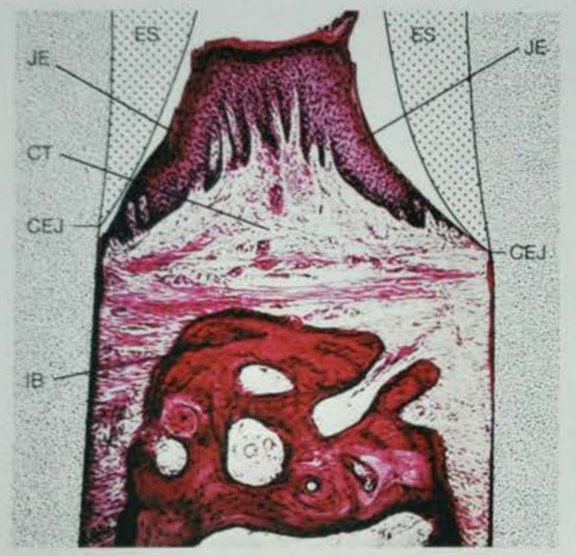


Fig 1-6 Histologic view of the interdental gingiva.[17] ES: enamel space; CEJ: cementoenamel junction; JE: junctional epithelium; CT: gingival connective tissue; IB: interdental bone septum. (Courtesy of *Niklaus P. Lang,* Bern, Switzerland.)

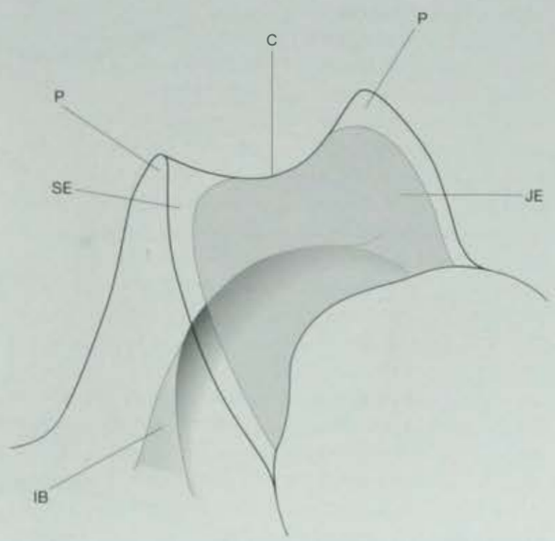


Fig 1-7 Interdental soft tissues. In this region, the junctional epithelia (JE) of adjacent teeth touch, resulting in the formation of a saddle-shaped, nonkeratinized interdental col (C) under the area of interproximal contact of the teeth. The soft tissues on the buccal and lingual aspects of the teeth bulge to form buccal and lingual papillae (P). IB: interdental bone septum; SE: oral sulcular epithelium.

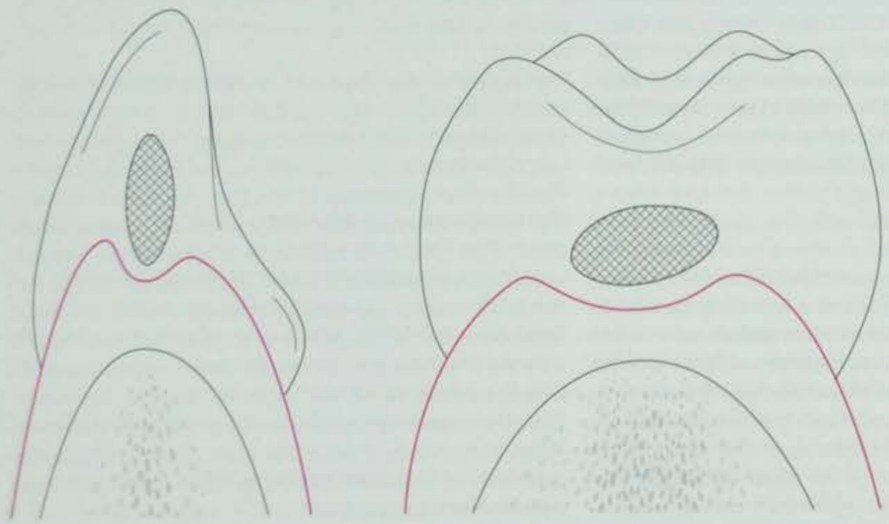


Fig 1-8 The geometry of the interdental col changes from anterior to posterior.

Interdental gingiva

The interdental gingiva fills the space between two contacting teeth and has a free part and an attached part. The shape of the interdental gingiva is determined by the adjacent tooth surfaces, the interdental contact area, and the interdental bone septum (Figs 1-6 and 1-7). The tissues on the buccal and lingual aspects of the teeth bulge outward to form the buccal and lingual *papillae*. The saddle-shaped depression between the two papillae is referred to as the *interdental col*.[18] The shape and depth of the interdental col are determined by the size and shape of the interproximal contact area. The epithelium covering the col normally is not keratinized or parakeratinized.[19]

The interproximal contact area is most coronal between the two central incisors and becomes progressively more apical toward the more distal parts of the arch. Therefore, the papillary height decreases from anterior to posterior. Conversely, the distance between the peaks of the papillae and thus the width of the col increase progressively from anterior to posterior[20] (Fig 1-8).The papillae are responsible for the typical scalloped shape of the gingival margin along the teeth.

1.1.2 Periodontal Fiber Apparatus and Cementum

The periodontal fiber apparatus develops during tooth eruption and root growth. Functionally arranged collagen fiber bundles insert on the root surface, forming two distinctive components, one supra-alveolar and the other alveolar. The supra-alveolar component (connective tissue attachment) provides attachment between the teeth and the marginal gingiva (Fig 1-9), whereas the alveolar component provides attachment between the teeth and the bony sockets in which they are suspended. The fiber bundles inserting into the cementum and cribriform plate of the alveolar bone lining the alveoli are called *Sharpey's fibers*. Most Sharpey's fibers extend diagonally in the apicoronal direction from the surface of the cementum to the bone (Fig 1-10).

Principal fibers of the periodontal ligament extending horizontally and radially can be found in the region of the crestal alveolar bone, the root apex, and furcations. In the unloaded state, the fibers are slightly wavy. When subjected to functional loading, they stretch to permit physiologic tooth mobility, which helps to absorb and counteract the forces acting on the teeth.



Fig 1-9 Histologic view of the supra-alveolar fiber apparatus (SAF) as seen by polarization microscopy. ES: enamel space; CEJ: cementoenamel junction; RC: root cementum; D: dentin. (Courtesy of *Peter Schüpbach,* Zurich, Switzerland.)

The periodontal ligament contains blood vessels, lymph vessels, and a dense network of sensory nerve endings that serves to monitor and control functional forces acting on the teeth. A rich cell population comprising fibroblasts, cementoblasts, osteoblasts, osteoclasts, and their respective progenitor cells completes this picture of highly vital tissue. Its vitality is also reflected in the collagen turnover, which is significantly higher than that of other connective tissues.[21]

Although mineralized, the cementum is vital connective tissue. The mineral content of the cementum ranges be-

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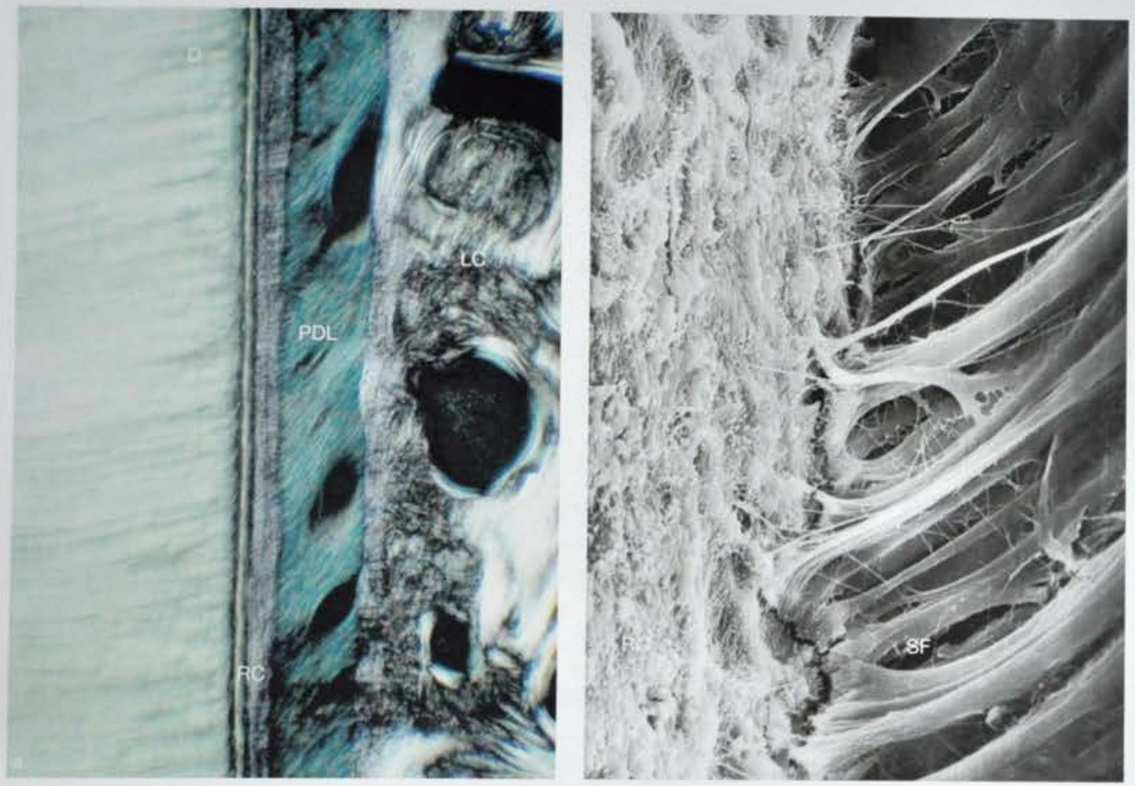


Fig 1-10 (a and b) Histologic and scanning electron microscopic views of the apicocoronal course of Sharpey's fibers (SF) in the periodontal ligament (PDL). D: dentin; RC: root cementum; LC: cribriform plate. (Courtesy of *Peter Schüpbach*, Zurich, Switzerland.)

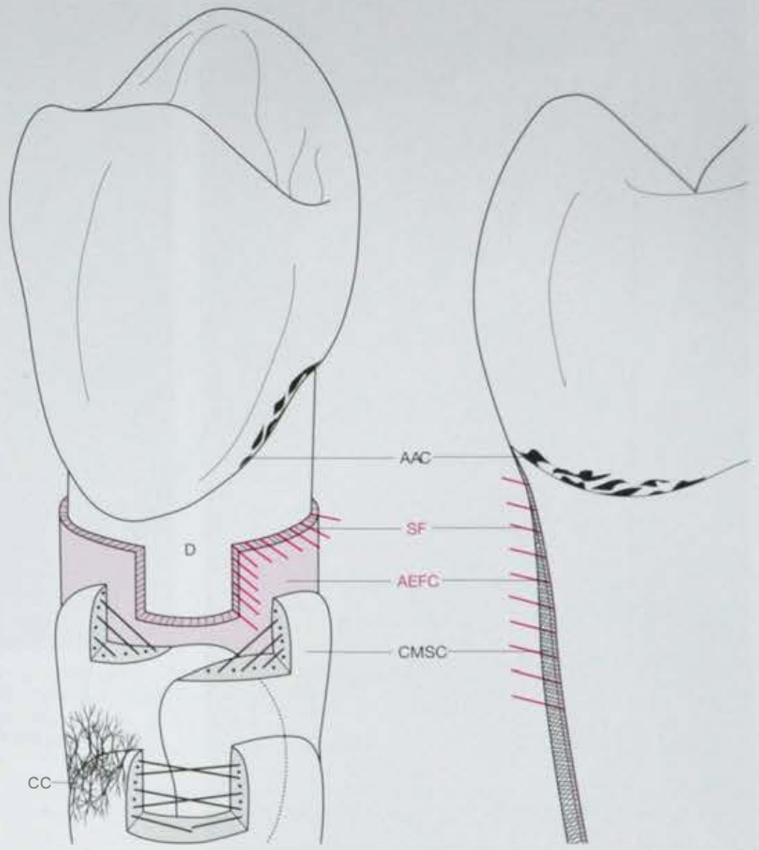


Fig 1-11 Location of the different types of cementum on the root surface. D: dentin; CC: cementocytes; AAC: acellular afibrillar cementum; SF: Sharpey's fibers; AEFC: acellular extrinsic fiber cementum; CMSC: cellular mixed stratified cementum.

tween that of other dental hard tissues and bone. Different types of cementum have been identified in histologic studies investigating the distribution of cementocytes and the composition and course of fiber components.[22] Based on these criteria, *cellular versus acellular cementum* and *fibrillar versus afibrillar cementum* can be distinguished (Fig 1-11).

Acellular afibrillar cementum (AAC) appears as small islands or "tongues" of cementum located at the cervical enamel margin. It is probably secreted by cementoblasts. AAC is thought to develop after completion of preeruptive enamel maturation, during the time of tooth eruption when the enamel comes in contact with the connective tissue because of discontinuities in the reduced enamel epithelium.

Acellular extrinsic fiber cementum (AEFC) is located directly on the dentin in the cervical and middle thirds of the root. As the site of insertion of extrinsic *Sharpey's* fibers, the AEFC is primarily responsible for anchorage of the tooth in the alveolus. This type of cementum forms both preeruptively and posteruptively.

Cellular intrinsic fiber cementum (CIFC) does not contain Sharpey's fibers. Consequently, it does not contribute to tooth anchorage. All fiber bundles in the CIFC are located exclusively within the cementum and thus are referred to as *intrinsic fibers* as opposed to *extrinsic fibers*. More precise information about the formation and function of this type of cementum is lacking, but it is thought to function primarily as repair cementum protecting against ankylosis and resorption of the root surface. Because CIFC is continuously produced and secreted by cementoblasts on the root surface throughout an individual's lifetime, its thickness increases throughout life. Cementocytes are enclosed in lacunae within the cellular intrinsic fiber cementum and can communicate with each other and their surroundings by means of cytoplasmic processes.

Cellular mixed stratified cementum (CMSC) is the relatively thick layer of cementum covering the middle and apical thirds of the root surface. It is called *mixed stratified cementum* because it contains extrinsic fibers crossing through a network of intrinsic fibers. Therefore, this type of cementum plays an important part in anchorage of the tooth in the alveolus. CMSC is produced by both cementoblasts and fibroblasts, and it also contains cementocytes enclosed in lacunae.[22]

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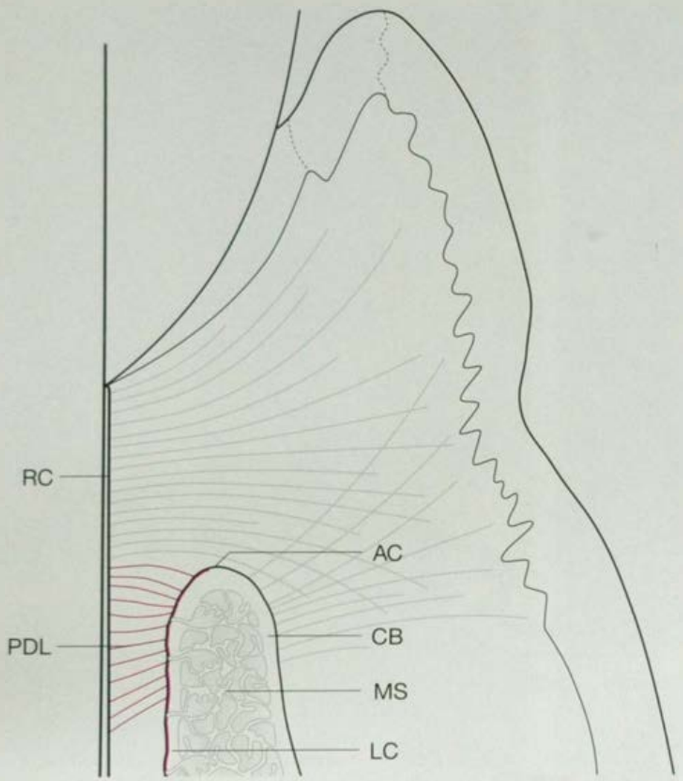


Fig 1-12 Alveolar process in the cervical region. At the alveolar crest (AC), the external cortical bone (CB) merges with the portion of alveolar bone that lines the alveolus, which is referred to anatomically as the *cribriform plate* (lamina cribriformis, LC) and radiologically as the *lamina dura*. The cribriform plate (bundle bone) is the part of the alveolar bone where fibers from the periodontal ligament (PDL) insert. MS: marrow space with cancellous bone.

1.1.3 Alveolar Process

The alveolar processes of the maxilla and mandible develop in conjunction with tooth eruption and root growth. In the congenital absence of teeth, rudimentary development of the corresponding sections of the alveolar process occurs. Similarly, extensive resorptive changes can be expected when teeth are lost.

The alveolar processes consist of buccal and lingual *cortical plates* of compact bone, a cribriform plate (*lamina cribriformis*) lining the alveoli, and cancellous or trabecular bone between them. Radiographically, the cribriform plate appears as a radiodense line referred to as the *lamina dura*. The cribriform plate (*bundle bone*) is the portion of the alveolar bone where fibers from the periodontal ligament insert (Fig 1-12). In the maxilla, the cortical plate is thicker on the palatal aspect than on the buccal aspect of the roots. The mandibular cortical plate is denser than the maxillary cortical plate, especially in the anterior region and on the lingual and buccal aspects of the molars, where it is reinforced by the *internal and external oblique ridges*.

From a histologic perspective, the bone lamellae are considered the mineralized building blocks of the cortical bone (Fig 1-13). The osteon is the basic functional unit of the cortical bone. Each osteon consists of multiple, densely packed concentric layers of bone lamellae surrounding a central cavity referred to as the *haversian canal*. Each haversian canal contains a neurovascular bundle responsible for supplying blood and nerves to osteocytes in the mineralized bone matrix of the osteon. *Volkmann's canals* connect each haversian canal with those of adjacent osteons, the marrow spaces of cancellous bone, and periosteal blood vessels. However, the overall ratio of blood vessels to bone mass in the cortical bone is low.

The cancellous bone located between the buccal and lingual cortical plate and the cribriform plate consists of a loose network of bone trabeculae between which well-perfused and cell-rich marrow spaces are interposed (Fig 1-14).

The *endosteum lines* the medullary cavities and all other internal bone surfaces in the canals of the cortex, whereas the external surfaces of the bone are lined with *periosteum*. These are thin layers of nonelastic, collagen-rich connective tissue containing osteoblasts, osteoclasts, the corresponding precursor cells, and many blood vessels and nerves responsible for supplying blood and nerves to the bone as well as for bone regeneration.

Alveolar bone undergoes constant remodeling. Through the continuous breakdown and synthesis of lamellae and osteons, osteoblasts and osteoclasts interact to ensure the continuous adaptation to changing functional loads and tissue repair after microtrauma. The endosteum and periosteum play key roles in this complex metabolic activity. Because it is controlled by hormones and growth factors, the bone is a highly reactive and vital tissue.[1,23,24]

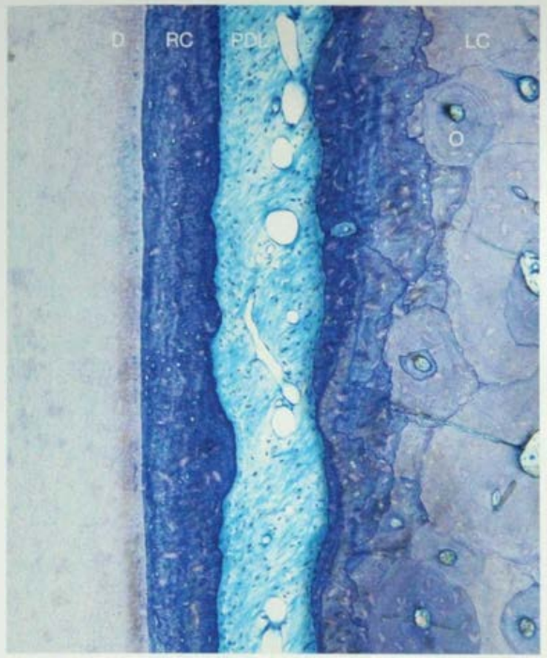


Fig 1-13 Histologic view of the mineralized components of the alveolar bone in the cribriform plate region (LC). Osteons (O), the basic functional units of the compact bone, are clearly visible. D: dentin; RC: root cementum; PDL: periodontal ligament. (Courtesy of *Peter Schüpbach*, Zurich, Switzerland.)

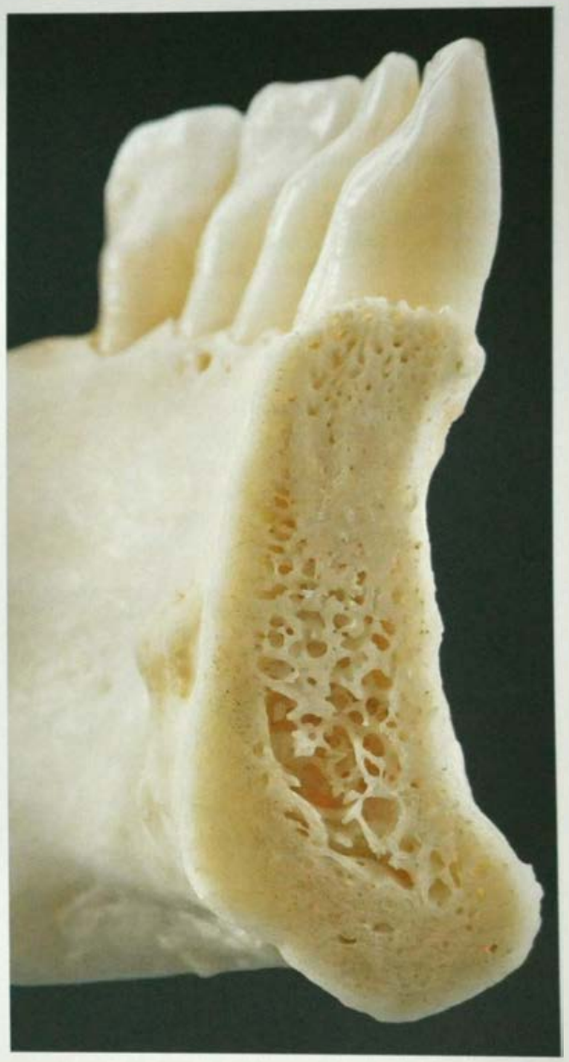


Fig 1-14 Section through the mandible in the region of the anterior teeth.

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1.1.4 Blood Supply and Innervation

Healthy periodontal structures are well perfused. The primary blood supply to the maxilla is through the posterior superior alveolar arteries and the anterior superior alveolar arteries coming from the infraorbital arteries. The mandible receives its main blood supply from the inferior alveolar arteries.

The alveolar arteries divide into the dental arteries, which enter at the apices of the roots to supply the teeth. Before doing so, they supply blood to the gingival tissues by giving off branches that pass vertically through the *interdental septa* and the *periodontal ligament* (Fig 1-15). The buccal and lingual gingiva are supplied by numerous *supraperiosteal branches* of the facial arteries, the infraorbital arteries, the incisive artery, and the greater and lesser palatine arteries in the maxilla and by the sublingual arteries, the buccal arteries, and the mental arteries in the mandible. Thus, arterial blood to the periodontal tissues is supplied by vascular sources from three different territories—the interdental septa, the periodontal ligament, and the oral mucosa—and these vessels exhibit frequent anastomoses (Fig 1-16).



Fig 1-15 Corrosion specimen from the inferior alveolar artery in the mandibular second molar region. The blood vessels supplying the periodontal ligament space and the interdental and interradicular septa are clearly visible. (From *Tillmann.*[25] Reprinted with permission.)

The periodontal ligament contains a very dense vascular network that plays an important role in the absorption and distribution of occlusal forces.[21]

Gingival connective tissue appears to have *two terminal capillary beds*—an *external network* of subepithelial capillary loops below the marginal gingiva and oral epithelium (external network) and an *internal network* of postcapillary venules located below the junctional epithelium, which seems to be of great importance in host defense against infection.[26] Venous drainage of the periodontal ligament occurs via arterioles and arteries.[21]

The periodontium contains autonomic nerve endings as well as sensory receptors, that is, mechanoreceptors and nociceptive nerve fibers capable of sensing and transmitting pain, pressure, and tactile signals. The sensory nerves originate in trigeminal brainstem nuclei and are conducted to the periodontal structures of the maxilla via the second branch of the trigeminal nerve and to the periodontal structures of the mandible via the third branch of the trigeminal nerve. In the maxilla, sensory innervation of the labial gingiva is supplied by infraorbital nerve endings in the anterior and premolar region and by posterior superior alveolar branches in the molar region. The anterior palatal mucosa is supplied by the incisive nerve, whereas the rest of the palatal mucosa is supplied by the greater and lesser palatine nerves. In the mandible, sensory innervation of the labial gingiva is supplied by the mental nerve in the anterior and premolar region and by the buccal nerve in the premolar and molar region. The lingual gingiva is innervated by the sublingual nerve.

The teeth are innervated by the superior alveolar nerves in the maxilla and by the inferior alveolar nerve in the mandible. The pulpodentin complex and the corresponding periodontal space share sensory innervation. Therefore, they form a highly sensitive functional unit that can sense even the slightest forces exerted on the teeth during swallowing and chewing in order to control the mandibular opening and closing reflexes appropriately. Together with the receptors in the periodontium, the proprioceptors in the tendons of the masticatory muscles play a key role in the control of masticatory forces, masticatory movements, jaw position, and speech.[21]

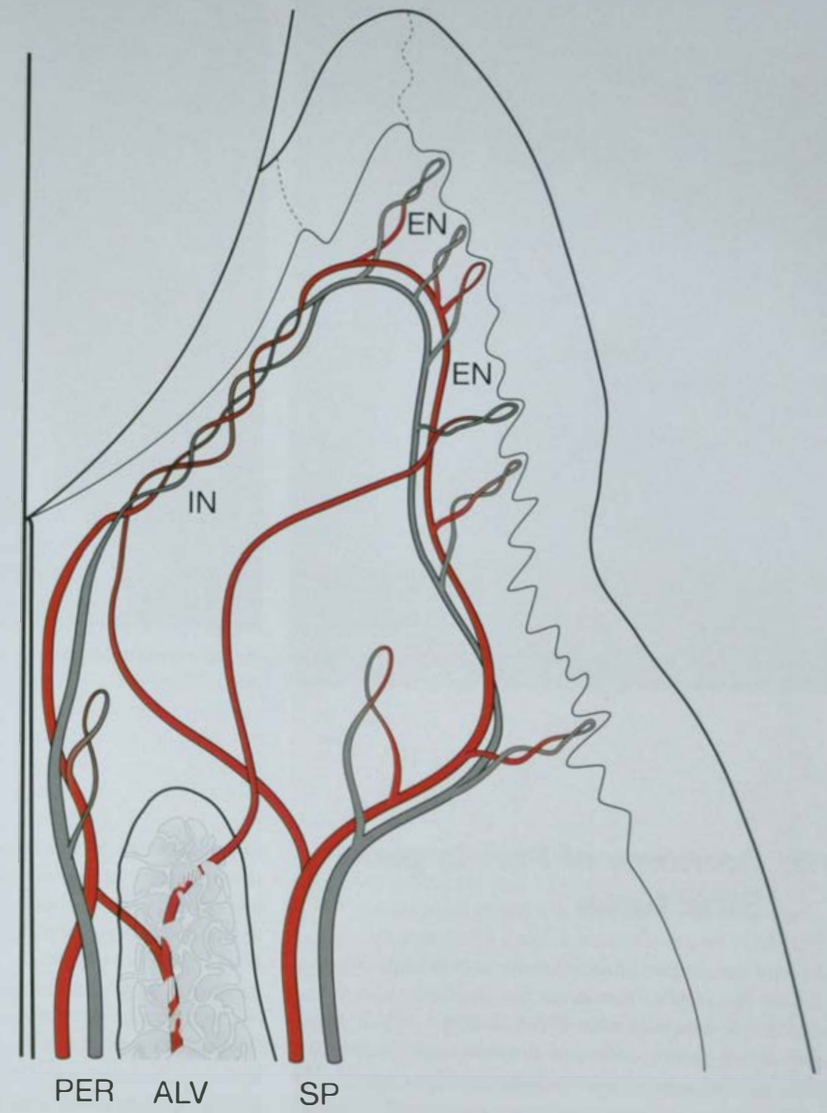


Fig 1-16 Periodontal blood supply. The periodontal tissue receives its blood supply from periodontal (PER), alveolar (ALV), and supraperiosteal (SP) blood vessels. IN: internal network (postcapillary venule plexus); EN: external network (subepithelial capillary loops).

Lymph from the periodontal tissues drains into lymph capillaries, which form a dense network in gingival connective tissue. Larger lymph vessels usually run along blood vessels and empty into lymph nodes. Lymph from periodontal tissues collects in the submental, submandibular, and deep cervical lymph nodes.[21]

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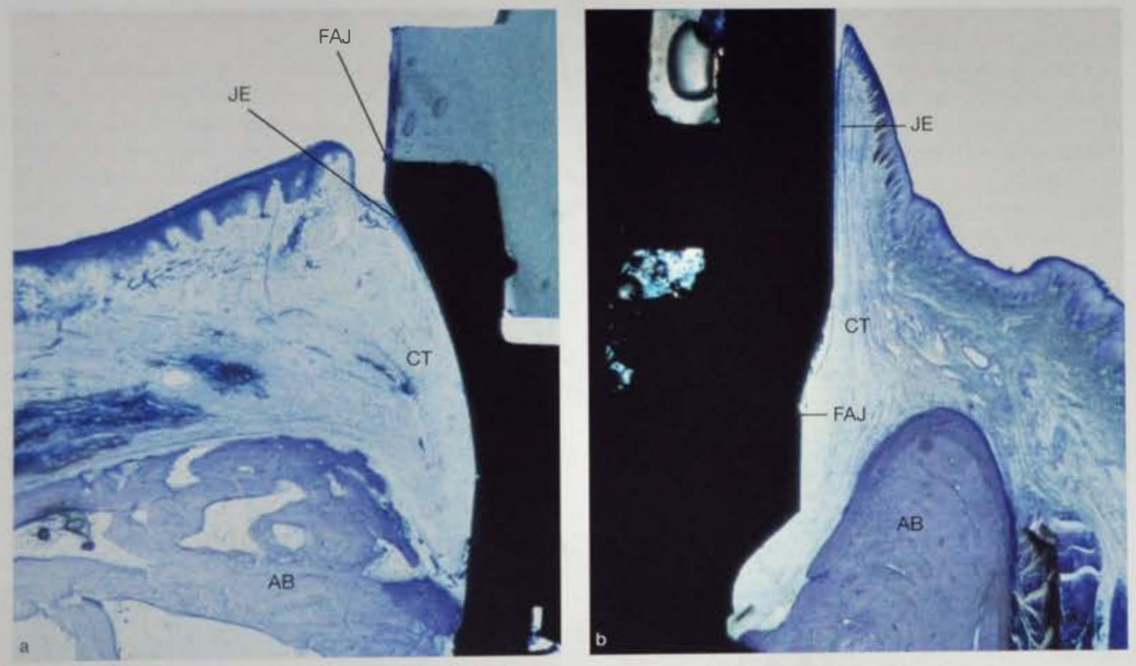


Fig 1-17 (a and b) Histologic views of peri-implant hard and soft tissues. JE: junctional epithelium; CT: connective tissue; AB: alveolar bone; FAJ: fixture-abutment junction. (Courtesy of *Peter Schüpbach*, Zurich, Switzerland.)

1.2 Anatomy of Peri-implant Structures

The anatomy of peri-implant structures is highly dependent on the implant position, the implant system, and the clinical procedure used[23,27,28] (Fig 1-17). In some cases, it can closely resemble the anatomy of structures around the natural teeth at first glance. Although it is impossible to find a general rule that accurately describes the complex architecture of the peri-implant tissue, one thing is certain: The establishment of adequate biologic width around an implant is crucial to the health of the peri-implant structures. The *biologic width* is defined as the sum of the heights of the junctional epithelium and the underlying connective tissue. As in natural teeth, the connective tissue height around implants should consistently fall within the range of approximately 1.0 to 1.5 mm.[23,29–31] Similar to conditions in natural teeth, the junctional epithelium around implants should have a height of 1.5 to 2.0 mm[23,29–31] and should be attached to the implant surface via hemidesmosomes and an internal basal lamina.[32]

The periodontal fibers insert into cementum on the root surfaces of natural teeth, whereas the connective tissue fibers around implants extend parallel to the surface of the implant and/or abutment[23,33,34] (Fig 1-18). Because the connective tissue around implants has a higher percentage of collagen fibers and a lower percentage of fibroblasts than that around natural teeth, it is very similar to scar tissue from a histomorphologic perspective.[35] Moreover, peri-implant connective tissue contains fewer blood vessels than the connective tissue around natural teeth. The gingiva around natural teeth is supplied by vascular sources from three different territories (the supraperiosteal region, the periodontal space, and interdental bone), whereas the *peri-implant mucosa* is only supplied by supraperiosteal vessels and a few vessels from the bone; moreover, no anatomical structure comparable to the periodontal space is present around implants.[36]

Because of these differences, a differential approach to diagnosis and treatment of peri-implant mucosa and the gingiva around natural teeth is necessary. Because of its scar tissue–like structure, absence of inserting fibers, and relatively poor blood supply, peri-implant tissue may be less resistant to mechanical and microbiologic impacts than the tissue around natural teeth.[24] Furthermore, the lower level of perfusion of peri-implant tissue might have a negative effect on healing after surgical interventions. It is important for the clinician to consider these factors when performing plastic-esthetic periodontal surgical procedures involving implants.

A few more important differences should be mentioned. The presence of keratinized gingiva seems to be related to the presence of nonelastic collagen fibers in the underlying connective tissue.[14] Because the majority of fibers in the periodontal space are nonelastic, there is always a band of keratinized gingiva around natural teeth, even if only minimal.[14] Implants, on the other hand, may be seated in either keratinized mucosa or lining mucosa.

Apart from keratinization, the attachment of peri-implant tissue is another important factor to consider. The gingiva around natural teeth forms as part of the biologic development process, whereas peri-implant mucosa forms as the result of the wound healing process following surgical implant placement or second-stage surgery. In cases where the junction between the keratinized mucosa and the lining mucosa comes to lie coronal to the bone in individuals with a high peri-implant soft tissue cuff, peri-implant mucosa may be mobile in spite of keratinization (Fig 1-19).

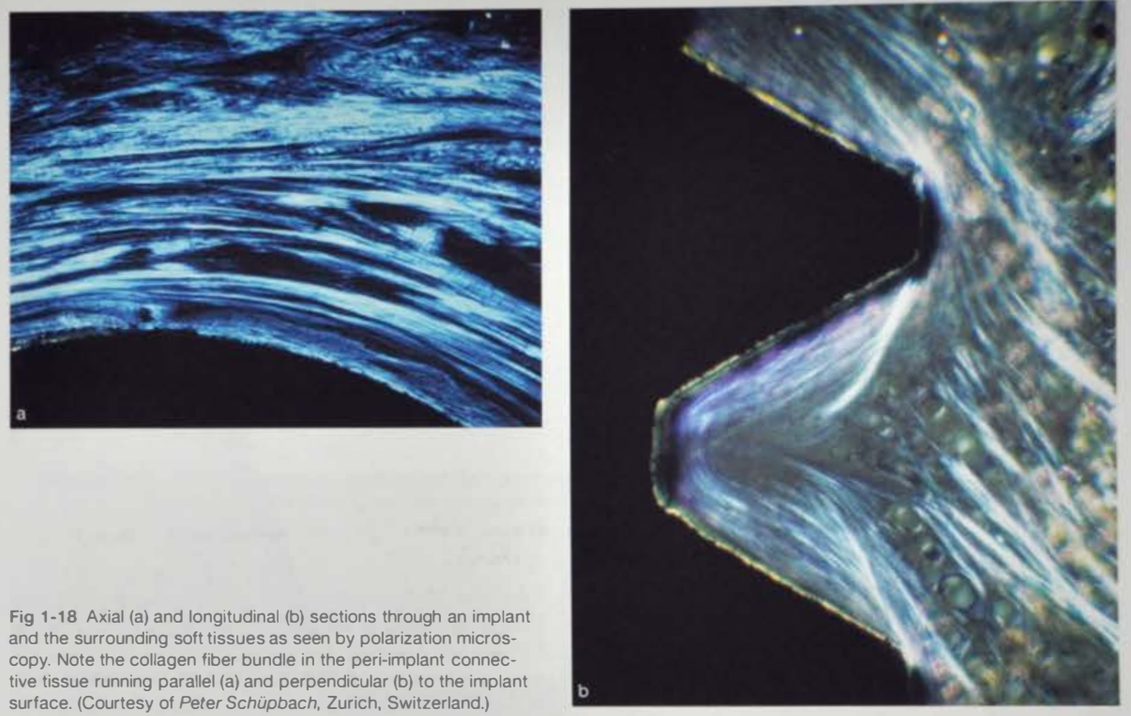


Fig 1-18 Axial (a) and longitudinal (b) sections through an implant and the surrounding soft tissues as seen by polarization microscopy. Note the collagen fiber bundle in the peri-implant connective tissue running parallel (a) and perpendicular (b) to the implant surface. (Courtesy of *Peter Schüpbach*, Zurich, Switzerland.)

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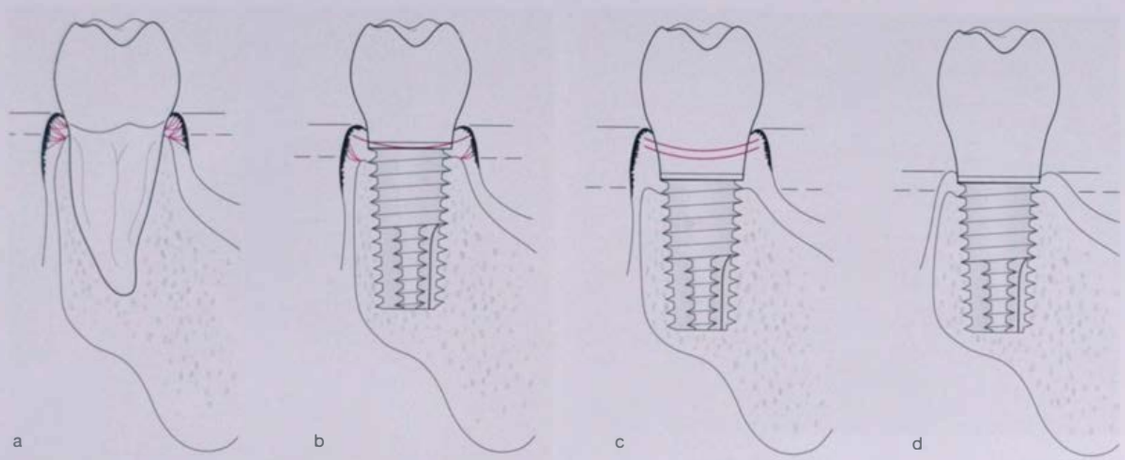


Fig 1-19 In contrast to the mucosa around natural teeth (a), peri-implant mucosa may be either keratinized (b and c) or nonkeratinized (d). Peri-implant mucosa may be mobile and not attached to the underlying peri-implant bone in spite of keratinization (c).

1.3 Biologic Relationships and Their Clinical Relevance

1.3.1 Biologic Width

The fact that teeth or implants emerge through the oral mucosa means that they interrupt the integrity of the epithelial lining. This places special configurational demands on the affected structures. The fundamental task of the gingiva or peri-implant mucosa at these weak spots is to protect the underlying anatomical structures from mechanical and biologic stress (Fig 1-20).

The gingiva fulfills this task by forming a combination of *epithelial* and *connective tissue attachments* on the tooth surface.[15] Epithelial attachment has a biologic protective function, while connective tissue attachment appears to confer mechanical stability.[37] The *biologic width* is the sum of these two structures.[38] Therefore, the biologic width can be understood as the body's response to the special challenges at the site where a tooth emerges through the oral mucosa.

The biologic width around natural teeth was found to be a mean of 2.04 mm, calculated as the sum of the levels of connective tissue attachment (1.07 mm) and epithelial attachment (0.97 mm).[15] The level of connective tissue attachment remains very constant, whereas the level of epithelial attachment is subject to strong individual variation.[15,16]

Likewise, the protective function of peri-implant mucosa is to establish the required biologic width around an implant. Although its connective tissue fibers run not perpendicular but rather parallel to the implant or abutment surface, the dimensions of epithelial and connective tissue attachment are comparable to those of natural teeth.[23]

Many contemporary periodontal, dental implant, and prosthodontic concepts are shaped by recent knowledge concerning the establishment and violation of the biologic width, although many questions and correlations have yet to be definitively explained (Fig 1-21).

Biologic width and dental prosthetics

The biologic width is of relevance to the prosthetic restoration of teeth only when intrasulcular restoration margins will be used for esthetic or functional reasons.[39] If the preparation margin extends to the epithelial or connective tissue attachment zone apical to the bottom of the sulcus, the microbiologic contact zone will be displaced apically. As the body reacts to this *violation of the biologic width*, adaptive and adjustment processes in the epithelial and connective tissue attachment zone can be expected.[40]

The affected tissues can launch two different types of response. The first is a self-regulatory response that attempts to restore adequate biologic width. This response is associated with the loss of alveolar bone and the clini-

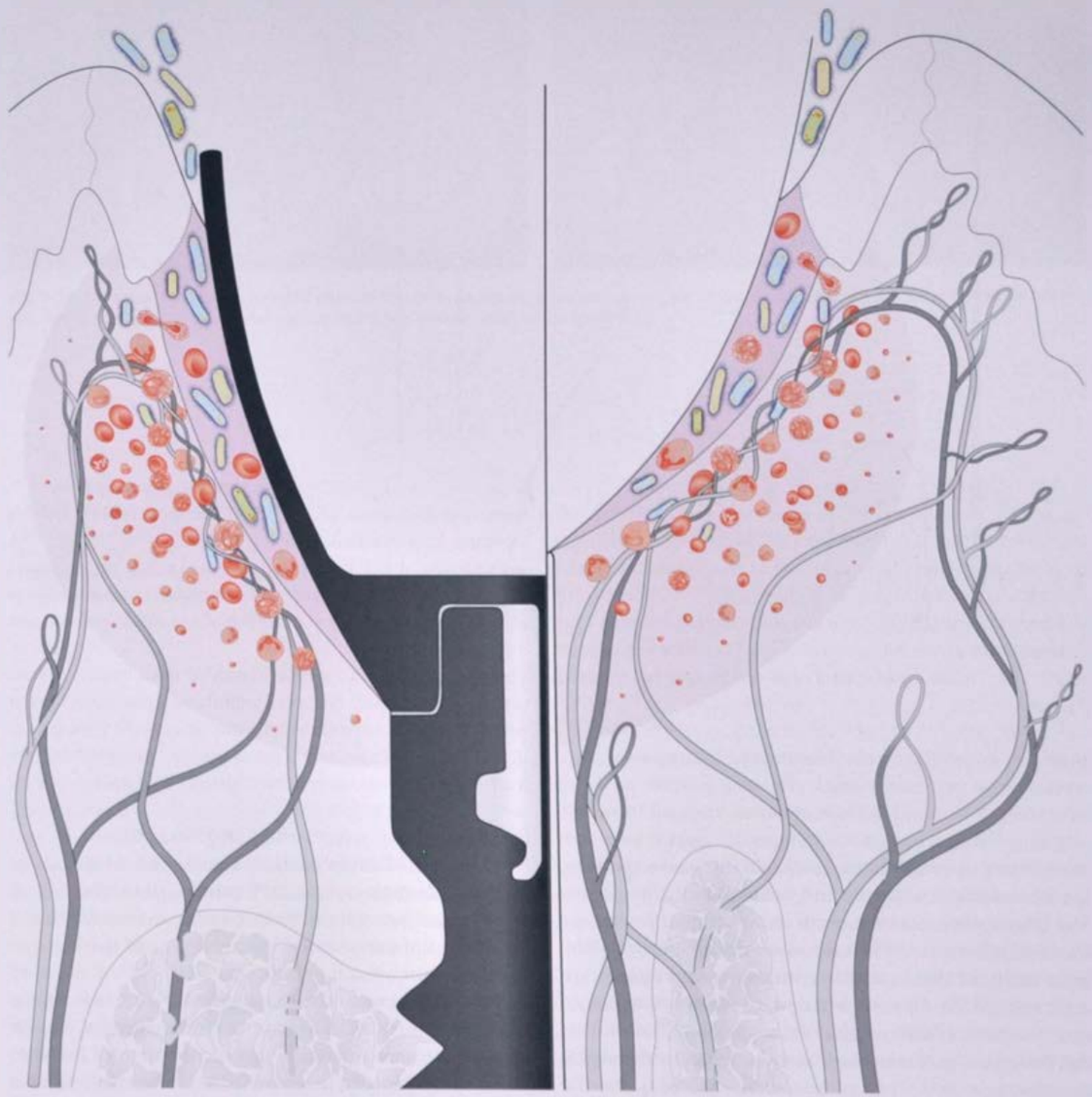


Fig 1-20 The establishment of the biologic width can be understood as the body's response to special microbiologic challenges at the site of emergence of implants and teeth in the oral cavity. The junctional epithelium functions as a semipermeable membrane that allows active interaction between microorganisms from the oral cavity on the one side and the host immune system on the other to keep the bone from becoming infected. Apical to this microbiologic contact zone, there is always a completely intact layer of connective tissue of more or less constant dimension that appears to serve as a barrier protecting the underlying alveolar bone.

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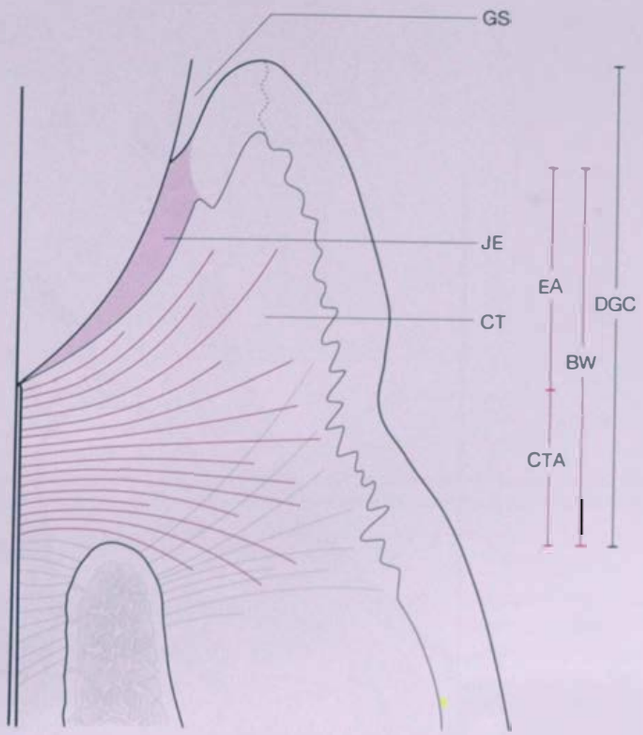


Fig 1-21 Biologic width (BW) and dentogingival complex (DGC). GS: gingival sulcus; JE: junctional epithelium; CT: gingival connective tissue; EA: epithelial attachment; CTA: connective tissue attachment.

cal picture of *gingival recession*. If this self-regulatory mechanism fails, *chronic inflammation* of the gingiva and other processes may occur as a secondary response (Fig 1-22). To enable the body to restore an adequate biologic width in this case, the clinician must either surgically reduce the alveolar bone to an appropriate height or orthodontically move the tooth, and thus the restoration margin, the corresponding distance from the alveolar bone.

At the present time, there is no evidence of a method that reliably predicts how the body will react to such a violation of the biologic width in a given case, but the possibility that the thickness of the affected alveolar bone might have a significant impact on this process has been discussed. Notwithstanding, the rule of thumb is: If the restoration margin is located within the sulcus, the preparation margin must be placed coronal to the bottom of the sulcus to prevent violation of the biologic width.[41]

In clinical practice, it is extremely difficult to estimate how far intrasulcularly a preparation margin can be placed in a given patient. The dimensions of biologic width are subject to great individual variation. Consequently, all published reference values are mean values with limited applicability.[16] Furthermore, the probing depth or clinical sulcular depth measured at chairside is not always consistent with the histologic sulcular depth.[42] According to *Kois*,[43] it is better to measure

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Fig 1-22 Violation of the biologic width can result in two responses, a self-regulatory response associated with the loss of alveolar bone and the formation of gingival recession (a) or chronic inflammation of the gingiva (b).

the total dentogingival complex by sounding the osseous crest with a periodontal probe. High total gingival complex values suggest a relatively deep sulcus that would allow preparation to extend relatively far into the sulcus, whereas low values suggest that caution is advised.[43]

In any case, each of these methods—depth measurements and bone sounding—can be considered an improvement of clinical procedure compared to relying on statistical mean values. Even so, reliable determination of the amount of biologic width actually present in a given patient is not possible using either method. Therefore, it would seem prudent to make it a general rule to place an intrasulcular preparation margin as coronal in the sulcus as possible. Placing the restoration margin at an intrasulcular depth of 0.2 to 0.5 mm can be considered safe for all conceivable anatomical variations.[44] Because the sulcus is usually slightly deeper interproximally, the intrasulcular margin can be placed slightly deeper in that region.[45]

Contrary to scientific theory, clinical practice has shown that most patients tolerate restoration margins that seem to lie slightly apical to the bottom of the sulcus.[44] It is therefore conceivable that there is a certain range of tolerance to inflammatory response, the extent of which may vary from one patient to another.

Should a restoration margin be placed any deeper than the safe intrasulcular range of 0.2 to 0.5 mm, a thin retraction cord should be inserted with gentle pressure into the coronal part of the epithelial attachment prior to preparation.[46] This is vitally important; cord placement prevents the preparation from extending too far past the base of the sulcus. This procedure seems to minimize or prevent the risk of biologic complications.

Key points:

The preparation of intrasulcular restoration margins must be viewed critically from a biologic perspective. The most frequent consequences of biologic width violation are chronic inflammation of the gingiva[47] and gingival recession.[48] Therefore, restoration margins should be placed supragingivally or crestally whenever possible. Should a restoration margin end in the gingival sulcus, the clinician should estimate the dimensions of the available biologic width. This can be accomplished by measuring the clinical sulcular depth (probing depth) or total dentogingival complex using a periodontal probe. Preparation margins that do not extend more than 0.2 to 0.5 mm into the sulcus appear to be the safest. Should the preparation margin be placed any deeper, the insertion of a thin retraction cord with gentle pressure into the coronal part of the epithelial attachment prior to preparation can reduce the risk of later biologic complications (Fig 1-23).

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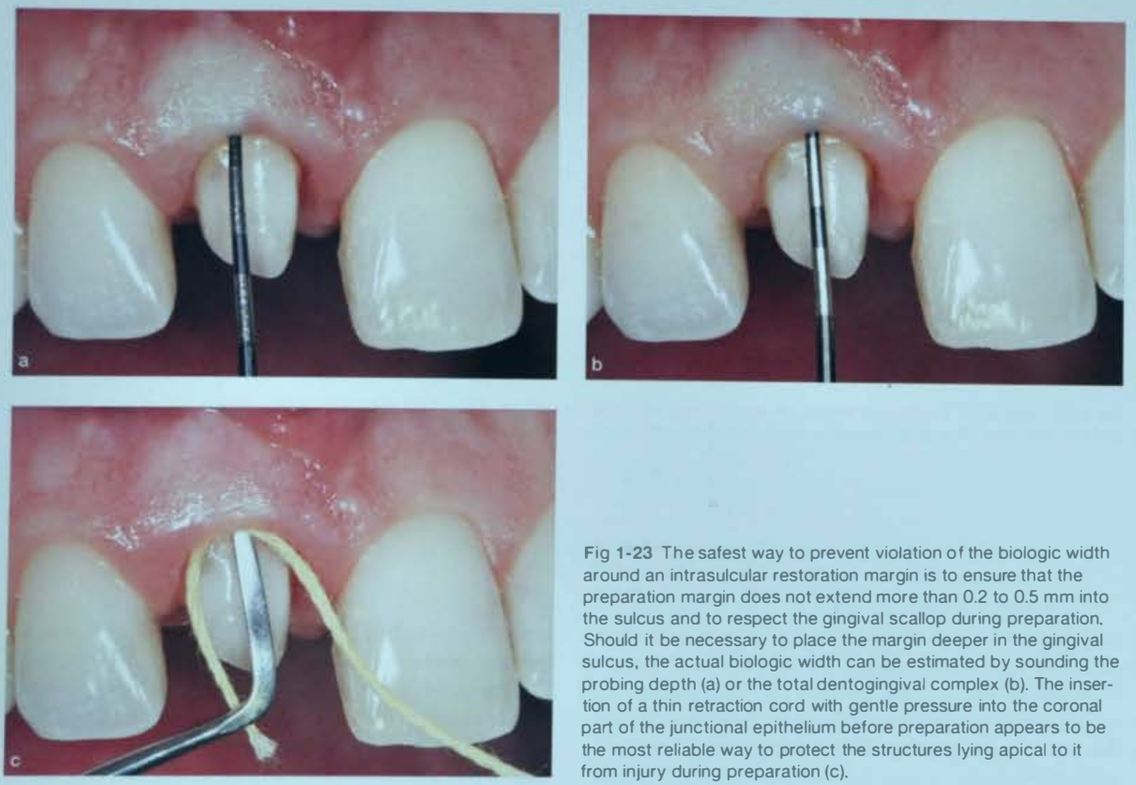


Fig 1-23 The safest way to prevent violation of the biologic width around an intrasulcular restoration margin is to ensure that the preparation margin does not extend more than 0.2 to 0.5 mm into the sulcus and to respect the gingival scallop during preparation. Should it be necessary to place the margin deeper in the gingival sulcus, the actual biologic width can be estimated by sounding the probing depth (a) or the total dentogingival complex (b). The insertion of a thin retraction cord with gentle pressure into the coronal part of the junctional epithelium before preparation appears to be the most reliable way to protect the structures lying apical to it from injury during preparation (c).

Biologic width and resective periodontal surgery

If periodontal surgery is to result in predictable apical displacement of the gingival margin, then the biologic width must be regarded as a constant dimension.

Whenever connective tissue or epithelial attachment is completely or partially removed during external gingivectomy or apically displaced during apical flap repositioning, the biologic width is always reestablished during the course of the healing process. Once healing is complete, a soft tissue height of approximately 3 mm and 4 mm above the bone level can be expected at buccal/lingual and interproximal sites, respectively.[45,49,50]

Because the reestablishment of biologic width can result from the coronal growth of the gingiva, the apical development of soft tissue in association with the related resorption of marginal alveolar bone, or a combination of these two processes, it is difficult to predict the final gingival margin position (Fig 1-24). This causes problems for the clinician during esthetic crown lengthening, for example, because the predicted gingival margin position is a defined goal of treatment that should be met as precisely as possible. To obtain successful and predictable results when performing such procedures, the clinician must precisely adapt the technique to the specific anatomical conditions present at baseline (see chapter 10).

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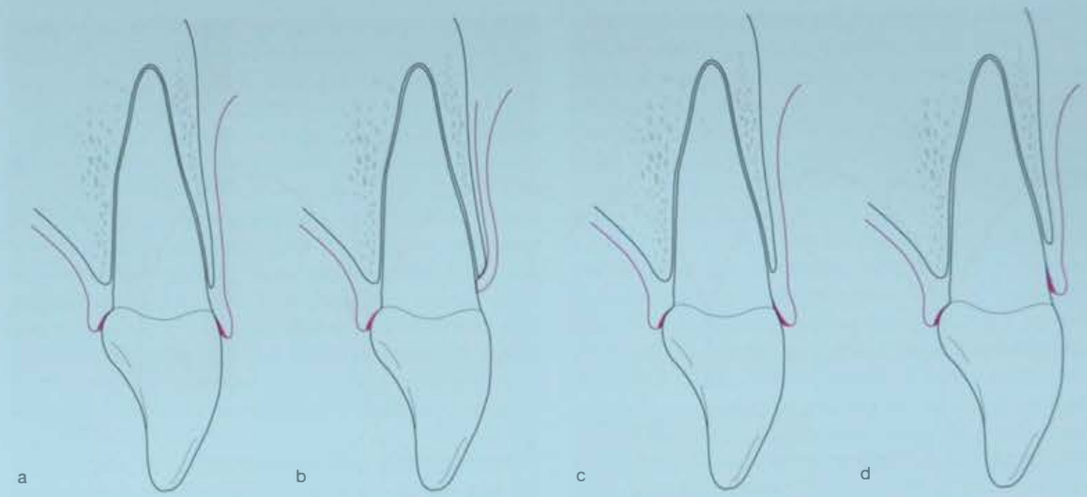


Fig 1-24 Whenever marginal connective tissue (a) is removed during the course of external gingivectomy or apically positioned flap surgery (b), biologic width growth can occur in an apical (c) and/or coronal (d) direction during the subsequent course of healing.

Biologic width and implant dentistry

Achieving naturally beautiful results in the esthetic zone has become one of the greatest challenges in modern implant dentistry. Ensuring the best possible preservation or reconstruction of peri-implant hard and soft tissues is crucial to achieving this goal.

From the contemporary perspective, the results of animal studies suggest that the development of hard tissue defects after tooth extraction cannot be prevented entirely.[51–53] Furthermore, the surgical trauma associated with implant bed preparation,[54] occlusal overloading following prosthetic implant loading,[55,56] peri-implant inflammation,[24,57] and the establishment of biologic width around implants during the course of healing[58] can lead to an additional loss of peri-implant bone secondary to the loss of soft tissue. From biologic and esthetic perspectives, the goal must therefore be to prevent, as far as possible, additional loss of peri-implant bone during the establishment of biologic width around an implant.

A number of studies have been conducted to elucidate the processes surrounding the development of biologic width around implants. Although the only available prospective, controlled histomorphologic study data are based on animal models, these findings can be extrapolated to understand the situation in humans, as documented using individual biopsy specimens. These studies fundamentally explain the radiographic changes in the peri-implant bone as detected in numerous human experimental studies. The results of exemplary animal studies investigating the establishment of biologic width around dental implants will be summarized below.

Ericsson et al[59,60] performed various studies on the establishment of biologic width around crestally positioned two-piece implants after one-stage and two-stage healing. They concluded that vertical bone loss must be expected around implants placed in a one-stage or two-stage approach and determined that the most coronal bone-to-implant contact lies at a mean of 1.1 to 1.3 mm apical to the implant-abutment connection.

They also identified two spatially distinct types of inflammatory infiltrate present in the peri-implant connective tissues. The first type (plaque-related inflammatory infiltrate) is located lateral to the junctional epithelium, and the second type is present in the region of the implant-abutment connection. The latter type of inflammatory infiltrate extends approximately 0.5 mm in the coronal,

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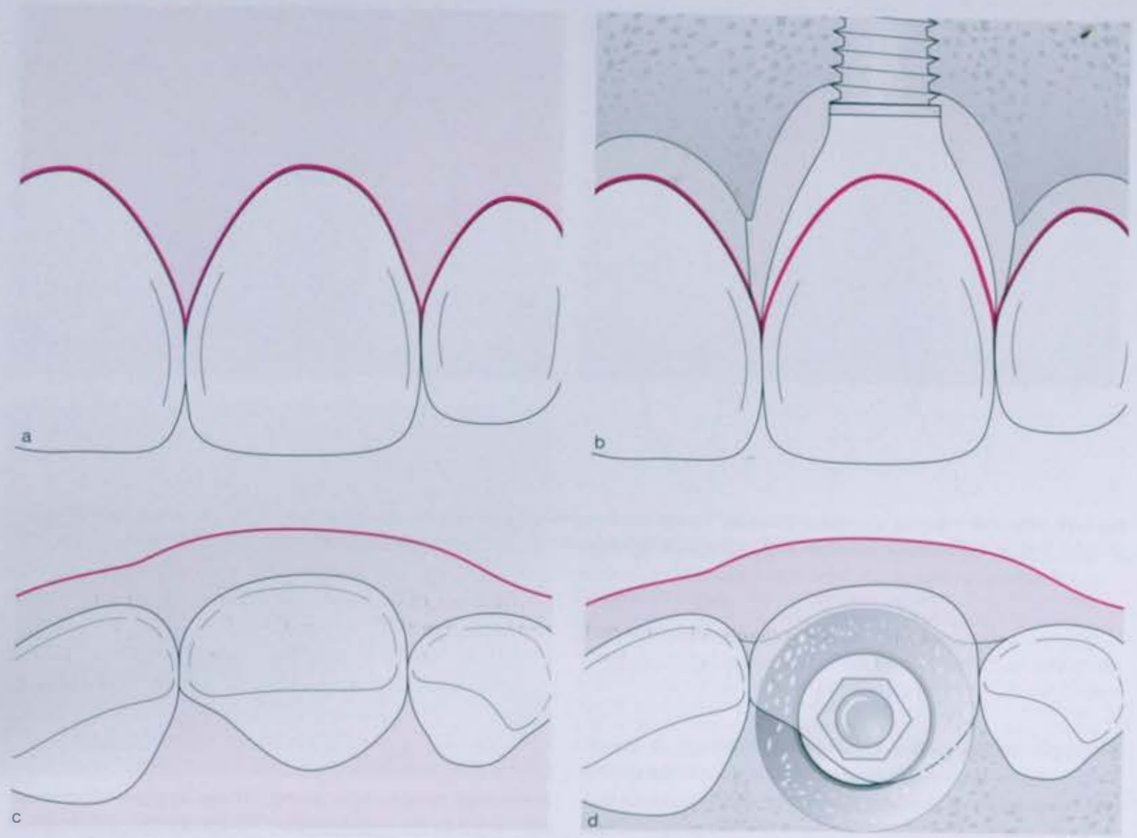


Fig 1-25 (a to d) The establishment of biologic width around an implant is a three-dimensional process similar to that around natural teeth.

apical, and lateral directions, and there is always an approximately 0.8-mm-wide layer of healthy connective tissue between the bone and the infiltrate. *Ericsson's* team interpreted this to mean that the microspace between the abutment and the implant shoulder is at the center of the inflammatory response associated with the formation of the inflammatory infiltrate.

The bone is apparently protected from this inflammatory infiltrate and kept sterile in all spatial directions by a constant layer of healthy connective tissue, similar to the situation in natural teeth. Consequently, the establishment of biologic width around a dental implant is a three-dimensional process, and the peri-implant bone loss occurring in association with this process has a horizontal component as well as the aforementioned vertical component[61] (Fig 1-25).

Other animal studies confirmed the findings of *Ericsson's* group,[59,60] which, although obtained using *Brånemark* implants, are fundamentally valid for other implant systems as well.[29,62]

Hermann et al[63,64] compared the resorption and remodeling processes occurring in peri-implant bone during the course of establishment of biologic width around one- and two-piece implant systems based on radiographic and histologic evidence collected in animal studies; they found that bone loss was directly related to the insertion depth of the implants. In the group of animals with one-piece implants, they observed that it was possible to stop bone loss at the rough-to-smooth junction of the implant. In animals with two-piece implants, bone loss could be expected to extend up to 2 mm apical to the implant-abutment connection and, in some cases, beyond the rough-to-smooth junction of the implant. However, subsequent animal studies and clinical studies have failed to confirm these findings.[29,65,66]

Nonetheless, it can be assumed that different implant systems and differences in their macrodesign and microdesign characteristics result in remodeling and adaptive processes of variable extent.[29,67] In the case of two-piece implants systems, the type of *abutment material* used also seems to play a role,[68] but the extent to which different *implant surface characteristics* and different *biomechanical characteristics* of the implant-abutment connection may be of relevance is unclear.

In an animal study prompted by questions relating to implant design, *Berglundh* and *Lindhe*[31] demonstrated that the *thickness of the peri-implant soft tissue* affects the extent of bone resorption occurring after second-stage surgery in association with the establishment of biologic width. They observed that animals with iatrogenic thinning of peri-implant soft tissues at the time of second-stage surgery developed greater peri-implant bone loss than did a nonmanipulated control group. They hypothesized that a minimum thickness of peri-implant soft tissue is needed for the establishment of biologic width and that, if necessary, the body's self-protective mechanism will ensure that these conditions are met at the expense of peri-implant bone.

Animal studies also showed that repeated *insertion and removal of threaded implant components* results in apical migration of the junctional epithelium with a consequent loss of peri-implant bone. This can be interpreted as repeated trauma to the connective tissue attached to the abutment and impairment of the related wound healing processes, which can be particularly relevant in the case of deeply inserted implants.[30]

The establishment of biologic width around an implant is part of an important endogenous fallback system. From the biologic and esthetic perspectives, an important goal of continuing research and development must be to improve methods to encourage the growth of the biologic width in a coronal direction without additional loss of peri-implant bone. The development of an implant capable of allowing the growth of the biologic width in the coronal direction based on the existing bone level falls under the heading of *periointegration*.

In this context, ssome recent trends can be observed in the development of implant dentistry. The first trend involves attempts to improve the microbiologic seal at the implant-abutment connection. The goal is to use the prosthetic advantages of two-piece implant systems without suffering disadvantages in terms of the establishment of biologic width. Achieving a *tight microbial seal at the implant-abutment connection* and *preventing micromovement* in this region are the main goals of these scientific efforts.

The second research trend involves efforts to optimize the *distribution of forces* in peri-implant bone in the coronal portion of implants based on the biomechanical findings of finite-element analysis. Microretention and bioactive surfaces should help to stabilize the bone in this region. Adequate wall strength in the coronal portion of an implant also appears to be an important factor.

One-piece scalloped implants were developed in an attempt to meet these demands while allowing for a scalloped shape of peri-implant bone according to the model of the natural teeth.[69] Theoretically, scalloped implants should enhance the preservation of hard and soft tissues between two implants. However, due to the lack of clinical success, the initial euphoria surrounding the scalloped implant design has sharply declined.

Platform switching pursues the same goal with a new design concept based on the theory that horizontally shifting the microbiologic contact zone away from the peri-implant bone and more toward the center of the implant will prevent bone loss.[70] Great hopes are pinned on the further development of platform switching. Although the first clinical and animal study findings support the platform switching concept and the hypothesis that it leads to horizontal shifting of the biologic width and thus allows for preservation of peri-implant bone in a more coronal position, they also showed that the bone preserving effect does not occur in every case and that the extent of this effect is variable[71,72] (Fig 1-26).

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Fig 1-26 Innovative implant designs are being developed with the goal of enhancing the growth of the biologic width in the coronal direction.

Unlike the gingiva around natural teeth, the biologic width around implants lacks the insertion of connective tissue fibers horizontally into the abutment or implant surface and strong perfusion of the marginal soft tissue. Consequently, implants may have a lower resistance to external mechanical and microbiologic stresses.[24] In the future, it might be possible to enhance the resistance of the biologic width around implants by modifying the implant and/or abutment surface to allow connective tissue fibers to attach to implants similar to the way they attach to the cementum of natural teeth.[73]

Key points:

The fact that implants, like natural teeth, are exposed to the microbial environment of the oral cavity triggers adaptive processes intended to protect deep structures from infection. These processes result in the formation of biologic width, which leads to a three-dimensional loss of peri-implant bone due to remodeling processes.[61] Other undesirable consequences include soft tissue changes, consisting of gingival recession and loss of papillary height on the buccal and interproximal surfaces, respectively. From biologic and esthetic perspectives, it is not desirable to have the establishment of biologic width around an implant result in a loss of bone or soft tissue. Therefore, researchers are currently discussing a number of different factors that could have a positive effect on bone remodeling, including the stability of the implant-abutment connection, the microbial seal of the implant-abutment connection, and the microstructural and macrostructural characteristics in the coronal portion of implants. It is unclear whether other as yet unidentified factors may also play a role. The challenge in the future will be to identify all of the relevant factors and to understand how they interact. The goal would be to apply this knowledge to create new implant designs and clinical treatment protocols capable of predictably achieving more complete and stable preservation of peri-implant hard and soft tissues in the long-term.

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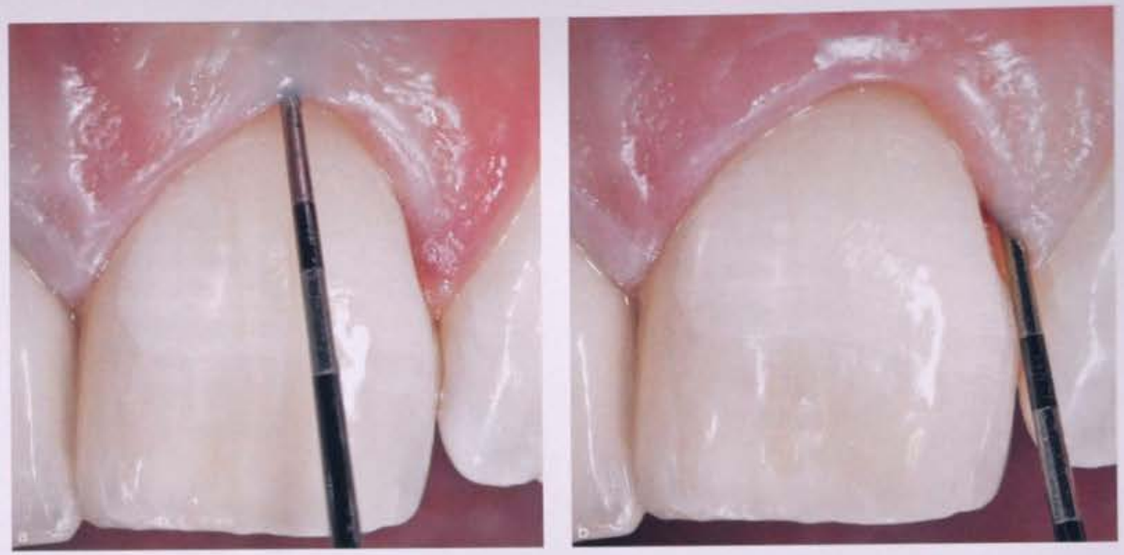


Fig 1-27 (a and b) The dentogingival complex can be measured by sounding to bone with a periodontal probe. The dimensions of the normal dentogingival complex are approximately 3.0 mm buccally and lingually and a mean of 4.5 to 5.0 mm interproximally.

1.3.2 Dentogingival Complex

The dentogingival complex is the sum of all supracrestal soft tissue components. Histomorphologically, the *dentogingival complex* is the sum of the biologic width and the gingival sulcus. In natural teeth, the vertical dimension of the dentogingival complex is approximately 3.0 mm at buccal and lingual sites. At interdental sites, the values are slightly higher (about 4.5 to 5.0 mm), presumably due to the support provided to the interdental soft tissues by adjacent teeth.[43]

Like the biologic width, the dentogingival complex is subject to individual variation.[15,16] Unlike the biologic width, however, the dentogingival complex can be measured by sounding to the alveolar bone with a periodontal probe under local anesthesia and increased pressure (Fig 1-27). Therefore, the clinical relevance of the dentogingival complex is much greater than that of the biologic width, which cannot be measured at chairside.

The dimension of the dentogingival complex is of greatest relevance to the clinician when the gingival contour is to be changed in the context of esthetic crown lengthening (see chapter 10). Measurement of the dentogingival complex is also useful where intrasulcular restoration margins are used.

1.3.3 Position of the Osseous Crest

The osseous crest is positioned 1 to 2 mm apical and parallel to the cementoenamel junction. The interdental bone septa rise slightly in the coronal direction, whereas the facial and lingual aspects of the alveolar bone crest arch apically (Fig 1-28). The degree of scallop of the osseous crest flattens progressively from anterior to posterior (Fig 1-29).

Dehiscence and fenestration of the alveolar bone are not uncommon, particularly in the maxillary anterior region (Fig 1-30).

The presence of supporting bone is important because it provides a supportive base for and positional stability to the soft tissue of the dentogingival complex.[74] Gingival recession can develop only in the presence of alveolar

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Fig 1-28 The alveolar bone follows the cementoenamel junction at a distance of 1 to 2 mm.



Fig 1-29 Like the cementoenamel junction, the degree of scallop of the alveolar bone decreases progressively from anterior to posterior.

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Fig 1-30 Dehiscence and fenestration of the alveolar bone are common, particularly in the maxillary anterior region.

Table 1-1

Classification of osseous crest type according to *Kois*[43]

Crest type	Incidence	TDC, buccal	TDC, interdental
Normal	85 %	3.0 mm	3.0–4.5 mm
Low	13 %	> 3.0 mm	> 4.5 mm
High	2 %	< 3.0 mm	< 3.0 mm

TDC: total dentogingival complex.

bone dehiscences, which would allow the supracrestal soft tissue to recede without violation of the biologic width (see chapter 9).

Three types of relationships can be distinguished between the osseous crest and soft tissue: normal crest, low crest, and high crest[43] (Table 1-1).When the dimension of the dentogingival complex is measured, the vertical distance from the osseous crest to the free gingival margin can vary. Under healthy periodontal conditions, the osseous crest type of the dentogingival complex can be determined by clinical measurement. However, the dentogingival complex and the osseous crest type do not differ in terms of their clinical relevance.

1.3.4 Gingival Biotypes

Clinical differences in the shape, position, and thickness of the marginal periodontium can be distinguished. *Normal, thick flat, and thin scalloped gingival biotypes* or phenotypes can be distinguished based on these differences.[75]

The thin scalloped biotype is characterized by a highly scalloped gingival architecture, relatively thin and fragile gingival tissue, a narrow band of keratinized gingiva, the frequent occurrence of osseous dehiscence and fenestration, triangular anatomical crowns with short interproximal contacts in the incisal third, and a flat emergence profile.

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The thick flat biotype is characterized by a relatively flat soft tissue and bony architecture, thick, dense, and fibrotic soft tissue, a wide band of keratinized gingiva, and rectangular or square anatomical crowns with a pronounced emergence profile and long interproximal contacts that often extend into the cervical third. The interdental papillae are long in the thin scalloped biotype, whereas those in the thick flat biotype are short.[76,77]

Individuals with the thin gingival biotype have a high risk of developing gingival recession on buccal tooth surfaces and in the papillary region after prosthetic, orthodontic, and surgical interventions. Conversely, individuals with the thick gingival biotype are less susceptible to gingival recession but have an increased risk of inflammation and pocket formation following treatment.[76,78–80]

The classification of thick and thin gingival biotypes is subjective and operator dependent because the borderline between what constitutes the different biotypes can be unclear (Fig 1-31). Based on clinical experience, there seems to be a direct correlation between tooth morphology and gingival biotype. Therefore, it would seem that tooth morphology could be useful as an objective parameter of gingival biotype, as was proposed by *Olsson* et al.[76,77] However, there is no scientific evidence confirming this hypothesis.

From the current perspective, the gingival biotype is one of the most important prognostic factors of the predictability of a plastic-esthetic periodontal surgery or implant surgery.

1.3.5 Keratinized Gingiva Around Teeth and Implants

As mentioned previously, there is always at least a minimal band of keratinized gingiva around natural teeth. For many years, a band of keratinized gingiva several millimeters wide was considered the prerequisite for keeping the periodontal tissue inflammation free and stable.[4,81,82] *Lang* and *Löe*[82] conducted a clinical study showing that sites with less than 2 mm of keratinized gingiva and less than 1 mm of attached gingiva exhibited significantly more signs of inflammation. Subsequent studies did not confirm these findings.[83–85] Furthermore, long-term clinical studies showed that the incidence of gingival recession on buccal tooth surfaces with narrow gingiva was not higher than that at surfaces with a wide zone of keratinized gingiva.[86–89] The fact that gingival recession is frequently associated with the narrow band of keratinized gingiva would seem to imply that the narrow band of keratinized gingiva is a consequence rather than the cause of gingival recession.[90]

The thickness of the gingival tissue at the affected tooth surfaces is probably more important for the development of recession. Thin gingival tissue seems to be the least resistant to the development of recession in individuals with toothbrush trauma or plaque-related inflammation.[91–93]

Ericsson and *Lindhe*[94] studied the relationship between the presence of keratinized gingiva and the development of gingival recession at sites with subgingival restoration margins and inflammatory changes. Eight months after placing cotton floss ligatures around the necks of the mandibular third and fourth premolars to induce experimental periodontitis in dogs, they performed surgical periodontitis treatment, consisting of an apically positioned flap in the control group and a gingivectomy in the test group. The keratinized gingiva was largely preserved in the apically positioned flap group and completely removed in the gingivectomy group.

After 4 months of intensive oral hygiene, the height of the gingival margin was marked by notching the affected teeth, and steel bands were cemented to the teeth at an intrasulcular depth of 1 mm. After another 6 months without oral hygiene, the animals were killed and histologically examined. Recession occurred more frequently in the test group than in the control group. However, the histologic examination showed that the healed gingiva was thinner after a gingivectomy that after an apically positioned flap. The authors therefore discussed a potential effect of gingival thickness on the development of recession in the group lacking keratinized gingiva.

Wennström and *Lindhe*[95] compared plaque-induced gingival inflammation in dogs with a wide zone of keratinized gingiva to that in dogs with a surgically narrowed zone of keratinized gingiva. No clinical signs of inflammation were detected in either the test group or the control group during the period in which adequate oral hygiene was provided. After 40 days without oral hygiene, clinical signs of inflammation developed. Inflammation was more severe around teeth with a narrow zone of keratinized gingiva than around those with a wide zone of keratinized gingiva.

Contrary to the clinical assessment, the subsequent histologic evaluation showed that the inflammatory infiltrates in the test group and control group were nearly identical in extent. The only difference was a *smaller*



Fig 1-31 The classification of thick and thin gingival biotypes can be indistinct. Furthermore, it would appear that a scalloped margin and a flat gingival margin can be present independent of the given biotype.

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absence keratinizovaneho ging. kolem implu vede epitel k recesu, ale nově spojená s odhadem přes 2 mm implantu

dimension of marginal soft tissue *in the buccolingual direction* and a *lower degree of keratinization* of the covering epithelium in the group with the narrow zone of keratinized gingiva. The authors concluded that the inflammatory responses of teeth with a wide zone of keratinized gingiva were not significantly different from the responses of teeth with a narrow zone after 40 days without oral hygiene. The reduced thickness of the marginal soft tissue and the lower degree of keratinization of the covering epithelium in teeth with a narrow zone of keratinized gingiva only led to greater visibility of the blood vessels, which was clinically misinterpreted as a sign of more severe inflammation.

These results could explain why thin gingival tissue is more prone to recession in the presence of inflammation than thick gingival tissue. Although the size of the inflammatory infiltrate is the same in both cases, it occupies a larger proportion of the available soft tissue space at sites with a thin gingiva than at those with a thick gingiva. This could lower the resistance of the tissues, which could lead to the development of gingival recession in response to external stimuli.

In contrast to natural teeth, implants may be seated entirely in lining mucosa. The question of whether the presence of an adequate zone of masticatory mucosa around implants improves implant survival rates remains controversial,[96–98] although there is increasing evidence that the absence of keratinized tissue around implants can promote the development of peri-implant inflammation and recession.[99–102] After reviewing the literature, *Bühler-Frey* and *Burkhardt*[103] came to the conclusion that there is scientific evidence demonstrating that the absence of keratinized and attached mucosa around implants is associated with the development of gingival recession but is not correlated to the implant survival rate. In this context, the question of whether the thickness of the peri-implant mucosa affects the development of gingival recession has yet to be answered from a scientific perspective.

Although the impact of keratinized gingiva on the health and stability of gingival and peri-implant tissue is the subject of some controversy, it is certainly important from a clinical perspective. The presence of keratinized tissue makes it easier for the clinician to perform prosthetic procedures and makes it easier for the patient to perform home oral hygiene. Consequently, surgical procedures to widen the keratinized tissue components would appear to be useful, particularly where subgingival restoration margins and implants are involved.

From an esthetic perspective, detached from the medical debate, the presence of keratinized tissue is absolutely essential. A harmonious and even gingival margin as well as inflammation-free, pale pink, stippled, and keratinized tissue surfaces are symbols of perfect "pink esthetics." Therefore, it is inconceivable that good results of plastic-esthetic periodontal or implant surgery could ever be achieved without keratinized tissue (Fig 1-32).

přítomnost kerat. ging. usnadňuje domácí hygienu

z estetického hlediska je přít keratinizované ging. nezbytná

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Fig 1-32 Although the biologic significance of keratinized gingiva around teeth (a) and implants (b) is the subject of controversy, the presence of keratinized gingiva is absolutely essential from an esthetic perspective.

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CHAPTER 2

MICROSURGERY: A NEW DIMENSION

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2.1 Principles of Microsurgery

Microsurgery is the collective term for surgical procedures performed with the aid of optical magnification, which allows the clinician to perform very precise surgery with smaller instruments and finer suture materials than was possible before. The use of a microsurgical technique makes it possible to consistently minimize tissue trauma and maximize the precision of wound closure, two factors that play a decisive role in postoperative outcome (Figs 2-1 and 2-2).

Microsurgical and minimally invasive surgical procedures are already widely used in many medical specialties such as eye surgery, neurosurgery, and plastic surgery, where they have achieved significantly enhanced outcomes not possible with conventional macrosurgical procedures.[1–3] The idea that the deep healing of a wound can never be better than the quality of its surface closure was first expressed by a plastic surgeon.[4] Wound margin necrosis can be very detrimental to the postoperative outcome (see chapter 3). Necrosis generally is caused by an insufficient blood supply to the affected tissue regions, which can result from iatrogenic crushing of delicate microvascular structures in the capillary bed during surgery and the subsequent blockage of these vessels by microthrombi. Consequently, the use of a microsurgical technique can lead to a significant reduction of surgical trauma. As it minimizes tissue trauma while allowing more precise wound closure, microsurgery performed under an operating microscope or loupe results in a quality of healing that can rarely be achieved by conventional macrosurgery.

The concept of microsurgery has also gained increasing significance in periodontal surgery in recent years. However, because microsurgery is generally associated with greater time and costs, the use of microsurgical techniques is justified only if they are clearly superior to the conventional surgical alternatives.[5] In periodontology, this is most commonly the case in regenerative surgery and plastic-esthetic periodontal surgery.

In *guided tissue regeneration*, for example, closed healing of the membrane is absolutely essential to the success of the regenerative procedure. Studies have shown that membrane exposure and subsequent bacterial contamination of the regeneration site occur in up to 80% of cases, depending on the specific technique and type of materials used.[6–8] These complications compromise treatment outcomes and are associated with extensive tissue loss. A controlled clinical study by *Cortellini* and coworkers[9] demonstrated that the introduction of a new flap design could reduce the exposure rate by approximately one-third. The additional use of a microsurgical concept by the same authors decreased the exposure rate even further, to only 7.7%.[10,11] *Wachtel* and coworkers[12] made similar observations. In their controlled clinical study, the use of a microsurgical concept in combination with enamel matrix protein derivatives to repair infra-alveolar periodontal defects resulted in primary healing in nearly 90% of all microsurgically treated defects.

In the field of *plastic-esthetic periodontal surgery*, *Burkhardt* and *Lang*[13] conducted a controlled clinical comparison study of 10 patients with bilateral Miller Class I and Class II gingival recessions at maxillary sites that were repaired with pedicle flaps used in combination with subepithelial connective tissue grafts. In a split-mouth design, root coverage was accomplished by conventional macrosurgery on one side and by microsurgery on the other. Fluorescence angiography was performed to evaluate the course of healing immediately after surgery and 3 and 7 days later. Clinical outcome variables were assessed before surgery and 1, 3, 6, and 12 months postoperatively.

Fluorescence angiography showed that the incidence of postoperative anemia was lower at microsurgically treated sites than at macrosurgically treated sites at the time of the immediate postoperative assessment. This difference persisted over the course of wound healing, as was clearly reflected by faster vascularization at microsurgically treated sites. The authors also demonstrated the statistically significant superiority of the microsurgical technique, as determined based on the percentage of coverage of previously exposed root surfaces 1 year after surgery (Tables 2-1 and 2-2 and Fig 2-3).

Francetti and coworkers[14] reported similar results after a 12-month clinical study.



Fig 2-1 (a to c) The use of conventional macrosurgical instruments and suture materials results in a relatively high level of surgical trauma to the periodontal soft tissues. Precise approximation of the wound margins is often difficult to achieve under these conditions.

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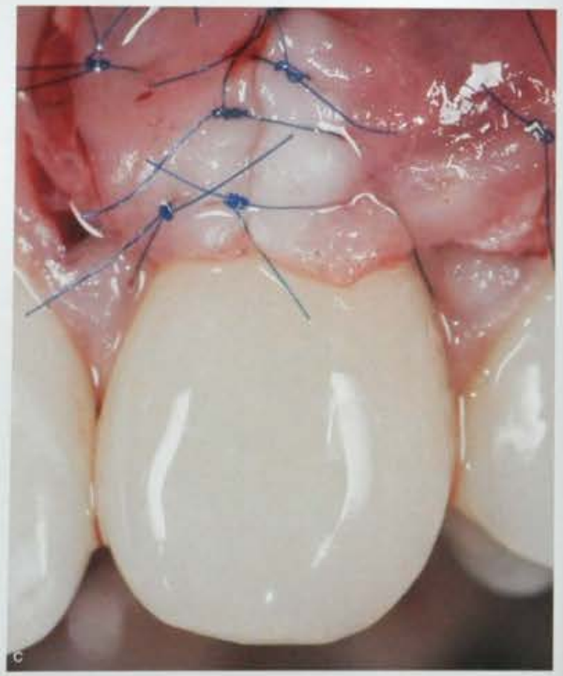


Fig 2-2 (a to c) The use of microsurgical instruments and suture materials minimizes trauma to the soft tissues. Precise approximation of the wound margins is easier to achieve.

Table 2-1

Results of the angiographic assessments performed immediately after surgery and 3 and 7 days postoperatively, expressed as the percentage of vascularization at the surgical site*

Treatment	Day 0 (%)	Day 3 (%)	Day 7 (%)
Microsurgery	8.9 (± 1.8)	53.3 (± 10.5)	84.8 (± 13.5)
Macrosurgery	8.0 (± 1.8)	44.5 (± 5.7)	63.9 (± 12.3)

*The microsurgical results were clearly superior to the macrosurgical results at all three sampling times. (From *Burkhardt* and *Lang*.[13] Reprinted with permission.)

Table 2-2

Coverage of exposed root surfaces 1 and 12 months after surgery, expressed as the percentage of coverage*

Treatment	Day 0 (%)	Day 12 (%)
Microsurgery	99.4 (± 1.7)	98.0 (± 3.4)
Macrosurgery	90.8 (± 12.1)	89.9 (± 8.5)

*Microsurgery resulted in statistically significant improvement of clinical treatment outcomes. (From *Burkhardt* and *Lang*.[13] Reprinted with permission.)

Key points:

Microsurgery is a collective term for surgical procedures performed under optical magnification, that is, an operating microscope or loupe. *Magnification* makes it possible to perform surgical procedures *more precisely* and to use *finer and smaller instruments and suture materials* than are possible in conventional macrosurgery. This reduces surgical trauma and allows more precise approximation of the wound margins, both of which are prerequisites for *enhanced and predictable healing*. The use of microsurgical principles and procedures provides clinically relevant advantages over conventional macrosurgical concepts for regenerative and plastic-esthetic periodontal surgery. *Natural appearance, harmonious transitions* between tissue structures, and the *absence of scarring* in the esthetic zone have become essential parameters of a successful treatment outcome. Microsurgery is also superior to conventional macrosurgery in this regard. Further evidence suggests that the consistent use of microsurgical procedures can reduce postoperative *morbidity* following periodontal surgery.[15]

The advent of microsurgery in periodontics and implant dentistry has only just begun. Considering its potential, the popularity of microsurgery in dentistry seems likely to grow in spite of the fact that microsurgical techniques are more time-consuming and cost intensive and require additional training.

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Fig 2-3a The outcomes of coverage of gingival recession defects were assessed in a study by *Burkhardt* and *Lang*.[13] Sites treated by conventional macrosurgery or microsurgery were evaluated by fluorescence angiography immediately after surgery and 3 and 7 days after the interventions. (From *Burkhardt* and *Lang*.[13] Reprinted with permission.)

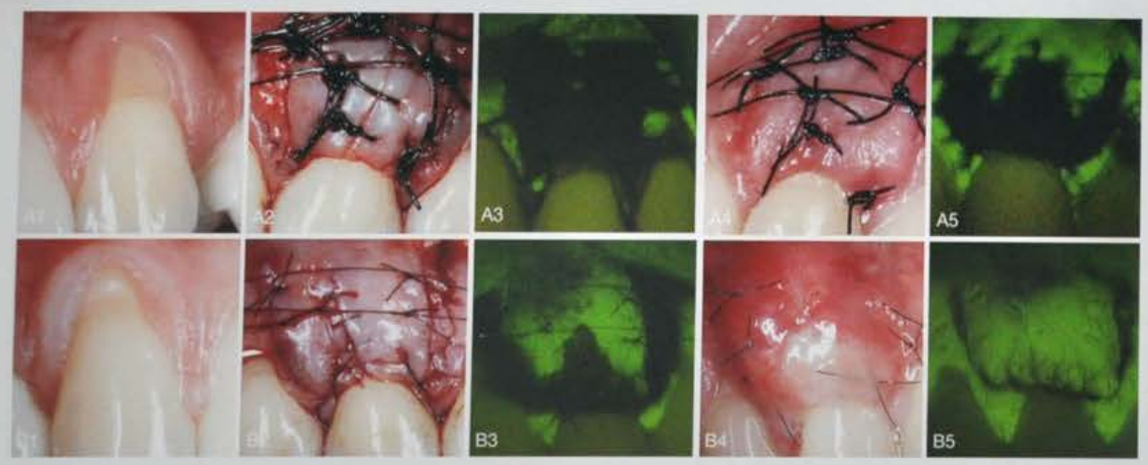


Fig 2-3b Clinical photographs and fluorescence angiograms were used to document the course of healing at sites treated by conventional macrosurgery (A1 to A5) or microsurgery (B1 to B5). The sites are shown at baseline (A1 and B1), immediately after surgery (A2 and A3, B2 and B3), and 7 days after the interventions (A4 and A5, B4 and B5). The corresponding clinical photographs and fluorescence angiograms are shown in each case. Anemic regions appear black in the angiograms. The vascularization of the microsurgically treated sites was clearly superior to that of the macrosurgically treated sites immediately after surgery and 7 days postoperatively. (From *Burkhardt* and *Lang*.[13] Reprinted with permission.)

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2.2 Technical Requirements

2.2.1 Optical Magnification Systems

Magnification is absolutely essential for improved visualization of the surgical field and more precise manipulation of fine tissues during microsurgery. Any optical magnification system used in microsurgery must meet the following requirements:

- It must produce an enlarged, upright, and nonreversed image of the surgical field.
- It must generate stereoscopic (three-dimensional) images that allow for exact depth localization.
- Optical distortion must remain below the perception threshold to prevent eye strain.
- The working distance between the system and the surgical field must be large enough to allow the surgeon to work comfortably and ergonomically.
- The system must be equipped with a light source that optimally illuminates the surgical field.

In principle, both binocular loupes and operating microscopes meet these requirements.

Binocular loupes

Binocular loupes are magnifying eyeglasses in which loupes are mounted on the lenses. They have a lower range of magnification than operating microscopes but are less expensive and easier to use. Binocular loupes permit the surgeon to change the viewing angle at any time without having to adjust or even look at the lens system and without having to change his or her own working position. Different types of loupe can be distinguished based on their designs. The two types of loupe most commonly used in dentistry are Galilean loupes and Kepler loupes.

Galilean loupes

Galilean loupes have a convex and a concave lens and provide ×2 to ×3 magnification. Their main advantages are their small size, light weight, and relatively large field of view. Their main disadvantages are a relatively low level of magnification as well as a small working distance in some cases (Fig 2-4).

Kepler loupes (prism loupes)

Kepler loupes (prism loupes) contain a series of convex lenses and provide ×3 to ×8 magnification. They are ideal for periodontal microsurgery, where a magnification factor of ×3.5 to ×6.0 is recommended. Prism loupes of the Kepler design have very well-corrected optics that permit high magnification at an ideal working distance of 30 to 40 cm. The main drawback is that they are much larger and heavier than Galilean loupes and therefore require a special frame. The loupe system can be either bracket mounted to the frame of the eyeglasses or bonded directly to the lenses. Custom fitting by an optician is required in the latter case. Headband-mounted loupes are also available as an alternative but must be readjusted after each use.

Loupe systems are mounted at a certain forward and downward tilt angle (relative to the horizontal plane), which permits the surgeon to work with the head in a comfortable position without straining the neck muscles (Fig 2-5).



Fig 2-4 The main advantages of Galilean loupes are their small size, light weight, and relatively large field of view. They provide ×2 to ×3 magnification.

Operating microscope

The main components of the optical system of an operating microscope are the magnification changer, objective lens, binocular tube, eyepieces (ocular lenses), and a light source.

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Fig 2-5 Prism loupes of the Kepler design are relatively large and heavy. They provide ×3 to ×8 magnification and are thus ideal for applications in plastic-esthetic periodontal and implant surgery.



Fig 2-6 Operating microscopes can achieve ×3 to ×40 magnification.

Magnification changer

The magnification changer consists of two Galilean telescopes with different magnification factors inserted in a cylinder. To change the magnification factor, the relative position of the two telescopes is changed in either direction by rotating the cylinder. This system provides four different magnification factors plus a free passage position without optics, corresponding to a magnification factor of ×1. With rotation of the cylinder, the combined action of the magnification changer, objective lens, and eyepieces makes it possible to increase the magnification through a range of magnification steps. Magnification ranges of ×6 to ×40 can be achieved with these systems. Operating microscopes of the latest generation allow a continuous change of magnification without blackout.

Objective lens

The objective lens forms an image of the object processed by the magnification changer while projecting illumination from the light source onto the field of view. Objective lenses with a focal length of 200 to 300 mm are available for use in periodontal surgery. Ideally, an objective lens with a focal length of 200 to 250 mm should be used. Lenses with a continuously adjustable focal length are also available. The focal width generally corresponds to the working distance, that is, the distance from the lens to the surgical field.

Binocular tube

The conventional binocular tube contains two inverting prisms that rectify the inverted image produced by the objective lens and collected by the lenses in the end region of the tube. Both straight and inclined binocular tubes are available for operating microscopes. The type used depends on the application. Straight tubes are positioned parallel to the axis of the microscope, and inclined tubes are set at a 45-degree angle to the axis of the microscope. Binocular tubes with continuously adjustable viewing angles (tilting tubes) were recently introduced.

For ergonomic reasons, only tilting tubes that permit continuously adjustable viewing are used in dental surgery. They can be seamlessly adjusted to any viewing angle between 0 and 60 degrees, giving the surgeon a greater degree of freedom to manipulate the microscope without changing seating positions.

All binocular tube systems come with an individually adjustable range of pupil distance. Precise adjustment of the pupil distance is essential for stereoscopic (three-dimensional) viewing of the surgical field.

Eyepieces

The role of the eyepieces, or ocular lenses, is to magnify the intermediate image generated in the binocular tube. Eyepieces with magnification factors of ×10 to ×20 are available for operating microscopes. The type of eyepiece used determines not only the magnification factor but also the size of the field of view. The higher the magnification factor, the smaller the field of view. In periodontal surgery, a ×10 eyepiece generally provides a good compromise between magnification factor and size of the field of view.

Modern eyepieces allow for the correction of emmetropic and ametropic eyes, which enable surgeons with refractive errors to work without glasses. They can compensate for refractive errors in the range of –8 to +8 diopters but not for astigmatism. Therefore, surgeons with astigmatism must wear glasses when using an operating microscope. If glasses are worn, the surgeon must first push back the eye cups and adjust both eyepiece diopter settings to 0.

Operating microscopes can achieve ×3 to ×40 total magnification, but magnification ranging from ×4 to ×24 is usually sufficient and most commonly used in dental surgery (Fig 2-6).

Light source

Optimal lighting is needed to achieve maximum visual acuity. High-intensity halogen bulbs and more recently introduced xenon bulbs, which are used with cold light mirrors designed to protect the surgical field from heat generated by infrared light, are most commonly used in operating microscopes. The objective lens projects the light in a coaxial path via two inverting prisms to the surgical field, that is, in the direction of view. An increasing number of cold light systems (xenon, halogen, and light-emitting diode [LED]) have been introduced by the industry in recent years. Two types can be distinguished: semistationary systems connected to an AC power source and battery-operated mobile systems. Mobile systems are preferred because of the mobility and comfort they provide for the surgeon (Fig 2-7).



Fig 2-7 (a and b) The light source of an operating microscope is incorporated in the optical system, whereas the light source of a loupe is attached to the frame of the magnifying eyeglasses.

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Table 2-3

Comparison of the advantages (+) and disadvantages (–) of loupes and operating microscopes

Feature	Loupes	Operating microscopes
Maximum magnification factor	×6 (–)	×24 (+)
Field of view	Larger (+)	Smaller (–)
Direct view of surgical field	Always possible (+)	Only indirect view possible in some cases (–)
Nonmagnified view (free passage position)	Possible (+)	Not possible (–)
Assistant scope	Not available (–)	Available depending on equipment model (+)
Optical zoom	Not available (–)	×4 to ×24 (+)
Shadow-free illumination	Possible with some light systems (+/–)	+
Flexibility/mobility of the system	+	–
Ergonomics/working comfort	–	+
Ease of handling	+	–
Protection against eye strain	–	+
Training time for surgeon	Shorter (+)	Longer (–)
Training time for assistant	Shorter (+)	Longer (–)
Camera/video documentation	Not possible (–)	Available depending on equipment model (+)
Acquisition cost	$1,000 to $3,300 (+)	$13,000 to $100,000 (–)



Fig 2-8 The Varioskop is a head-mounted microscope.

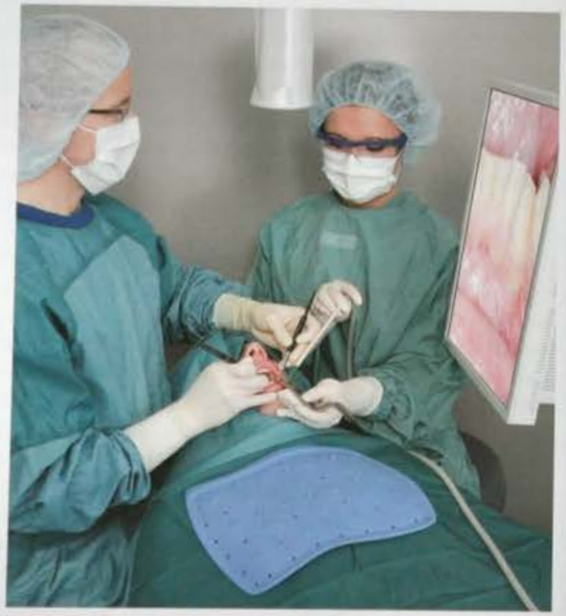


Fig 2-9 The Dentaloscope uses a flat-screen monitor to display three-dimensional camera images of the surgical site.

Comparison of loupes and operating microscopes

In contrast to loupes, operating microscopes are ergonomic by nature and encourage a comfortable working position. In operating microscopes, the rays of light strike the retina in a parallel configuration, so no ocular convergence is necessary. This reduces eye strain. However, operating microscopes have a small field of view that must be frequently adjusted when different structures are viewed. This can be tiresome when the clinician is performing periodontal and dental implant surgery. Table 2-3 summarizes the advantages and disadvantages of loupes and operating microscopes. Researchers developing new generations of optical systems are attempting to combine the optical and ergonomic advantages of operating microscopes with the greater flexibility, ease of use, and lower cost of loupes (Figs 2-8 and 2-9).

Ultimately, the decision to use a loupe or operating microscope should be determined by the treatment outcome. In endodontic surgery, operating microscopes achieve results that are clearly superior to those achieved using loupes. In fact, some procedures can only be performed using microscopes. In periodontal and implant surgery, on the other hand, none of the available operating microscopes has been shown to be clearly superior to loupes. Therefore, they are not routinely used for these indications. The extent to which technical innovations such as the integration of autofocus can result in wider application of operating microscopes in periodontal microsurgery remains to be seen.

All of the microsurgical procedures presented in this book can be performed using a Kepler-type prism loupe with ×3.5 to ×5.0 magnification.

2.2.2 Periodontal Surgical Instruments

Very precise and controlled guidance of the surgical instruments is essential in periodontal surgery, particularly when microsurgical procedures are performed. Therefore, surgical instruments should have rounded nonslip handles to allow secure rotation among the digits with the best fine motor control: the thumb, index finger, and middle finger. This is essential to produce small and precise coordinated movements. In addition, the instruments must be long enough (at least 18 cm) to be held securely in the thumb, index finger, and middle finger in a pen grip. The handles should also be well balanced: Slight top-heaviness facilitates precision work.

Macro instrument set for periodontal surgery

As macrosurgical instruments must sometimes be used for microsurgical procedures in plastic-esthetic periodontal and implant surgery, a special macro instrument set for general periodontal surgery is presented in Fig 2-10. These instruments are designed with two goals in mind: to meet the specific requirements of periodontal surgery and to keep the number of instruments as small as possible. The interchangeable tips of the instruments are made of surgical steel to provide optimal hardness, and their handles are made of titanium to make them lightweight.

Micro instrument set for periodontal microsurgery

The instruments used in periodontal microsurgery are basically the same as those used in conventional periodontal surgery. Although they are finer and smaller, they must be sturdy enough to effectively handle the gingival tissues, which can be relatively tough. Stainless steel is the material of choice for microsurgical instruments because it provides a greater degree of hardness and flexibility.

When purchasing instruments for periodontal microsurgery, the clinician should choose only needle holders and forceps with smooth jaws. Blood easily adheres to diamond-coated inserts or ridges, which can make it more difficult to grasp very fine sutures securely and can increase the risk of damaging or breaking the delicate suture threads used in microsurgery. Smooth carbide inserts have proved to be an excellent choice.

The individual components of an established microsurgical instrument are described in detail below (Fig 2-11).

Microsurgical scalpel handle

A microsurgical scalpel handle must have rounded handles to allow the surgeon to work safely and with adequate precision. The micro scalpel blade is inserted in the fitting at the top of the handle and locked in place by a rotating mechanism located at the end of the instrument (Fig 2-12). Particularly in the case of intrasulcular incisions, it is very difficult to make a precise incision with scalpel blades sized for conventional surgery (Fig 2-13a). Microsurgical scalpel blades with rounded ends and blades that cut in all directions therefore have been developed. They are also suitable for incisions in hard-to-reach places such as interdental spaces

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Fig 2-10 (a to c) The mamadent Macro instrument set.

Fig 2-10a
(left to right)
- Minnesota cheek retractor
- *Castroviejo* needle holder
- Dissecting forceps
- Surgical scissors
- Surgical forceps



Fig 2-10b
(left to right)
- *Hilger* cheek retractor
- Mouth mirror with lip retractor
- Furcation probe
- Periodontal probe
- Two scalpel handles
- *Rhodes* chisel
- Modified *Ochsenbein/ Kramer-Nevins* chisel
- Kirkland gingivectomy knife
- *Orban* gingivectomy knife
- Furcation curette
- *Langer* universal curette, angled
- *Langer* universal curette, straight
- Periosteal elevator
- Prichard periosteal elevator



Fig 2-10c
(left to right)
- *Hilger* cheek retractor
- Mouth mirror with lip retractor
- Furcation probe
- Periodontal probe
- Two scalpel handles
- *Rhodes* chisel
- Modified *Ochsenbein/ Kramer-Nevins* chisel
- *Kirkland* gingivectomy knife
- *Orban* gingivectomy knife
- Furcation curette
- *Langer* universal curette, angled
- *Langer* universal curette, straight
- Periosteal elevator
- Prichard periosteal elevator



Fig 2-11 The mamadent Micro instrument set.
(top to bottom)
- Microsurgical spring scissors
- Microsurgical combination forceps
- Microsurgical needle holder
- Microsurgical scalpel handle
- Papilla elevator

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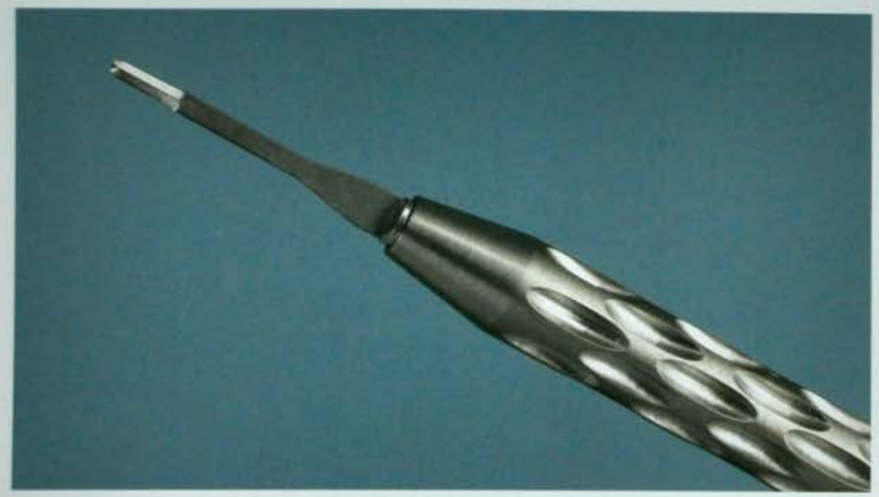


Fig 2-12 Microsurgical scalpel handle with a microscalpel blade attached.





Fig 2-13 (a) It is very difficult to make a precise intrasulcular incision without tissue loss when a macrosurgical scalpel blade is used. (b) In contrast, microsurgical scalpel blades offer greater precision.



Fig 2-14 (a and b) The use of bendable microsurgical scalpel blades can be useful in hard-to-reach areas.

(Fig 2-13b). The use of bendable microsurgical scalpel blades can also be useful in special situations (Fig 2-14).

Microsurgical combination forceps

Dissecting forceps are the most commonly used instruments in microsurgery. They come in different shapes and sizes. Straight dissecting forceps with fine working tips fulfill the requirements of plastic-esthetic periodontal and implant surgery. As mentioned above, the jaws of the forceps should have smooth tips to allow the surgeon to tie knots with very thin sutures without damaging the thread when grasping it with the forceps. Dissecting forceps are held in the nondominant hand when the clinician is tying knots.

The working tips of the forceps must be 1 to 2 mm apart when held loosely in the hand. It should not be necessary to apply great force to close the forceps. The jaws of the forceps must be perfectly aligned when closed. A small guide pin is positioned in the lower third of the forceps to guide the closure of the working tips. The jaws of the forceps should close over a distance of 1 to 3 mm on moderate pressure from the index finger and thumb. When greater pressure is applied, the tips of the jaws should not drift apart.

When sutures are placed, it is often necessary to grasp the tissue with surgical forceps for easier passage of the needle through the flap. As the subsequent knot-tying step is usually performed with the aid of dissecting forceps, combination surgical and dissecting forceps have been developed to permit the surgeon to perform both work steps without changing instruments. Combination forceps are basically dissecting forceps, the jaws of which resemble those of surgical forceps. When slight pressure is applied to the arms of the forceps, the jaws of the surgical forceps–like part close while the arms of the straight dissecting forceps–like part remain open. To close the dissecting forceps–like part in order to tie knots, the surgeon must apply greater pressure (Fig 2-15).

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Fig 2-15a Microsurgical combination forceps are dissecting forceps and surgical forceps in one. They are designed to prevent frequent instrument changes.





Fig 2-15 (b and c) Tissue can be securely grasped by applying light pressure to the combination forceps. Greater pressure must be applied while knots are tied.





Fig 2-16 (a and b) The papilla elevator is a micro periosteal elevator used to raise full-thickness flaps. It can be used in hard-to-reach areas due to its small size.





Fig 2-17 (a and b) The jaws of the microsurgical needle holder are smooth. The slender shape of the instrument tip makes it easier to work in hard-to-reach areas.

Papilla elevator

The papilla elevator is a micro periosteal elevator used to raise flaps. It has semisharp, disk-shaped working ends of different sizes designed for atraumatic dissection of fine tissue structures, especially in the interdental area (Fig 2-16).

Microsurgical needle holder

As needles of various sizes are used in periodontal microsurgery, the microsurgical needle holder should be designed to grasp very fine to fine needles. It must also be slender enough to access interdental areas. Just as with the combination forceps, the microsurgical needle holder should have smooth jaws to allow simple and controlled knot tying without damaging the suture thread. In conventional microsurgery, nonlocking needle holders are normally used because opening and closing the clasp of a locking needle holder could cause uncontrolled and unwanted movement of the working tip. In periodontal microsurgery, on the other hand, locking needle holders are very useful. The needle can be securely grasped and advanced in controlled rotating movements through the tough gingival tissue without the surgeon's having to exert too much pressure on the handles of the needle holder (Fig 2-17).

Microsurgical scissors

Curved microsurgical scissors with sharp working tips have proved ideal for periodontal microsurgical applications. They are mainly used to cut sutures and are sometimes used for controlled cutting of soft tissue. Microsurgical scissors also have rounded handles designed to facilitate rotational movement (Fig 2-18).

Technologic developments in the aforementioned microsurgical instruments include the incorporation of an additional joint in the handles of forceps and needle holders. Modifications in the geometry and transmission of forces at the working tips of the instruments have been made to further facilitate the secure and precise grasping of needles and sutures (Fig 2-19).

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Fig 2-18 (a to c) Microsurgical scissors are generally used to cut sutures but are sometimes used for controlled cutting of soft tissue (eg, periosteal slitting).

Fig 2-19 (a to c) The mamadent Master Microsurgical instrument set contains a needle holder and combination forceps. The additional joint in the instrument handle makes it possible to grasp needles and sutures more precisely and securely during suturing.

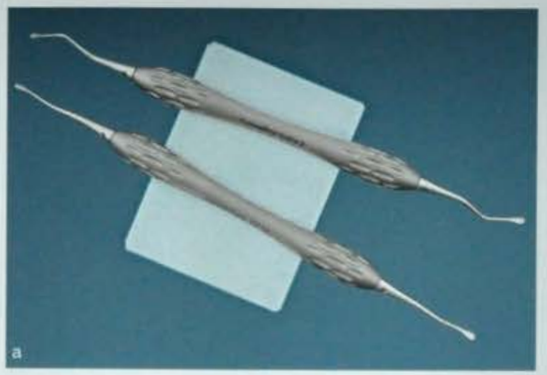






Fig 2-20 (a to c) Tunneling knives are specially designed for preparation of partial-thickness flaps according to the tunnel technique. To prevent perforation, only the side of the blade facing the periosteum or bone is sharp.

Tunneling knife

Special instruments are needed to perform advanced surgical techniques such as the tunnel technique of flap elevation without vertical releasing incisions. The buccal alveolar bone and overlying mucosa are curved, whereas most surgical instruments and scalpel blades are straight. Consequently, the use of conventional instruments to create partial-thickness flaps by the tunnel technique in this region carries a considerable risk of flap perforation.

The use of slightly curved dissection instruments could help to reduce the risk of perforation in these cases. Patented tunneling knives with such a curvature are specially designed for these situations. Two large platelike blades of different sizes are located at the working ends of the knife. The instrument is used with the sharp edge against periosteum or bone and the blunt edge against soft tissue. Tunnelling knife I has an angled blade and is designed for use in most sites. Tunneling knife II is straight and designed for use at sites with a very wide band of keratinized gingiva. To ensure safe and atraumatic elevation of partial-thickness flaps, the tunneling knife should always be sharpened prior to surgery (Figs 2-20 and 2-21).



Fig 2-21 Tunneling knives must be sharpened regularly with a flat Arkansas knife-sharpening stone.

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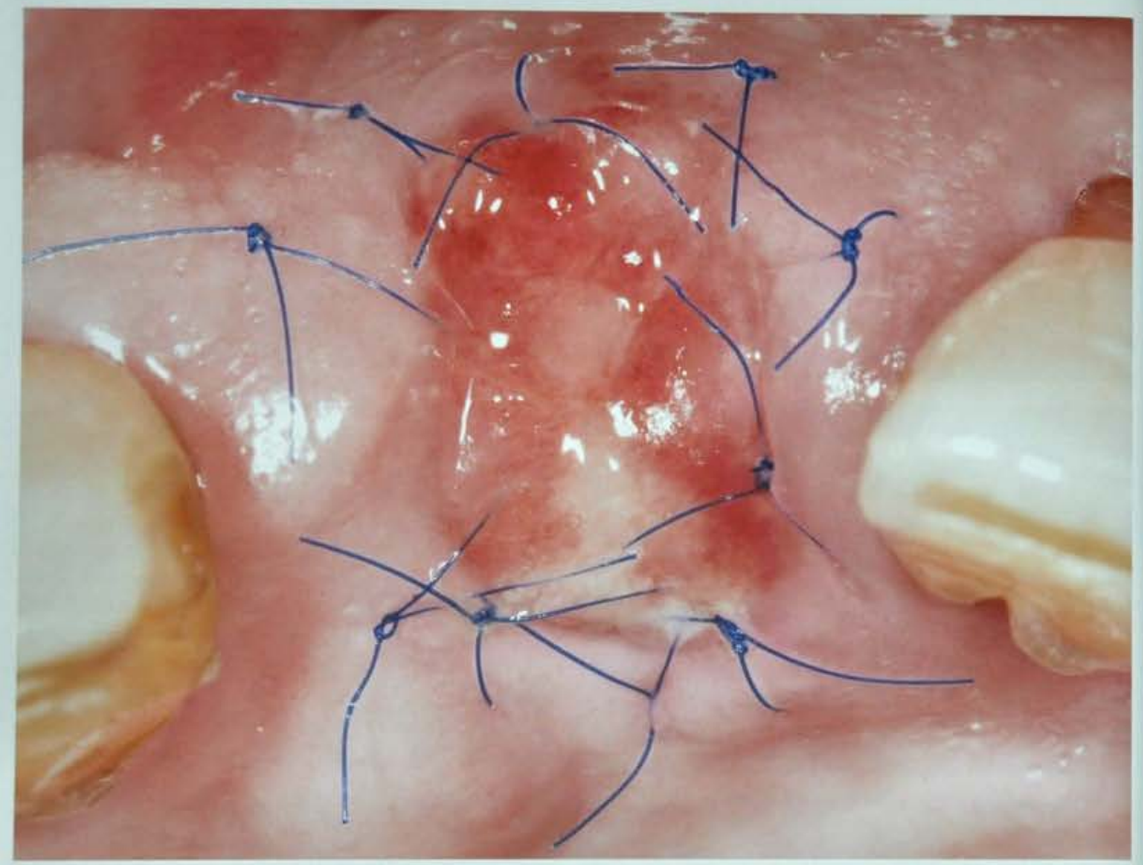


Fig 2-22 Synthetic microsurgical suture materials are characterized by high tissue compatibility and minimal plaque accumulation during the healing process.

2.2.3 Suture Materials

Different surgical procedures require the use of different suture materials. The physical and chemical properties of the suture material must be appropriate for the expected mechanical and biologic stresses on the wound. Suture materials used in periodontal microsurgery must meet a number of physical requirements including high tensile strength, high tearing strength, good knotting characteristics, and high knot security. Moreover, the suture materials should have a surface that facilitates atraumatic passage through the tissues without causing capillarity in order to minimize immune response in the affected tissues. *Capillarity* is the process by which suture materials, particularly those with multifilament fibers, draw fluids and microorganisms into the wound like the wick of a candle.[16] Consequently, it is also referred to as the *wick effect*. Last but not least, absorbable suture materials must have a defined absorption time.

Types of suture material

Suture materials may be classified according to the origin of their raw materials (*natural* versus *synthetic*), their ability to disintegrate in tissue (*absorbable* versus *nonabsorbable*), and their structure (monofilament versus multifilament). Monofilament sutures consist of a single strand of material, whereas multifilament sutures have several strands of material that are braided together.

Nonabsorbable sutures are generally preferred to absorbable sutures because the latter always induce inflammatory reactions in tissue when they disintegrate. If absorbable sutures must be used, they should preferably be made of synthetic materials. This is because compared to sutures made of natural materials, sutures made of synthetic materials cause milder inflammation as they disintegrate. Serafit, a suture made of polyglycolic acid, has proved to be a suitable synthetic product. Size 6-0 Serafit sutures have an absorption time of 60 to 90 days. Nonabsorbable sutures are characterized by high tissue compatibility.[17–19] Compared to multifilament sutures, monofilament nonabsorbable threads cause much less capillarity but are stiffer and therefore have poorer knotting characteristics and knot security. Seralene suture materials provide a good compromise between capillarity and knotting characteristics. These are synthetic monofilament sutures made of polyvinyl fluoride, which makes them very tissue compatible. Seralene 6-0 and 7-0 sutures have good knotting characteristics and relatively low stiffness. Still, precise knot-tying technique is necessary for secure suture closure when monofilament sutures are used.

Expanded polytetrafluoroethylene (e-PTFE) sutures are a special type of nonabsorbable suture (Fig 2-22). Sutures made of e-PTFE are monofilament threads with air pockets incorporated in the material. Their tissue compatibility is excellent, but their porosity (air content of 50% to 60%) results in a high swelling capacity, making e-PTFE sutures prone to bacterial biofilm colonization of the thread surface. These are major drawbacks, but e-PTFE also has some important advantages, such as excellent glide characteristics. Consequently, Gore-Tex CV-5 suture materials can be recommended as standard materials for macrosurgical suture applications in modern periodontal surgery.

The *European Pharmacopoeia (EP)* provides a standardized system for suture size classification in which size denotes the diameter of the suture thread. The EP classification is based on the metric system, and diameter is indicated in units of 0.1 mm on the metric scale. Under the EP system, the diameter of a size 1 suture ranges between 0.100 and 0.149 mm. Although the suture size printed on the label denotes the minimum diameter of the thread, the actual thread diameter usually lies at the upper end of the tolerance range.

The commonly used suture sizes such as 5-0, 6-0, and 7-0 are based on the *United States Pharmacopeia (USP)* system. To maintain uniformity, the USP has also adopted the metric classification system, and today both metric and USP size gauges are printed on the labels of most suture packaging. Table 2-4 provides a side-by-side comparison of the metric and USP suture size classification systems.

Table 2-4

Comparison of the European Pharmacopoeia (EP) and United States Pharmacopeia (USP) suture size classification systems

Metric (EP)	USP	Diameter (mm)
0.01	12-0	0.001–0.009
0.1	11-0	0.010–0.019
0.2	10-0	0.020–0.029
0.3	9-0	0.030–0.039
0.4	8-0	0.040–0.049
0.5	7-0	0.050–0.069
0.7	6-0	0.070–0.099
1.0	5-0	0.100–0.149
1.5	4-0	0.150–0.199
2.0	3-0	0.200–0.249
2.5	2-0	0.250–0.299
3.0	2-0	0.300–0.349
3.5	1	0.350–0.399
4	2	0.400–0.499
5	3	0.500–0.599
6	3	0.600–0.699
7	5	0.700–0.799
8	6	0.800–0.899
9	7	0.900–0.999

Surgical needles

Microsurgical needles must have high flexural strength to ensure that they do not bend when passed through tough tissues. Furthermore, they must be ductile enough to prevent breakage when overloaded. The material that best meets these requirements is high-quality stainless steel, which is usually plated with nickel or chrome to facilitate polishing.

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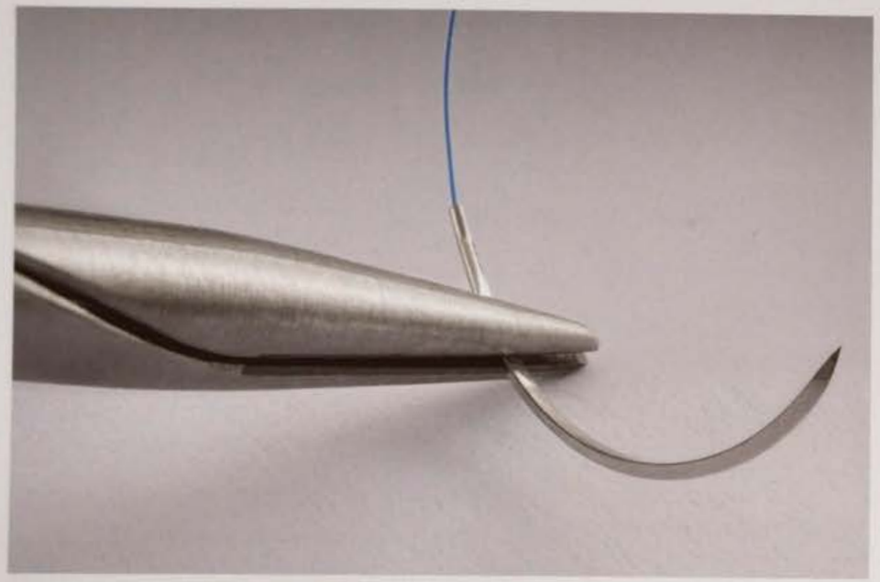


Fig 2-23 Atraumatic suture needles with a curved body and a triangular cutting tip have proven effective in plastic-esthetic periodontal and implant surgery.

Curved needles are easier to handle in tight spaces, and they guide the path of the suture in such a way that when the ends of the thread are pulled, it is possible to achieve apposition of the wound margins with a tendency for *eversion*. Straight needles, on the other hand, result in *inversion* of the wound margins, which should be avoided in periodontal surgery. When interdental sutures are placed, it should be possible to insert the needle through an interdental space in a single pass. This requires the use of longer needles, especially in the molar region. Therefore, needles with a 3/8 or 1/2 curve and an arc length of 8 to 15 mm are preferred for use in periodontal surgery.

Cutting needles with a triangular cross section have proved effective in periodontal microsurgery. Only the front third (tip) of the needle should be sharp, and the middle third (shaft) should be flattened for better retention in the needle holder. Round-bodied needles are not recommended because they bend more easily and are more difficult to pass through periodontal tissues. A polished surface enhances the ability of the needle to glide smoothly through tissues.

The junction between the needle and the thread is another important factor. Conventional needles are reusable and have an eye through which thread is inserted. The eye of the needle and the doubled strand of thread running through it produce a relatively broad suture footprint, which results in considerable tissue trauma.

Atraumatic suture needles were developed to solve this problem. Unlike conventional needles, the suture thread is glued or welded to the blunt end of the atraumatic suture needle, creating a smooth junction (swage) between the needle and the thread. Because these are disposable needles designed for single use only, they are always new and sharp. Consequently, the use of atraumatic suture needles results in a substantial reduction of tissue trauma. All of the evidence points to the benefits of using atraumatic suture needles in periodontal surgery, particularly when microsurgical procedures are performed (Fig 2-23).

A suture set commonly used in plastic-esthetic periodontal and implant surgery is shown in Fig 2-24 and Table 2-5.



Fig 2-24 The mamadent suture set contains an assortment of different suture materials used in plastic-esthetic periodontal and implant surgery. It contains absorbable and nonabsorbable suture materials for both macrosurgery and microsurgery.

Table 2-5

Characteristics of materials included in the mamadent suture set

Name	Material	Construction	Size	Needle length	Needle shape	Indications	Absorbability
Seralene DS12 6.0	Polyvinylidene fluoride	Monofilament	6-0	12 mm	3/8 circle needle	Penosteal sutures, anchoring sutures in the anterior region	Nonabsorbable
Seralene DS15 6.0	Polyvinylidene fluoride	Monofilament	6-0	15 mm	3/8 circle needle	Periosteal sutures, anchonng sutures in the posterior region	Nonabsorbable
Seralene DS12 7.0	Polyvinylidene fluoride	Monofilament	7-0	12 mm	3/8 circle needle	Standard microsurgical sutunng	Nonabsorbable
Seralene DS15 7.0	Polyvinylidene fluoride	Monofilament	7-0	15 mm	3/8 circle needle	Microsurgical suturing in the molar and premolar interproximal region	Nonabsorbable
Seralene HS8 7.0	Polyvinylidene fluoride	Monofilament	7-0	8 mm	1/2 circle needle	Detailed closure in hard-to-reach areas	Nonabsorbable
Gore-Tex CV-5	Polytetrafluorethylene	Monofilament	5-0	16 mm	3/8 circle needle	Standard macrosurgical suturing	Nonabsorbable
Serafit DS12 6.0	Polyglycolic acid	Mulitfilament	6-0	12 mm	3/8 circle needle	Subepithelial connective tissue graft fixation	Absorbable (60–90 days)

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2.3 Microsurgical Training for Clinical Practice

2.3.1 Adapting to the Use of Magnification

The use of optical magnification is becoming more and more commonplace in contemporary dentistry. Many clinicians already routinely use a *Galilean* loupe with ×2 to ×3 magnification. Magnification significantly reduces the visibility of the surgical field, making it much harder to control hand movements and work sequences. Clinicians must therefore adapt their old hand motor skills and master new ones (eg, picking up and putting down the needle when tying knots). There are specific courses that can facilitate the transition to working with optical magnification. As the power of magnification increases, a person's awareness of the physiologic tremor of the hands also increases. To ensure that this awareness does not impair performance during surgery, the clinician should learn appropriate behavioral and mental preparatory techniques before performing microsurgical interventions.

Lack of sleep or excessive stress in the period prior to surgery can impair fine motor control, affect hand muscle coordination, and cause increased tremor. Nicotine, caffeine, and certain medications are known to persistently aggravate physiologic tremors. Emotional factors such as stress and nervousness also have a negative effect on physiologic tremor. Therefore, the surgeon must make sure that he or she is well rested and in a relaxed state of mind when performing microsurgery. Proper training prior to the first microsurgical intervention can also help reduce tension and nervousness and is therefore highly recommended.

2.3.2 Training Exercises Using Rubber Dam

The most important skills to practice are the handling of suture materials and the tying of knots under optical magnification. Any surgeon wishing to perform microsurgery must be able to confidently pick up and guide a needle with microsurgical instruments, put down the needle in the field of view when tying knots, easily retrieve a needle placed outside the visual field, and tie instrument knots. These skills can be practiced by stretching a piece of rubber dam over a wooden board that has a hole cut out in the middle (Fig 2-25).

A simple exercise for practicing microsurgical skills and procedures for tying microsurgical knots under optical magnification with the aid of microsurgical instruments is described below.

Incision technique

Using a scalpel, the clinician makes a practice incision in a piece of rubber dam stretched over a wooden board. The incision should extend diagonally, either from left to right and up to down (right-handed surgeon) or in the reverse direction (left-handed surgeon). The placement of two additional parallel incisions prevents the need to apply excessive tension on the sutures.

In later training, the surgeon should change the position of the rubber dam to practice making incisions in different directions with the instruments at a different angle and the hands in an unaccustomed position.

Postural support

When the practitioner is working under magnification, movement of the instruments is controlled primarily by finger and wrist movement. Therefore, the surgeon's arms should rest comfortably on the operating table or on the armrests of the chair. Instruments are held in a pen grip while the little finger and ring finger rest against a stable surface for support (Fig 2-26). The support prevents premature fatigue and minimizes physiologic tremor.

Picking up the needle

The surgeon should use the needle holder to grasp the back third of the needle perpendicular to the axis of the needle. The following procedure is recommended.

With forceps in the nondominant hand, the surgeon should grasp the thread 3 to 4 cm away from the needle and lift it until only the tip of the needle is still on the undersurface. Now the needle holder can be used to grasp and secure the correct section of the needle. This procedure excludes the possibility of holding the needle with two instruments at the same time, which could result in bending. The tip of the needle should never be grasped because this contact could bend and blunt the tip.

Inserting the needle

Bite size is the distance from the incision line to the sites where the needle enters and exits the tissue on either side of the incision line. It is determined by the thickness of the flap or the desired depth of the suture path in the tissue. The more superficially the needle is to be passed through the tissue, the smaller the distance from the incision line to the needle insertion and exit sites. However, a minimum tissue thickness is needed to prevent the sutures from tearing the tissue and causing additional tissue trauma. Uniform bite size is crucial for precise suture closure without overlapping wound margins. Therefore, the distances between the incision line and the needle insertion and exit sites must always be equal (Fig 2-27).

The creation of uniformly sized sutures should be practiced on rubber dam. The correct distance between the incision line and the needle insertion or exit site is approximately twice the thickness of rubber dam. The



Fig 2-25 Microsurgical suture skills can be practiced by stretching a piece of rubber dam over a wooden board that has a hole cut out in the middle.

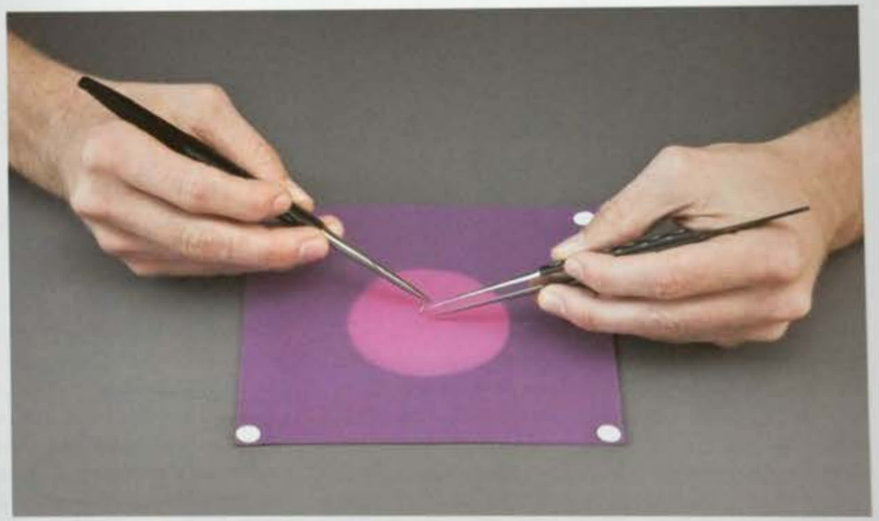


Fig 2-26 Microsurgical instruments are held in a pen grip. The working hand is supported via the little finger and ring finger.

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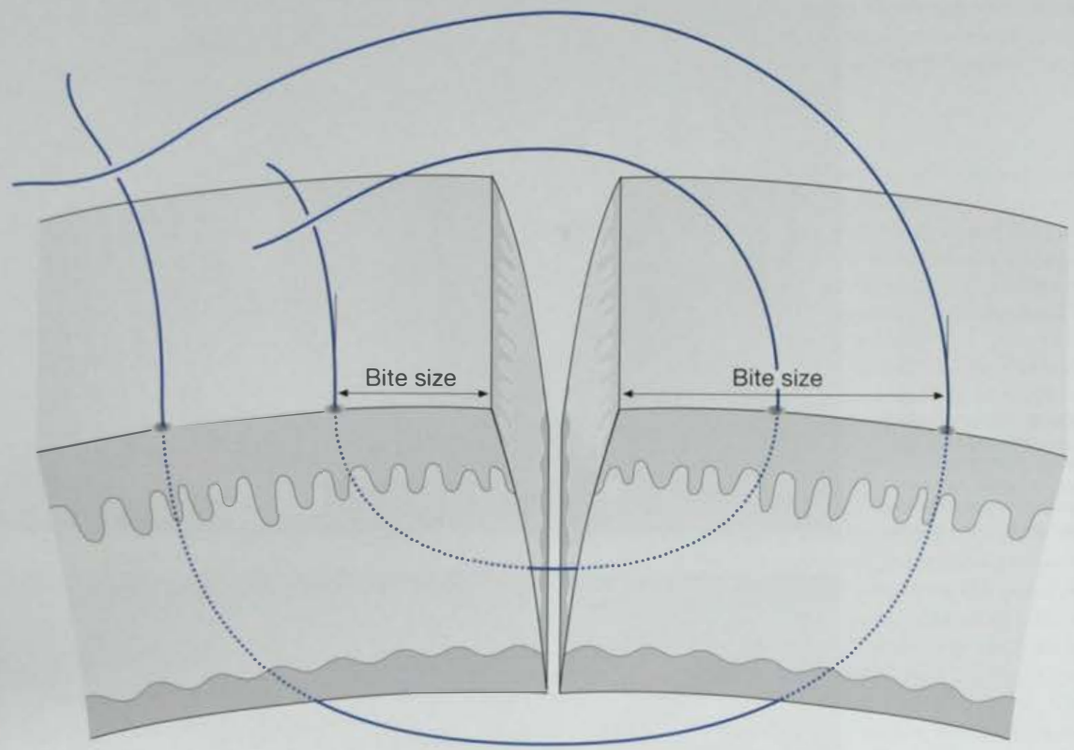


Fig 2-27 To achieve a uniform bite size, the distances between the incision line and the points where the needle enters and exits the tissue on either side of the incision line must be equal.





Fig 2-28 (a and b) The needle is inserted perpendicular to the surface of the rubber dam. Passage of the needle into and out of the rubber dam can be facilitated by gently pressing with forceps on the opposite side.

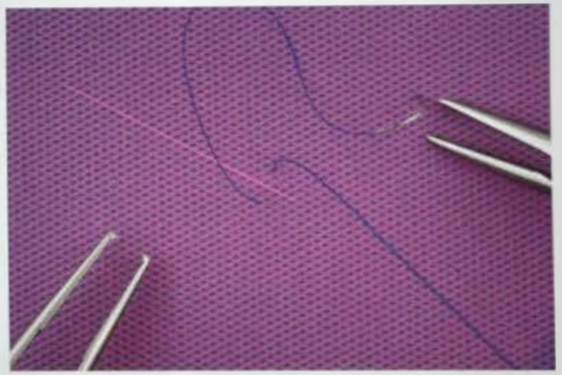


Fig 2-29 The needle should be set down within the field of view before a suture knot is tied so that it can be located immediately after this task is completed.

needle should be inserted at a 90-degree angle to the incision line and perpendicular to the surface of the rubber dam. The clinician can facilitate this positioning by holding the forceps against the underside of the rubber dam. Likewise, the surgeon can facilitate removal of the needle on the opposite side by gently pressing against the opposite side of the rubber dam with forceps (Fig 2-28). During insertion, the needle is pushed through the rubber dam as far as possible before the needle holder is opened and the needle is released. Next, the needle holder is used to grasp the shaft of the needle (middle third) and pull it all the way through the rubber dam. The needle should never be grasped by the tip if this can be avoided. Furthermore, use of another instrument in the nondominant hand to remove the needle from of the needle holder can easily bend the needle. If only the tip of the needle emerges from the exit site, the clinician should grasp it very gently without fully closing the jaws of the needle holder and then pull the needle out only as far needed to grasp its middle portion. Passage of the needle into and out of the material can be accomplished in one or two steps. After the needle has completed its passage through the rubber dam, the needle is either set down, preferably somewhere within the field of view, or inserted in the rubber dam to facilitate retrieval of the needle with the needle holder after the suture knot is tied (Fig 2-29).

Tying a surgeon's knot

Microsurgical sutures are tied with microsurgical instruments. A simple surgeon's knot, consisting of an initial double throw followed by a second single throw in the opposite direction, is commonly used. The clinician should practice tying a surgeon's knot on rubber dam until the movements become routine and refined. The terms *long end* and *short end* of the suture are used in the following explanations of the procedure. The long end is the one attached to the needle, whereas the short end is the one protruding from the insertion site.

1. The surgeon should grasp the long end of the suture approximately 3 cm away from the needle exit site using microsurgical forceps held in the nondominant hand.
2. The surgeon should center the needle holder directly above the incision line and between the two ends (long and short) of the suture using the dominant hand.
3. The clinician should form a double throw by wrapping the long end of the suture around the needle holder twice using the forceps held in the nondominant hand.
4. The short end of the suture should be grabbed with the needle holder and pulled through the double throw. This draws the short end in the needle holder toward the needle exit site while the long end is pulled toward the needle insertion site.
5. After releasing the short end of the suture, the surgeon should center the needle holder in the dominant hand above the knot and between the two ends of the suture.
6. The surgeon should make a single throw by wrapping the long end of the suture around the needle holder in the opposite direction once using the forceps in the nondominant hand.
7. The short end of the suture is grasped with the needle holder again and pulled through the single throw. This time, the short end of the suture is drawn in the opposite direction, back toward the insertion site.
8. The knot is gently tightened and placed lateral to the incision line (Figs 2-30 and 2-31).

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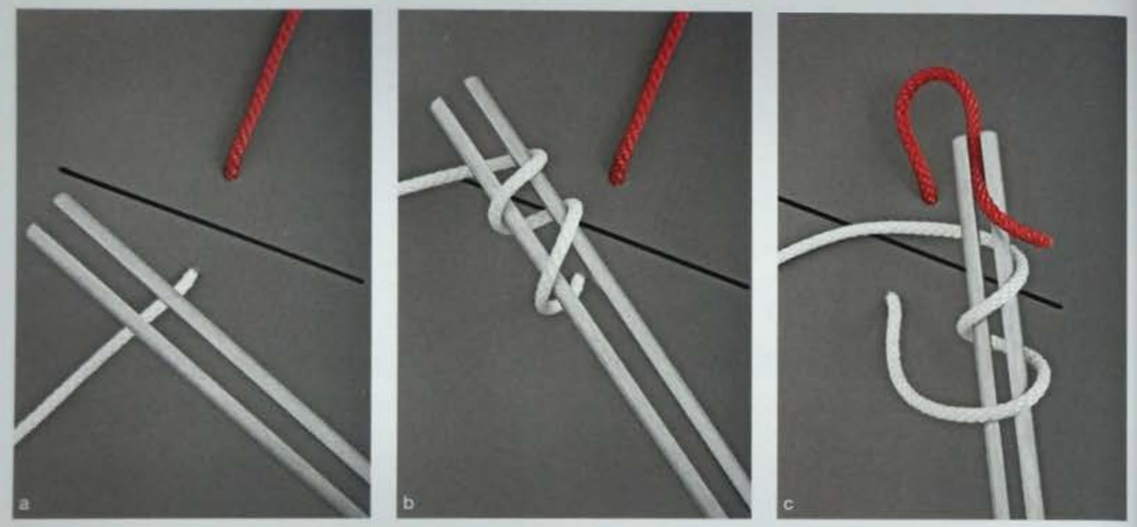


Fig 2-30 (a to c) First, the suture is pulled through the wound margins until just a small amount (about 1 cm) remains at the short end. Next, the long end of the suture is grasped approximately 3 cm away from the needle exit site using forceps, and the tip of the needle holder is centered between the two ends of the suture. A double throw is made by wrapping the long end of the suture around the needle holder twice using the forceps, and the short end of the suture is grasped with the needle holder.

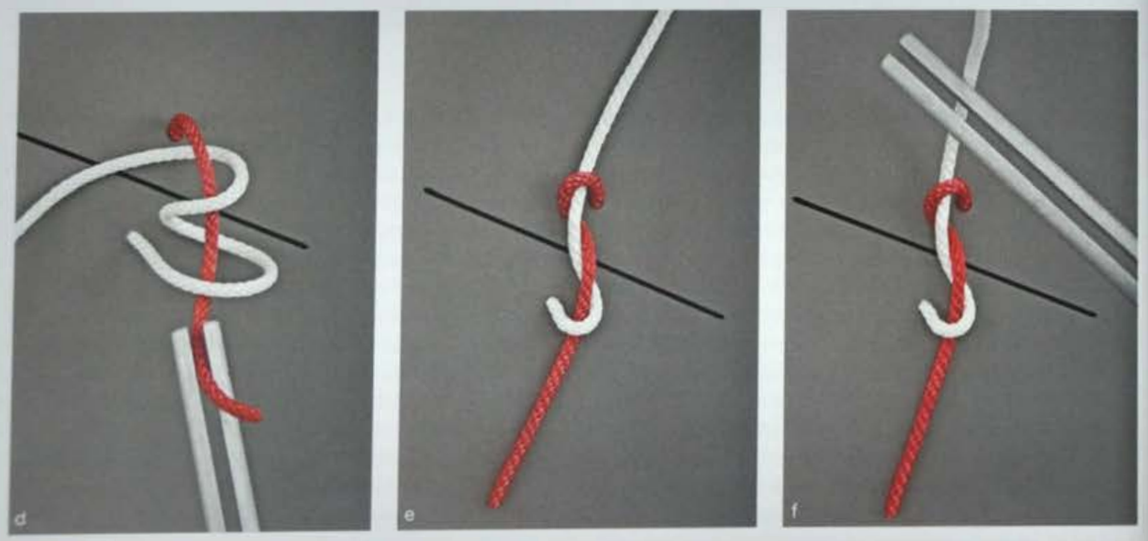


Fig 2-30 (d to f) The first throw is loosely tightened by pulling the short end of the suture through the double throw, in the direction of the needle exit site. The tip of the needle holder is then centered between the two suture ends again.

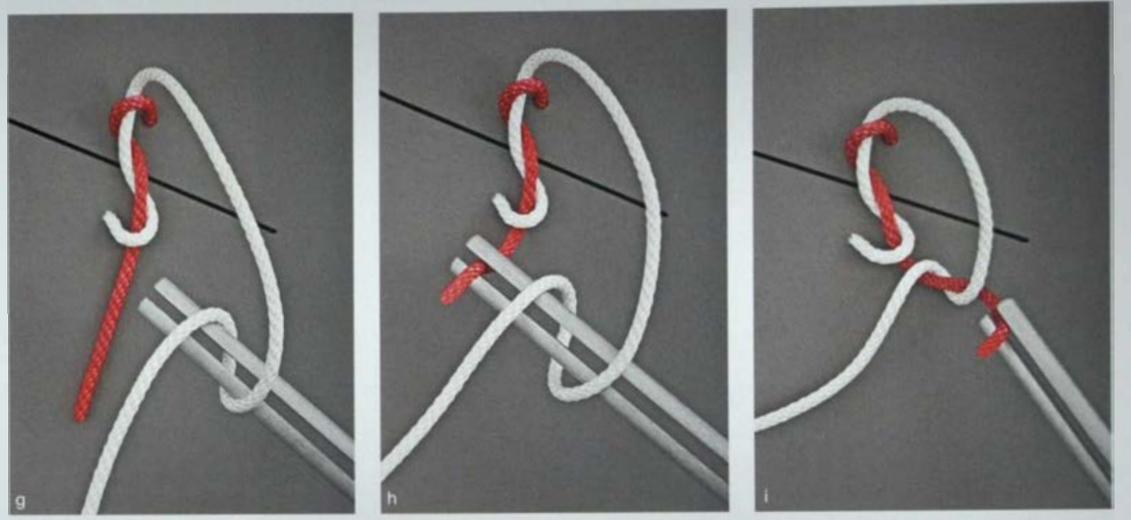


Fig 2-30 (g to i) A single throw is made by wrapping the long end of the suture once around the needle holder in the opposite direction using the forceps, and the short end of the suture is grasped again.

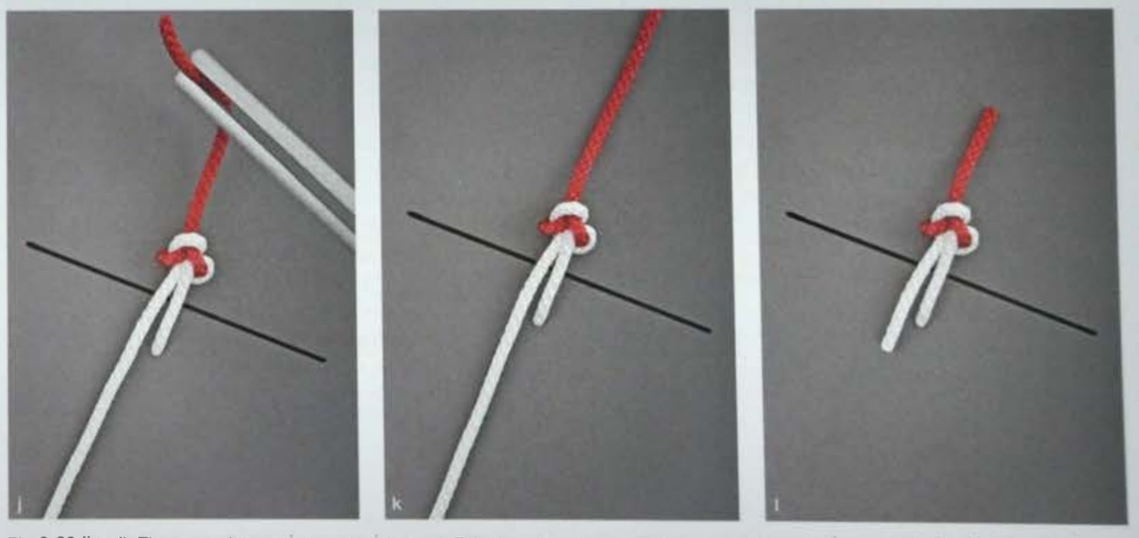


Fig 2-30 (j to l) The second throw is loosely tightened. This time, the short end of the suture is drawn in the opposite direction, back toward the insertion site. The knot is then placed lateral to the incision line.

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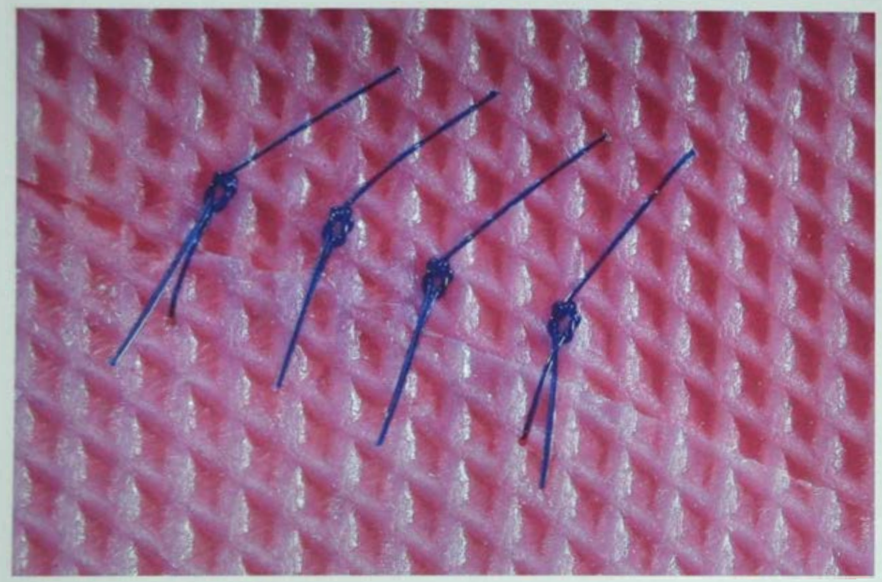


Fig 2-31 A simple surgeon's knot, consisting of an initial double throw followed by a second single throw in the opposite direction, can be tied with microsurgical instruments.



Fig 2-32 Pig jaws are very well suited for hands-on training in microsurgical procedures.

Cutting the sutures

The suture materials used in microsurgery are cut with microsurgical scissors. It is important to ensure that the cut ends are no shorter than 3 mm but also not much longer than that. If the needle is not in the field of view at first, then only the short end of the suture is cut with the microscissors after knot tying is completed and the end is removed from the field of view. The long end of the suture is then grasped with the forceps and cut. Finally, the thread grasped with the forceps is slowly drawn through the open jaws of the needle holder until the needle reappears in the field of view and can be grasped with the needle holder.

2.3.3 Advanced Training

Incision and flap design are further important elements of microsurgical training. In addition to learning the movement sequences, it is important to become accustomed to the unusual visual dimensions of microsurgery. When working under optical magnification, it is easy to overestimate the actual thickness of an elevated flap. Consequently, the flap could be too thin and prone to necrosis. The use of microsurgical procedures and instruments makes it possible to perform flap procedures that are completely different from those used in conventional surgery. The clinician should first practice these techniques on an appropriate model before performing them on a patient. Pig jaws are very well suited for hands-on training in microsurgical procedures (Fig 2-32). When performing surgical exercises under a microscope for the first time, the surgeon should take a microsurgical training seminar with an experienced instructor.

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CHAPTER 3

PRIMARY HEALING: THE KEY TO SUCCESS

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Primary wound healing is an essential part of successful reconstructive surgery. Rapid and unimpaired healing is crucial, particularly in plastic-esthetic periodontal and implant surgery, where soft and hard tissue grafts and artificial substitutes are frequently used. The survival and integration of grafts and graft substitutes depend on a number of factors, including the quality of the blood supply to the affected tissues and the prevention of bacterial infection. Both are crucial for achieving proper incorporation of graft materials into the surrounding tissues. The oral microflora contains a number of different bacteria. Primary wound closure over natural or artificial graft material ensures that healing will occur in an environment that is impossible or very difficult for microorganisms to enter.

Healing following plastic-esthetic periodontal and implant surgery is often complicated by the fact that the surgical wound is located on a rigid and avascular tooth or implant surface, resulting in an impairment of local immune defenses and a reduction of the supply of nutrients to vital tissues at the site.[1] Impaired healing can lead to wound dehiscence, tissue defects, and the formation of fibrotic tissue and hypertrophic scars, all of which adversely affect the cosmetic outcome. Optimal wound healing is crucial to the success of plastic-esthetic periodontal and implant surgery (Fig 3-1).

The term *wound healing* encompasses all of the physiologic regenerative processes involved in restoring the integrity of damaged body tissues. Because surgical wounds are created in a more or less controlled environment, the surgeon has a great degree of control over a range of factors involved in the wound healing process, from incision placement to wound closure.

The physiologic processes involved in wound healing will be described in the following section. Those factors crucial to achieving optimal wound healing following periodontal and implant surgery will be discussed in detail.

3.1 Principles of Wound Healing

3.1.1 General Principles

Wound healing occurs by one of two mechanisms: regeneration or repair. *Wound regeneration* refers to the replacement of lost or damaged tissue with identical tissue, resulting in restoration of the tissue to its original condition (restitutio ad integrum). *Wound repair*, on the other hand, involves the replacement of lost or damaged tissue by nonspecific scar tissue; therefore, the tissue is not restored to its original condition.[2] If a wound is caused by trauma, regenerative healing generally is not possible because these wounds tend to be extensive—in some cases, with complete tissue loss. In surgical wounds, on the other hand, regenerative healing is possible, and the surgeon should always strive to achieve complete regeneration of the damaged tissues to prevent formation of extensive scar tissue.

Reparative healing is basically determined by the wound closure status during the healing process. If a wound such as an abrasion is left to open, reparative tissue must form to cover the tissue defect and restore the integrity of the body surface. The reparative tissue formed by this route transforms into scar tissue during the later phases of healing. Generally speaking, *healing by secondary intention* (per secundam intentionem) occurs when the wound is left open to heal, whereas primary wound closure results in *healing by primary intention* (per primam intentionem).

From a biologic perspective, the end result of wound healing by primary or secondary intention is basically the same: wound closure. However, the two processes differ significantly in terms of the chronology of the different phases of wound healing and the quality of tissues formed during the healing process.

3.1.2 Primary and Secondary Wound Healing

Wound healing by primary intention is characterized by the relatively uncomplicated healing of a wound with formation of either very little or no scar tissue. In other words, the tissue is made intact and restored to its original condition. From a surgical perspective, the smooth, well-vascularized, tension-free, and precisely approximated wound margins are the most important conditions for healing by primary intention. After *primary wound closure*, a *thin but stable blood clot* forms between the wound margins, and *little to no local tissue ischemia* occurs. Consequently, *bacteria cannot infiltrate the wound*, particularly the deep tissue layers. *Blood circulation* to the wound is rapidly restored, and a provisional matrix quickly forms to cover the wound. Under favorable conditions, primary wound healing can occur within a few days in the absence of clinically detectable inflammation, wound secretion, and granulation tissue formation.[2,3]

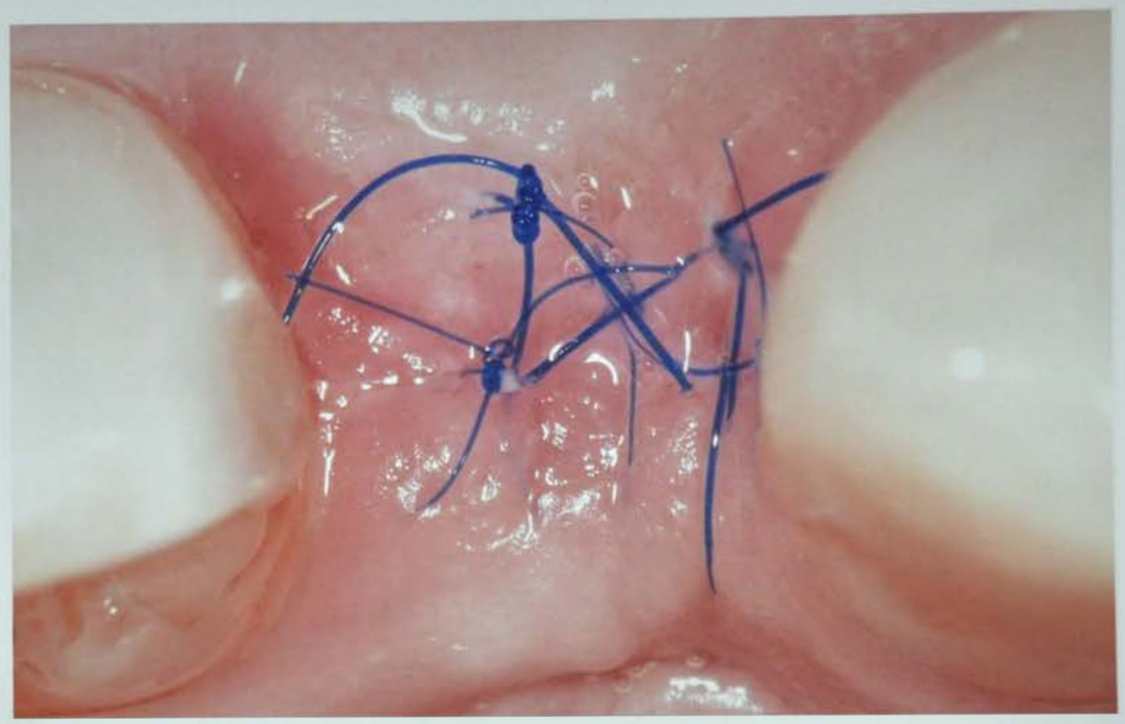


Fig 3-1 Immediately prior to suture removal 1 week after implantation and hard tissue augmentation, the site shows optimal wound healing, characterized by complete wound closure, minimal fibrin, and absence of signs of inflammation.

The surgeon should always attempt to create optimal conditions for primary wound healing, which normally ensures that the course of postoperative healing will be quick and uncomplicated. If these conditions are met, the acute inflammatory response that invariably occurs during the healing process will be short and hardly noticeable clinically, patient discomfort and impairment will be minimal, necrosis-related tissue defects will not occur, the regeneration processes below the surface can proceed unimpaired, and healing will culminate in nearly scar-free restoration of the original condition (Fig 3-2).

Secondary wound healing occurs if the wound is intentionally left open to heal or if primary wound closure is not possible due to the presence of tissue defects. Secondary healing is associated with the formation of reparative tissue. To quickly close the wound and rapidly restore the integrity of the epithelial lining of the oral cavity, the body produces low-grade scar tissue to bridge the gap caused by the damaged or missing tissue. Flap edge necrosis often occurs if the sutures exert too much tension on the flap, if the sutures are poorly knotted and loose, or if there is local tissue hypoperfusion, resulting in secondary healing after primary wound closure. Bacterial infection and the resulting immunologic reaction can delay healing.

The time required for wound healing is mainly determined by the size of the wound and the presence or absence of bacterial infection. Scarring usually remains after the process is completed. The texture and color of the scar tissue can vary greatly from that of the surrounding tissues. The surface of the scar tissue often

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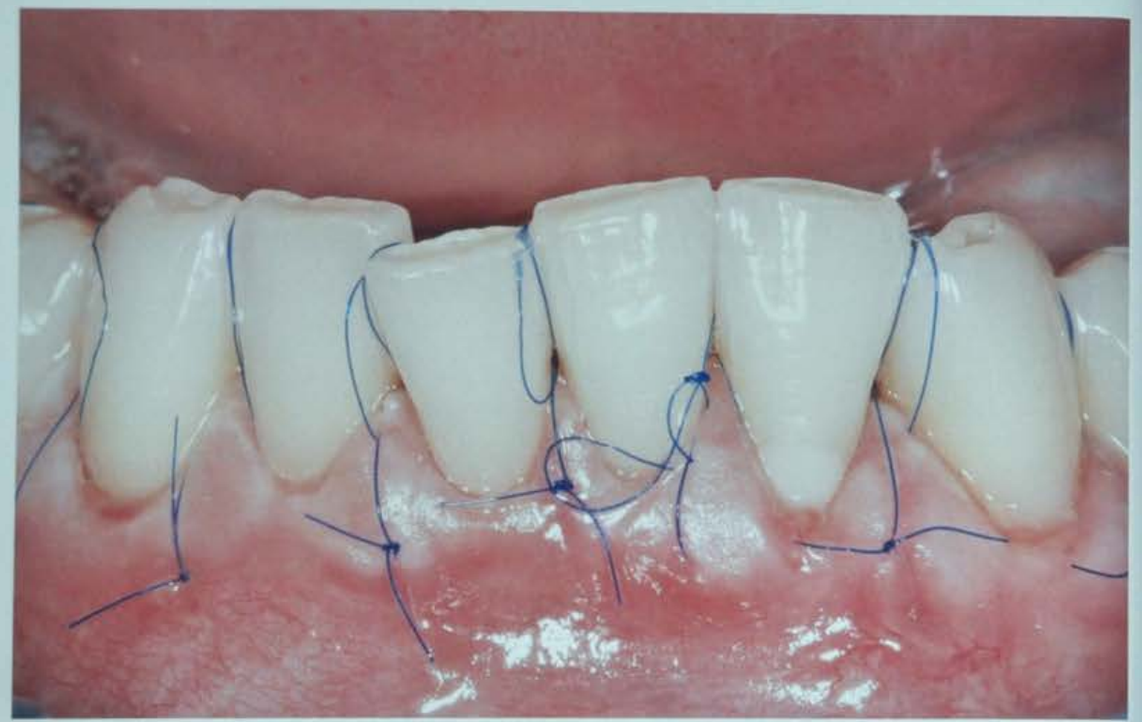


Fig 3-2 Healing by primary intention 1 week after placement of a coronally positioned flap for root coverage in a patient with gingival recession.

exhibits projections and irregularities because of the contraction of the collagen fiber–rich tissue during the course of healing.

Secondary healing is associated with a higher risk of bacterial infection, postoperative discomfort, and scar tissue formation. Hence, secondary healing of surgical wounds should be avoided whenever possible, especially if the surgery was performed for cosmetic reasons. There are exceptions, however: In cases such as gingival recession coverage and esthetic crown lengthening, specific areas of the wound are intentionally left open and allowed to heal by secondary intention (Fig 3-3).

3.1.3 Phases of Wound Healing

The process of wound healing encompasses all of the physiologic regenerative processes initiated by the body to restore the continuity of its tissues. Interactions between mesenchymal and epithelial cells, which are mediated and coordinated by a large number of chemical mediators with local and systemic effects (eg, growth factors and cytokines), play an important part. The overall wound healing process can be broken down into a series of distinct phases, which are described below.

Inflammatory phase

The inflammatory phase mainly functions to establish temporary wound closure in order to restore the integrity of the body surface. Dead cells are eliminated from the wound, and invading microorganisms are killed. The inflammatory phase is a two-part process consisting of an exudative phase and a resorptive phase.

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Fig 3-3 Differences in the healing outcomes of two vertical releasing incisions 1 week after surgery. (a) Primary wound healing. (b) Secondary wound healing.

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Exudative phase

The exudative phase is the first stage of wound healing. It occurs within the first 48 hours of an injury and is characterized by an influx of blood, lymph, and tissue fluid into the wound. The first local response, vasoconstriction, occurs within seconds. The affected blood vessels constrict to minimize blood loss. A blood clot consisting of platelets and red blood cells enmeshed in a network of plasma proteins forms on the wound. This cell complex is organized to form a fibrin-stabilized provisional matrix, which temporarily glues the wound together. In addition to stabilizing the wound, the provisional matrix serves as a reservoir for growth factors and as a scaffold to guide blood vessels and migrating cells into the wound. A narrower wound opening will lead to a smaller clot, which enables faster healing and closure of the wound. The overall effect is a rapid closure of the wound to limit exposure to the germ-laden oral cavity.[2,4]

Resorptive phase

The chemotactic stimulation within the wound attracts neutrophils to migrate down the provisional matrix into the wound after a period of roughly 6 hours. The neutrophils phagocytose the pathogens and ensure their intracellular elimination in the scope of a cell-mediated immune response. High levels of bacterial contamination are associated with excessive neutrophil stimulation, which can quickly result in the extracellular release of proteolytic enzymes. These enzymes can produce defects in endogenous tissues and cause local acidosis, resulting in cell damage. In a second wave of cell-mediated immune response, macrophages differentiating from histiocytes systematically degrade and eliminate the cellular and pathogenic debris. In this context, the exudation of plasma from the wound serves a number of purposes: It not only facilitates the distribution of locally released mediators and ensures sufficient mobility of the aforementioned immune cells in tissue but also serves as a nutrient medium for the later waves of fibroblasts migrating into the wound.

Restoration phase

After the initial differentiation and proliferation of mesenchymal cells, there is a continuous transition from the inflammatory phase to the restoration phase. Central elements of this process include the ingrowth of capillary tissue and formation of granulation tissue (proliferative phase) and redifferentiation of scar tissue (repair phase).[2]

Proliferative phase

The end of the inflammatory phase of wound healing is marked by the formation of new capillaries and their ingrowth into the wound. Anastomoses are formed to successively reestablish the blood supply to the wound. How smoothly this stage progresses is determined by the quality of blood supply to the wound margins, which is determined by how many adjacent vascular structures were injured by tissue trauma (eg, strain, contusion, or incision).

Subsequently, the proliferative phase occurs 24 to 74 hours after injury. This is an anabolic process, characterized by epithelization starting from the wound margins and transformation of the clot into well-vascularized, cell- and collagen-rich granulation tissue. The initial blood and fibrin clot serves as a guide that leads the migrating fibroblasts and endothelial cells to the wound.[2,4] In wounds healing by primary intention, only a small amount of granulation tissue has to form, so wound healing proceeds quickly, and the tensile strength of the wound increases rapidly. If a wound heals by secondary intention, massive quantities of granulation tissue must be formed to cover a larger defect, and it takes much longer to achieve stable wound conditions.

Repair phase

Repair is the final stage of wound healing. Epithelial closure of a wound is achieved by the lateral migration of epithelial cells along the margins of the wound to the granulation tissue. Scar formation after primary wound healing is minimal. In most cases, the scar line remaining after wound healing is inconspicuous or, ideally, invisible. Wound healing by secondary intention often results in wider, unesthetic scars, some of which result in functional impairment due to excessive tissue contraction.[3]

3.1.4 Clinical Assessment of Wound Healing

It can be hard to distinguish between primary and secondary wound healing a few days after surgery. To address this problem, *Wachtel* and coworkers[5] developed the Early Wound Healing Index (EHI) to facilitate differentiation between primary and secondary healing and to provide a more objective assessment of postoperative wound healing quality. The EHI distinguishes five classes of wound healing 5 days after surgery (Fig 3-4).

EHI 1

Grade 1 wound healing is characterized by complete flap closure with no fibrin line 5 days after primary wound closure (primary wound healing). Because of the excellent quality of wound healing, the sutures can be removed and the recommended postoperative wound management measures started at this time (see chapter 6).

EHI 2

Grade 2 wound healing is characterized by complete flap closure and a fine fibrin line 5 days after primary wound closure. In EHI 2, the sutures should be left in place another 2 days for further stabilization of the wound area. The sutures are removed and the recommended postoperative management measures started 7 days after surgery.

EHI 3

Grade 3 wound healing is characterized by complete flap closure with fibrin coverage of the incision line and adjacent parts of the flap 5 days after surgery (still classified as primary wound healing). The sutures are removed and the recommended postoperative management measures started 7 days after surgery.

EHI 4

Grade 4 wound healing is characterized by incomplete flap closure and partial necrosis of the wound margins. Due to the postoperative wound infection and the increased tissue pressure in the inflamed region, the wound margins drift apart, and secretions drain out of the wound. Healing occurs by secondary intention, and increased wound pain and marked swelling can be observed around the surgical site. The sutures can be removed 7 days after surgery. Complications such as scar formation cannot be excluded. Postoperative management of these cases is described in chapter 17.

EHI 5

Grade 5 wound healing is characterized by incomplete flap closure and necrosis of the wound margins. Because of the wound infection, pus drainage through the incision line or through the sulcus of adjacent teeth may be observed, depending on the situation. The most common surgical causes of impaired wound healing in these cases are flap edges that are too thin and thus poorly perfused and/or the lack of precise and tension-free primary wound closure. Pus sometimes drains from apparently well-approximated wound margins, for example, if graft necrosis has occurred deep within the wound. In these cases, healing occurs by secondary intention and is often accompanied by inflammation, which is frequently associated with significant problems such as increased wound pain and swelling. Complications must be expected in patients with EHI 5 wound healing, and a second surgery may be needed to correct these problems. The sutures can be removed 7 days after surgery. Postoperative management of these cases is described in chapter 17.

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EHI 1

No fibrin at the incision line



EHI 2

Slight fibrin at the incision line



EHI 3

Fibrin at the incision line and adjacent parts of the flap



EHI 4

Open wound with suppuration



EHI 5

Open or closed wound with localized pus collection

Fig 3-4 The Early Wound Healing Index (EHI) distinguishes five classes of wound healing, as determined 5 days after surgery.[5] It provides an objective assessment of wound healing. The clinical photographs show the characteristics of healing in different cases 5 days after regenerative periodontal surgery.

3.2 Factors That Influence Wound Healing

A number of local (Table 3-1) and systemic (Table 3-2) factors influence the healing of surgical wounds. All should be taken into consideration to achieve primary wound healing (EHI 1, 2, or 3), which is the quality of healing required for successful plastic-esthetic periodontal and implant surgery.

3.2.1 Local Factors that Influence Wound Healing

Absence of inflammation

Gingival inflammation and periodontal disease negatively affect the quality of the marginal soft tissue. The inflammatory process results in a marked decrease in collagen content and a significant increase in blood flow, interstitial fluid, and inflammatory cells in the soft tissues. Apart from impairing wound healing after surgery, this also causes technical problems during surgery. In the presence of inflammation, the marginal soft tissue has a spongy consistency and an increased bleeding tendency that makes it difficult to achieve precise microsurgical incisions, flap elevation, and approximation of the wound margins. Because plastic-esthetic periodontal and implant surgery are elective procedures, they should only be performed in the absence of inflammation.

All inflammatory periodontal conditions must be eliminated prior to plastic-esthetic periodontal and implant surgery to ensure the predictability of the planned procedure. Before surgery, patients with inflammatory periodontal diseases must receive adequate periodontal pretreatment by a dental hygienist or dental assistant with comparable training. The periodontal pretreatment program should include multiple professional supragingival and subgingival tooth cleaning sessions as well as personal oral hygiene instruction and motivation. One of the established plaque and bleeding indices should be used to evaluate the efficacy of personal oral hygiene. Plastic-esthetic periodontal or implant surgery should not be performed unless the Plaque Index (PI) score is less than 20% and the Papillary Bleeding Index (PBI) score is less than 5% (see chapter 6).

Root surface biocompatibility

When periodontal plastic surgery is performed to cover exposed roots, the biocompatibility of the root surface is important for the healing process and treatment success. Even in individuals with optimal personal and professional oral hygiene, exposed root surfaces are always covered with a thin layer of biofilm. The biocompatibility of the root surface is crucial to achieving attachment of the soft tissue to the tooth surface after root coverage surgery. Therefore, the root surface should be mechanically cleaned immediately prior to surgery to thoroughly remove the biofilm and the microorganisms in it. If this is not accomplished, there is a high risk that the soft tissue will not attach to the root surface after surgery. This could result in the formation of periodontal pockets instead of new attachment to the root surface of the affected teeth (see chapter 9).

Use of a microsurgical approach

One of the most important keys to achieving optimal wound healing is the use of a microsurgical approach. The five basic elements of a microsurgical approach are *optical magnification*, *microsurgical instruments*, *microsurgical suture materials*, *microsurgical flap designs*, and *microsurgical suturing techniques*. The central goal of treatment based on these five elements is to achieve primary wound healing by handling the tissues atraumatically and with maximum precision (see chapter 2).

Flap design

Mucoperiosteal flaps, *mucosal flaps*, or a *combination of the two* can be used in plastic-esthetic periodontal and implant surgery. In mucoperiosteal flap procedures, a full layer of soft tissue (ie, periosteum, connective tissue, and epithelium) is elevated from the bone surface by blunt dissection. Mucosal flaps, on the other hand, are elevated by sharp dissection of subepithelial connective tissue while the periosteum and parts of the connective tissue are left on the bone. Consequently, mucosal flaps are usually thinner than mucoperiosteal flaps and do not contain any of the well-perfused periosteal soft tissue.

Mucoperiosteal flaps are technically simpler, whereas mucosal flaps are more demanding. In addition to enhanced healing, mucosal flaps have a number of other advantages, such as better flap mobility, which facilitates primary wound closure. Consequently, mucosal flaps are preferentially used in plastic-esthetic periodontal and implant surgery (see chapter 4).

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Blood supply to the flap margins

The flap margins are the most critical zones during the entire wound healing process. Ischemia-related necrosis or impaired wound healing in the region of the flap margins immediately results in wound dehiscence. This leads to secondary healing in association with deep bacterial infection. Maintenance of a good blood supply to the flap margins must be a central goal of all intraoperative and postoperative treatment measures.

The risk of flap edge necrosis is inversely proportional to the thickness of the flap. The thinner the edges of the flap, the smaller the number of vessels supplying the flap edges and, hence, the higher the risk of postoperative necrosis. When a mucosal flap is elevated, it is crucial that the *flap does not thin out toward the edges.* When the initial incision is made, the scalpel blade should always be held perpendicular to the surface of the soft tissues. If these fundamental rules are observed, the elevated flap will have square-cut margins of uniform thickness instead of acute-angled margins. This design has particular advantages in terms of flap perfusion. Intersecting incision lines should be slightly overcut to achieve a flap of uniform thickness, even along the edges (see chapter 4).

Atraumatic soft tissue handling is essential for good postoperative flap perfusion and the prevention of flap edge necrosis. Basic prerequisites for optimal wound healing include the use of a sharp scalpel blade and atraumatic tissue dissection (see chapter 2).

Flap thickness

In many cases, flap thickness is crucial not only for perfusion along the flap edges during the initial phase of wound healing but also for the final outcome of periodontal surgery.[6,7] *Baldi* et al[6] compared coronally advanced flap procedures for root coverage to determine whether flap thickness was a relevant predictor of root coverage in patients with gingival recession. They determined that complete root coverage was possible in 100% of all sites with a flap thickness greater than 0.8 mm. The complete-coverage rate for thinner flaps was lower, and the difference was statistically significant.[6] These findings suggest that the mean thickness of mucosal flaps should be uniform and no less than 1.0 mm. Flap thickness has important clinical implications (see chapter 4).

Flap tension

Precise approximation of the wound margins without tension is another critical factor for achieving primary wound healing following surgery.[8–10] Flap repositioning is often necessary in plastic-esthetic periodontal and implant surgery. It is crucial that the sutures do not exert tension on the wound margins because tension could result in constriction and collapse of blood vessels, impairing flap perfusion and consequently increasing the risk of impaired healing and flap necrosis. Flap tension is also associated with a risk of postoperative flap retraction, which could result in secondary wound healing and its related problems.

Tension-free approximation of the wound margins is therefore crucial to the success of plastic-esthetic periodontal and implant surgery. Adequate flap mobility can be ensured through the use of an appropriate flap design and releasing incisions (see chapter 4). Size 6-0 and 7-0 microsurgical suture materials will tear if too much force is used when the sutures are tied.[11] In clinical practice, this has actually proved to be a useful limitation because it prevents the surgeon from exerting excessive tension on the edges of the flap during suture closure.

3.2.2 Systemic Factors

Diabetes

Individuals with diabetes (type 1 and type 2) often have impaired wound healing.[12] The tissue perfusion disorders associated with diabetic micro- and macroangiopathies impair local immune defenses and wound healing. Consequently, diabetic patients have a high risk of suboptimal wound healing and necrosis, particularly when diabetes is poorly managed.[12,13]

When treating diabetic patients, the surgeon should consult the attending primary care physician or specialist to determine how well the disease is controlled. The glycohemoglobin fraction (HbA1c), as a percentage of total hemoglobin, has been shown to have high diagnostic value for long-term monitoring of blood glucose management. An HbA1c of less than 6.5% indicates that diabetes is well managed, and predictable and satisfactory results of plastic-esthetic surgery can be expected in these patients.[14] Elective surgery should never be performed on individuals with poorly managed or uncontrolled diabetes. Even if performed in patients with well-managed diabetes, surgery should preferably be performed under prophylactic antibiotic coverage (see chapter 6).

Table 3-1

Local factors that influence wound healing

Absence of inflammation	• Periodontal pretreatment and good personal oral hygiene help to eliminate inflammation of the marginal gingiva. • Treatment prerequisites: Plaque Index (PI) < 20%. Papillary Bleeding Index (PBI) < 5%.
Root surface biocompatibility	• Biocompatibility is particularly relevant for root coverage in gingival recession treatment. • Mechanical cleaning of exposed root surfaces is required immediately prior to surgery.
Use of a microsurgical approach	• Optical magnification. • Microsurgical instruments and suture materials. • Atraumatic tissue handling.
Flap design	• Mucosal flaps are technically more difficult to raise but easier to reposition and suture.
Blood supply to the flap margins	• Acute-angled flap margins should be avoided. • The initial incision should always be made with the scalpel blade held perpendicular to the tissue surface. • Intersecting incision lines should be overcut. • Trauma to the wound margins should be minimized.
Flap thickness	• Minimum flap thickness is 1 mm.
Flap tension	• Tension-free approximation of the wound margins is crucial.

Smoking

Nicotine and the toxic aerosols in tobacco smoke have systemic effects on wound healing in the oral cavity that occur in combination with local factors directly influencing the healing of oral tissues. In this context, the most relevant effects of smoking are a dose-dependent reduction of blood flow to tissues supplied by terminal vessels and reduced immune defense.[15,16] The surgeon can assume that wound healing complications will occur in smokers, even if the surgery is carefully planned and precisely executed. Therefore, elective plastic periodontal and implant surgery should never be performed on smokers.[17–20] Short-term abstinence from smoking prior to surgery is not sufficient. Long-term complete nicotine abstinence could be acceptable, but there is no scientifically validated evidence indicating how long this period of abstinence should be. However, it can be assumed that a minimum of 6 months of nicotine abstinence is required before surgery.[21]

Immunosuppression

Immunosuppressive medications such as cytostatics and corticoids diminish the immunologic competence of the patient and therefore may impair or delay wound healing.[22] Patients who have received organ transplants require long-term immunosuppressive therapy to prevent transplant rejection. Immunosuppressive therapy is not an absolute contraindication to plastic-esthetic periodontal and implant surgery. However, surgical procedures should never be scheduled for a patient undergoing immunosuppressive therapy before the patient's physician is consulted, and procedures should always be performed under prophylactic antibiotic coverage. Precise approximation of the wound margins and primary wound closure are necessary to minimize complications during healing in patients who are taking immunosuppressive medications.[22] Compliance with all relevant hygiene requirements is mandatory (see chapter 6).

HIV and AIDS

Modern antiviral drugs and treatment protocols have significantly improved the feasibility and prognosis of surgery in HIV-infected patients in recent years. Immunocompetence, ie, the presence of adequate quantities of $CD4^+$ T cells in the blood, determines whether treat-

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Table 3-2

Systemic factors that influence wound healing

Diabetes	• Consult with the patient's physician. • Plastic surgical interventions may be performed if the diabetes is well managed (HbA1c < 6.5 %). • Extensive surgery should be conducted under prophylactic antibiotic coverage, even if the diabetes is well managed.
Smoking	• Periodontal and implant surgery should never be performed in active smokers. • Plastic surgical procedures may be performed if the patient has abstained from nicotine for at least 6 months.
Immunosuppression	• Consult with the patient's physician. • Antibiotic prophylaxis is required for surgery.
HIV and AIDS	• Consult with the patient's physician. • Surgical procedures may be performed during the latency phase. • Antibiotic prophylaxis is required for surgery. • Strict compliance with hygiene requirements is mandatory.
Patient-specific factors	• Each patient has an individual healing capacity. • Accurate preoperative prediction of the individual healing capacity of a given patient is not possible.

ment is feasible. The physician managing the patient with HIV should always be consulted to determine the optimal timing of surgery. Periodontal and implant surgical procedures are contraindicated during the acute phases of HIV infection and after the outbreak of AIDS[22] but may be performed under prophylactic antibiotic coverage during the latency phase of HIV infection.[23] Strict compliance with all relevant infection-control procedures is essential to ensure the protection of these patients and the dental personnel treating them (see chapter 6).

Patient-specific factors

Even if all known factors relevant to healing are taken into account, patient-specific factors result in individual differences in wound healing. The reasons for these differences have been scarcely investigated and, in most cases, only speculatively discussed in the literature. Age plays an important role. General medical studies have clearly shown that patients older than 70 years have significantly lower rates of successful wound healing than younger patients.[24]

Genetic predisposition, especially the expression of growth factors, appears to be another major patient-specific factor in wound healing. Growth factors are involved in various stages of wound healing: They are chemotactic for fibroblasts, and they stimulate immune cells and angiogenesis.[25] High levels of central cytokines such as platelet-derived growth factor, transforming growth factor β, platelet-derived angiogenesis factor, platelet factor 4, and platelet-derived epidermal growth factor have been shown to improve an individual's wound healing capacity.[25]

Platelet-rich plasma is a concentrated source of preoperatively harvested and processed autologous platelets, which contain large quantities of growth factors involved in wound healing. An adjuvant treatment approach involves the intraoperative application of platelet-rich plasma to surgical wounds in an attempt to improve wound healing. The results reported in the literature are inconsistent,[26] and the effects demonstrated so far have been limited, particularly in the field of plastic-esthetic periodontal surgery.[27] It is generally assumed that topically administered growth factors have a short duration of action and thus are unable to achieve any profound effects in the wound.[26]

Enamel matrix proteins, which are commonly used in regenerative periodontal therapy, are also reported to improve and accelerate wound healing. In vitro studies have shown that enamel matrix proteins are able to stimulate both periodontal and gingival fibroblasts.[28] Because these cells increase secretion of transforming growth factor β1, the application of enamel matrix proteins could have a positive effect on soft tissue healing.[29–31] They also seem to have a certain positive effect on angiogenesis during the early healing phase, which could also be beneficial.[32] Furthermore, enamel matrix proteins produce an antimicrobial environment, which could additionally boost wound healing processes.[33–35] Reports in the literature regarding the effects of enamel matrix proteins on wound healing are contradictory. Some clinical studies have shown that they have positive effects,[36,37] whereas others could not demonstrate any effect.[38]

To date, there is no definitive checklist of parameters that a clinician can use to predict a patient's wound healing capacity or the effects of a given treatment on the wound healing capacity. Basic research in molecular biology could make an important contribution by uncovering more of the mechanisms underlying wound healing and elucidating the correlations between them, which could be translated into clinically useful applications in the future.

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CHAPTER 4

INCISIONS, FLAP DESIGNS, AND SUTURING TECHNIQUES

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4.1 Incisions

Correct incision placement is crucial to the success of plastic-esthetic periodontal and implant surgery. The incisions determine the accessibility and visibility of the surgical field. The type of incision affects the mobility of the tissue, the ability to close the wound without tension, the quality of postoperative flap perfusion, and, most importantly, the final gingival margin position. Plastic periodontal and implant surgical procedures differ from other forms of mucogingival surgery in that the flap is often moved from its original position and must be adapted accordingly. Careful preoperative incision planning is crucial because the possibilities for later adjustments are very limited and technically challenging.

The goal of surgery and the type of procedure needed to meet this goal are the main considerations during preoperative planning. However, individual conditions such as the volume and quality of tissue (masticatory versus lining mucosa), the expected alveolar bone contour, and the width of interdental spaces must also be factored into the decision-making process. Esthetic aspects, particularly the possibility of postoperative scar formation, also play an important role. In this context, microsurgical concepts, instruments, and suture materials open the door to new surgical possibilities.

When flaps are elevated, it is crucial to ensure that the flap is not too thin and, more importantly, that the margins are not beveled. Flap thickness has a huge impact on wound healing and thus on the outcome of any surgical procedure (see chapter 3). To achieve proper flap design, some fundamental technical details must be observed during incision placement. When the initial incision is made, the scalpel blade should always be held perpendicular to the tissue surface regardless of any anatomical restrictions that might be present. This is the only way to achieve right-angled flap margins of adequate thickness on both sides of the incision line. Furthermore, intersecting initial incisions should be slightly overcut to achieve a flap with clearly defined margins and corners of uniform thickness.

Two basic types of incision will be discussed in the following sections: *incisions made along the gingival margin* (horizontal incisions) and *releasing incisions*.

4.1.1 Incisions Made Along the Gingival Margin (Horizontal Incisions)

Sulcular incisions

Sulcular incisions (*intracrevicular* incisions) leave the marginal soft tissue completely intact. To make a sulcular incision, the surgeon inserts the blade in the sulcus and guides it apically toward the alveolar bone while maintaining contact with the tooth or root surface. The blade follows the long axis of the tooth. All of the available gingival tissue is incorporated in the flap without damaging the gingival margin. Round microsurgical scalpel blades with cutting margins on both sides are ideal for sulcular incisions (Fig 4-1).

Marginal and paramarginal incisions

Marginal incisions are placed exactly at the level of the gingival margin (marginal incision line) (Figs 4-2), whereas *paramarginal* incisions are placed parallel and slightly apical to the gingival margin (paramarginal incision line) (Figs 4-3). The soft tissue coronal to a paramarginal incision line may be either de-epithelialized or completely removed, depending on which type of procedure is performed.

For both marginal and paramarginal incisions, it is important to make the initial incision as perpendicular to the tissue surface as possible to ensure that the flap margins are not too beveled. Beveled margins make it impossible to achieve precise approximation of the wound margins and greatly increase the risk of flap edge necrosis.

Marginal and paramarginal incisions follow the scalloped contour of the gingival margin. Interdentally, the incision is extended to the adjacent tooth. The blade is then reapplied to ensure that the incisions in this area overlap in order to obtain a clearly defined flap of uniform thickness, even in the interdental peak areas (Fig 4-4).

Marginal and paramarginal incisions are used in esthetic crown lengthening procedures. Because both marginal and paramarginal incisions result in a loss of marginal tissue, the width of the keratinized gingiva determines which of the two types of incision will be used. The band of keratinized gingiva should not be reduced to less than 2 mm.

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Fig 4-1 When the sulcular incision is performed correctly, all of the available marginal soft tissue is included in the flap.



Fig 4-2 Marginal incisions are placed exactly at the level of the gingival margin.



Fig 4-3 Paramarginal incisions are placed parallel and slightly apical to the gingival margin.



Fig 4-4 Types of incision made along the gingival margin (horizontal incisions). S: sulcular; M: marginal; PM: paramarginal.

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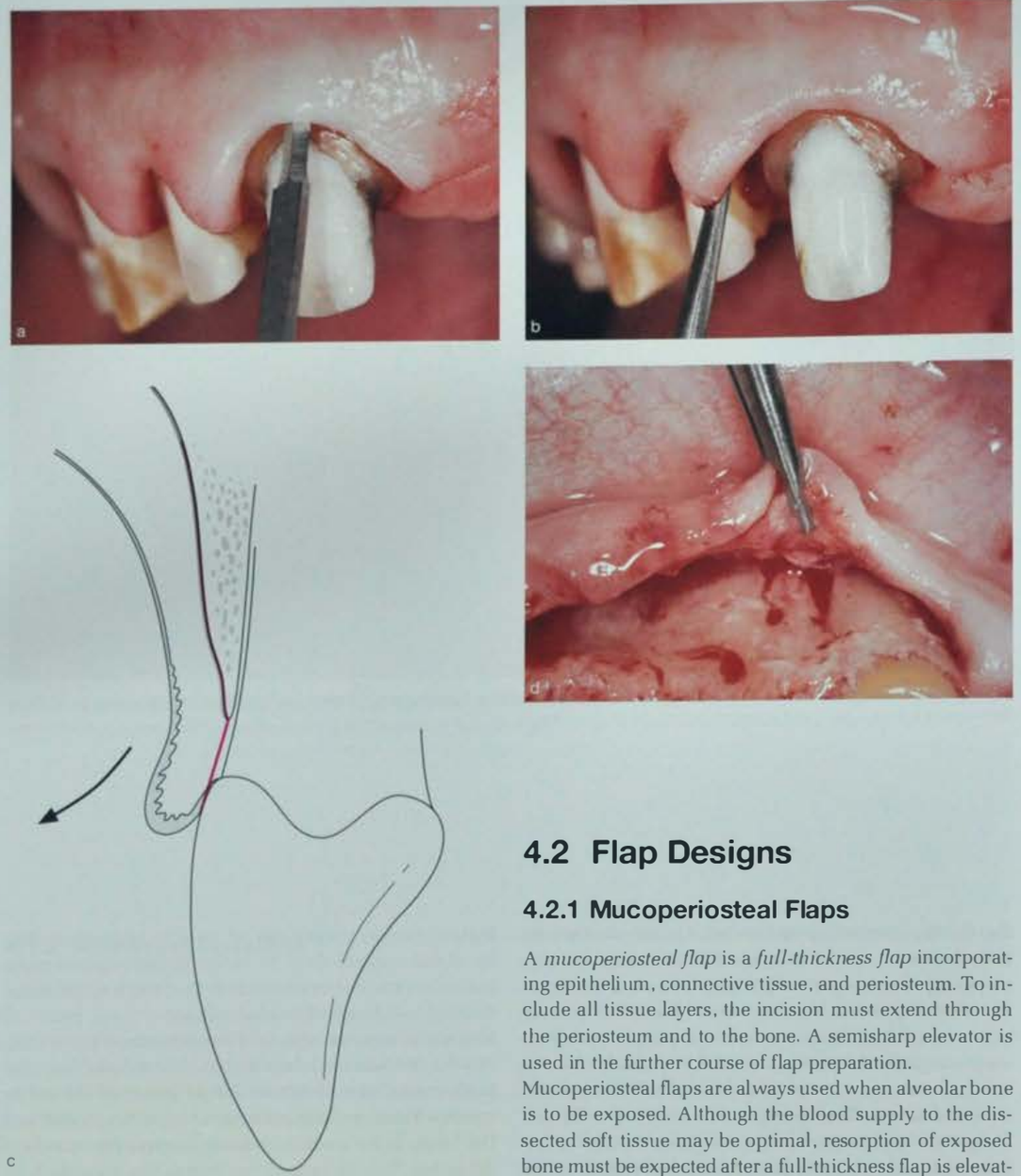


Fig 4-7 (a to d) In mucoperiosteal flaps, the incisions are made to the bone. Full-thickness flaps include all of the soft tissue covering the bone and thereby expose the bone completely.

4.2 Flap Designs

4.2.1 Mucoperiosteal Flaps

A *mucoperiosteal flap* is a *full-thickness flap* incorporating epithelium, connective tissue, and periosteum. To include all tissue layers, the incision must extend through the periosteum and to the bone. A semisharp elevator is used in the further course of flap preparation.

Mucoperiosteal flaps are always used when alveolar bone is to be exposed. Although the blood supply to the dissected soft tissue may be optimal, resorption of exposed bone must be expected after a full-thickness flap is elevated.[2–8] Technically, the mucoperiosteal flap is a relatively simple procedure (Fig 4-7). *Periosteal slitting* may be performed as needed to increase flap mobility (Fig 4-8).

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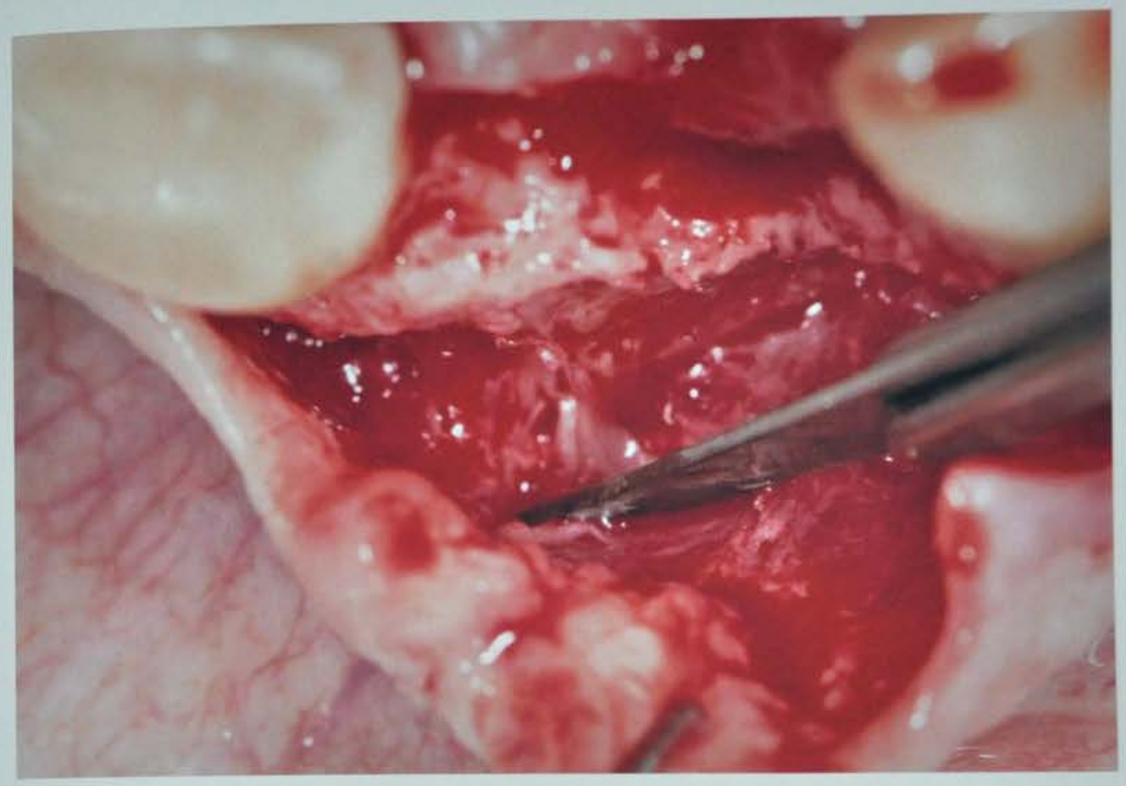


Fig 4-8 The mobility of full-thickness flaps is limited due to the high proportion of inelastic fibers in the periosteum. Periosteal slitting is an effective way to increase flap mobility. This can be done with a scalpel, as shown, or with microsurgical scissors.

4.2.2 Mucosal Flaps

A *mucosal flap* is a *partial-thickness flap* incorporating only epithelium and subepithelial connective tissue. The soft tissue covering the bone is reflected, leaving the periosteum and a thin layer of connective tissue on the bone. The periosteum is not cut. This type of flap is prepared by sharp dissection. To prevent flap perforation, the surgeon should not hold the flap up with forceps when dissecting the flap but rather should observe the blade while it is being worked beneath the mucosa.

The mucosal partial-thickness flap technique achieves ideal flap mobility. Periosteal sutures permit stable fixation of mucosal flaps when a flap is displaced apical, coronal, or lateral to its original position. Therefore, mucosal flaps play an important role in plastic-esthetic periodontal and implant surgery.

The tricky thing about mucosal flaps is that, to achieve uncomplicated healing, an adequate thickness of connective tissue must be left on the periosteum, but at the same time the flap must not be too thin, especially along the margins. When a mucosal flap is elevated, the initial incision should always be made perpendicular to the tissue surface. After the perpendicular initial incision is made, the scalpel is angled increasingly parallel to the tissue surface as it is guided into the deeper tissue layers. Intersecting initial incisions must be slightly overcut to achieve a flap with clearly defined margins and corners of uniform thickness. The use of a wide scalpel blade (eg, No. 15) facilitates the flap preparation procedure (Fig 4-9). With the tunneling technique, flaps are also el-

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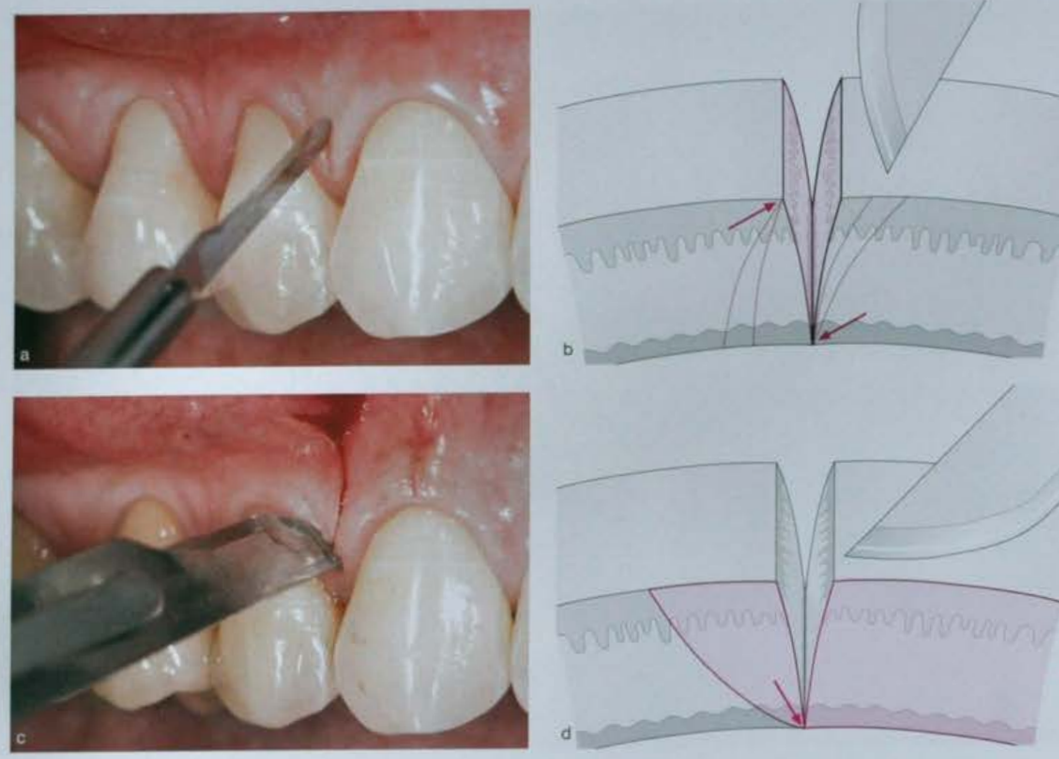


Fig 4-9 (a to d) When the initial incision for a mucosal flap is made, the scalpel blade must always be held perpendicular to the tissue surface (a and b), and the flap margins in the area of intersecting initial incisions should be slightly overcut (c and d).



Fig 4-9e This technique ensures that the flap is not too thin and, above all, that it does not thin out along the margins.



Fig 4-9 (f to h) Partial-thickness flaps are prepared by sharp dissection. They contain epithelium and connective tissue. The periosteum, which contains a high proportion of inelastic fibers, is left on the bone. Consequently, the mobility of partial-thickness flaps is ideal.

evated according to the partial-thickness flap technique. The risk of flap perforation in conjunction with the tunneling technique can be minimized by using flexible microblades or the Tunneling Blades specifically designed for this purpose (Fig 4-10). Partial-thickness flaps have a good blood supply, which enhances connective tissue graft incorporation on the flap side as well as the periosteal side.[9] Because bone resorption can be expected after partial-thickness flap procedures, the gap between the partial-thickness flap and the full-thickness flap should be fully closed or minimal.[4–6,8,10–12]

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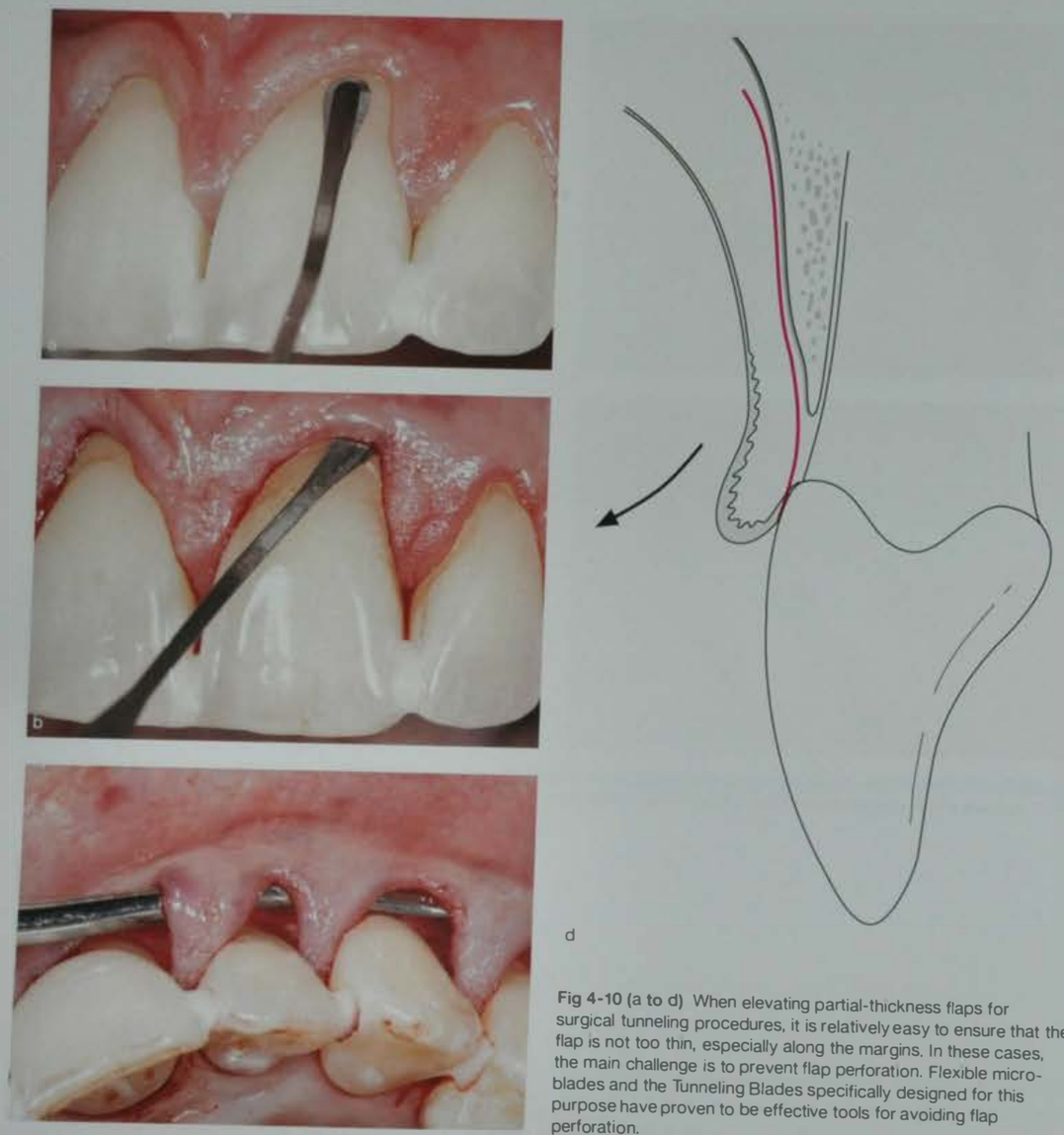
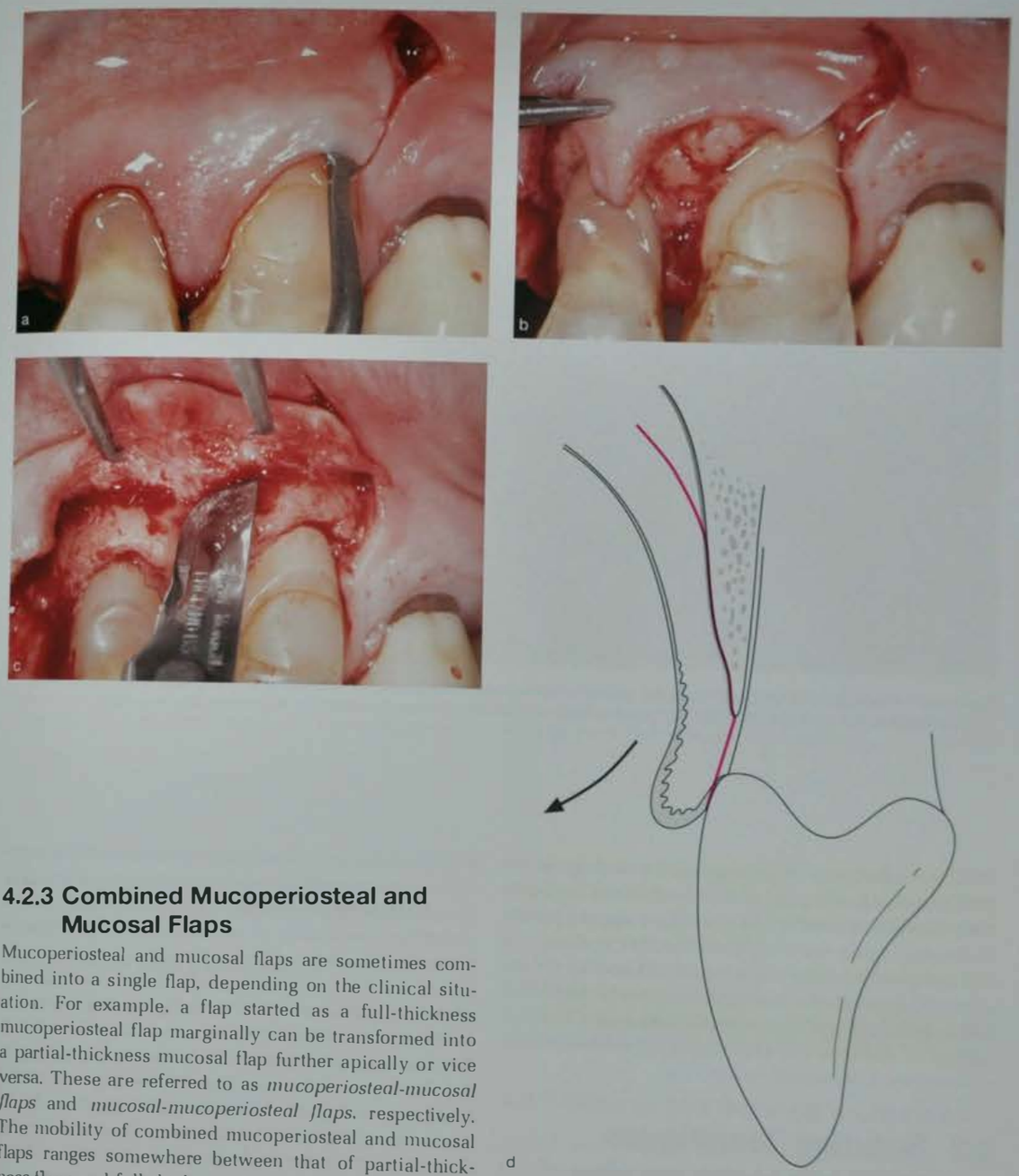


Fig 4-10 (a to d) When elevating partial-thickness flaps for surgical tunneling procedures, it is relatively easy to ensure that the flap is not too thin, especially along the margins. In these cases, the main challenge is to prevent flap perforation. Flexible microblades and the Tunneling Blades specifically designed for this purpose have proven to be effective tools for avoiding flap perforation.

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4.2.3 Combined Mucoperiosteal and Mucosal Flaps

Mucoperiosteal and mucosal flaps are sometimes combined into a single flap, depending on the clinical situation. For example, a flap started as a full-thickness mucoperiosteal flap marginally can be transformed into a partial-thickness mucosal flap further apically or vice versa. These are referred to as *mucoperiosteal-mucosal flaps* and *mucosal-mucoperiosteal flaps*, respectively. The mobility of combined mucoperiosteal and mucosal flaps ranges somewhere between that of partial-thickness flaps and full-thickness flaps with periosteal slitting (Fig 4-11).

Fig 4-11 (a to d) The mucoperiosteal-mucosal flap is prepared coronally as a full-thickness flap and apically as a partial-thickness flap.

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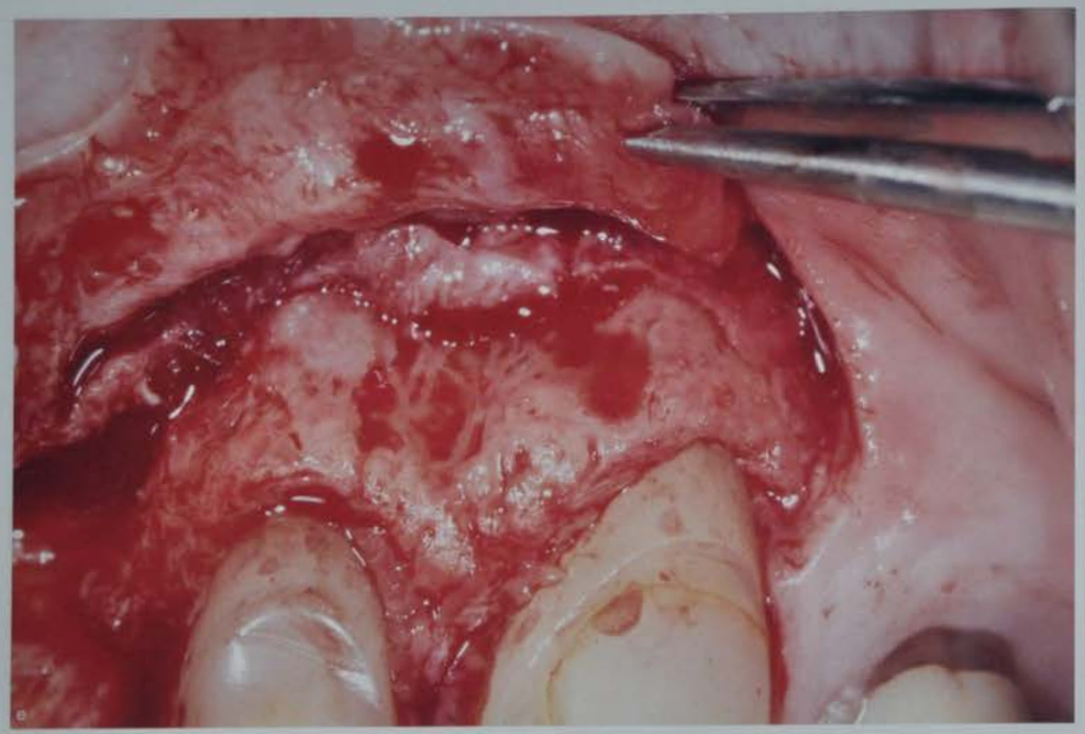


Fig 4-11e A mucoperiosteal-mucosal flap is designed so that the periosteum is elevated with the flap coronally and is left on the bone apically. Splitting the apical portion of the flap provides better flap mobility than periosteal slitting alone in full-thickness flaps.

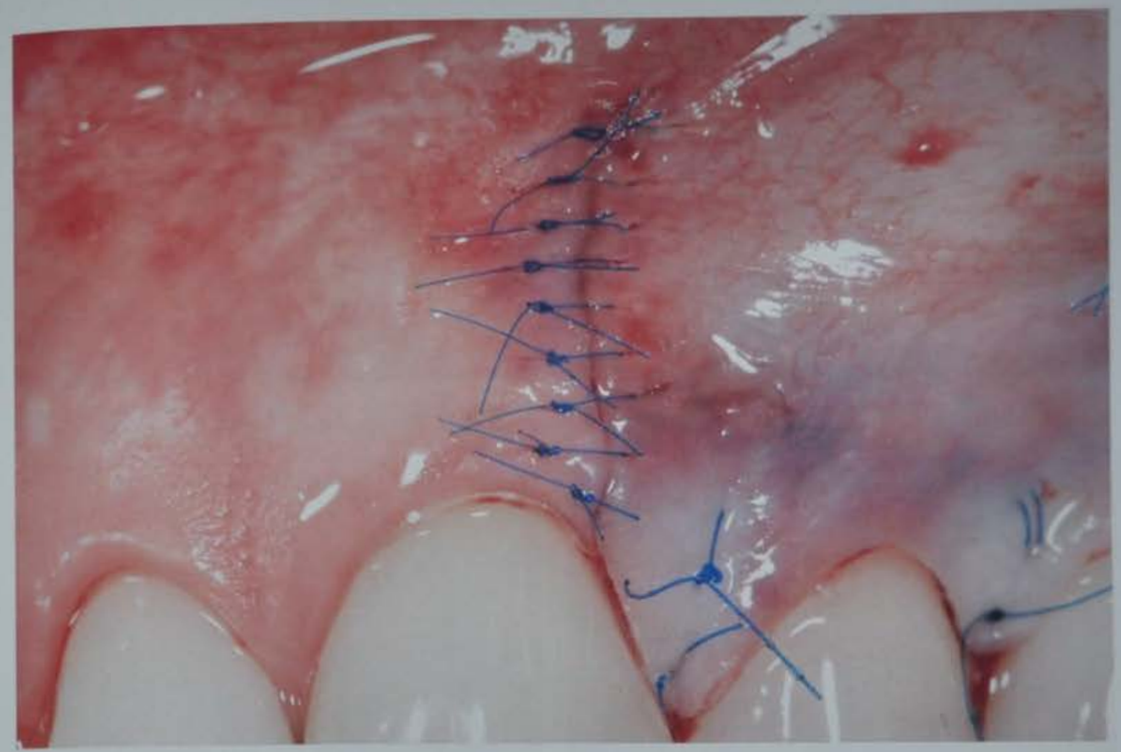


Fig 4-12 Status after closure of a vertical releasing incision in a coronally positioned flap used for root coverage in a patient with gingival recession. In plastic-esthetic periodontal and implant surgery, it is crucial that the sutures ensure passive fixation of the flap, establish intimate contact of the wound margins, and ensure adequate stabilization of the wound during the early healing phase.

The risk of flap perforation is greatest at the level of the mucogingival junction because the soft tissue is usually very thin at that location. In addition, a slightly prominent bony ledge can sometimes be found along the mucogingival junction. If a partial-thickness flap is to be used in a patient with thin gingiva, it can be combined with a full-thickness flap in the critical area of the mucogingival junction. The resulting flap is referred to as a *mucosal-mucoperiosteal-mucosal flap.*

4.3 Suturing Techniques

Optimal wound healing depends on a number of factors, as was discussed in chapter 3. The oral cavity does not provide optimal conditions for wound healing. The mouth is a wet and microbiologically contaminated environment, and wounds located there cannot be completely immobilized during healing. Precise and stable suture closure is thus crucial to successful healing following plastic periodontal and implant surgery. Sutures ensure *passive fixation of the flap* in the position established during surgery, *approximate the margins of the wound as intimately as possible* (especially important if grafts initially depending on diffusion for nutrition are used), and *stabilize the wound* during the early healing phase. The selected suture materials, suturing techniques, and soft tissue management must ensure that suture knots do not come undone and that both the suture materials and the soft tissues will be able to resist the mechanical stresses exerted on them during the early healing phase. All of these conditions must be met to achieve healing by primary intention and, more importantly, an optimal surgical outcome without scar formation (Fig 4-12).

4.3.1 Preparatory Measures

Incisions should be placed in *keratinized tissue* whenever possible to facilitate precise approximation of the wound margins. Incision and flap techniques that allow correct and *tension-free* approximation of the wound margins should be used to ensure that the wound is not under significant tension during suture closure. This is the only way to ensure that the sutures provide the necessary wound stability without pulling out of the soft tissue during healing. If mobile and immobile components of a flap are to be connected, then suturing should always be performed *from mobile to immobile* tissue. This prevents the sutures from tearing through the tissues of the immobile flap margins. Gentle lifting of the immobile portion of the flap with a papilla elevator facilitates precise suture placement.

Wetting of the surgical field facilitates the use of microsurgical suture materials, so frequent irrigation of the surgical field is recommended.

4.3.2 Sutures and Suturing Techniques

Sutures and suturing techniques vary according to the specific mechanical tasks to be performed.[13] The types of sutures used in the surgical techniques presented in this book are described in the following pages.

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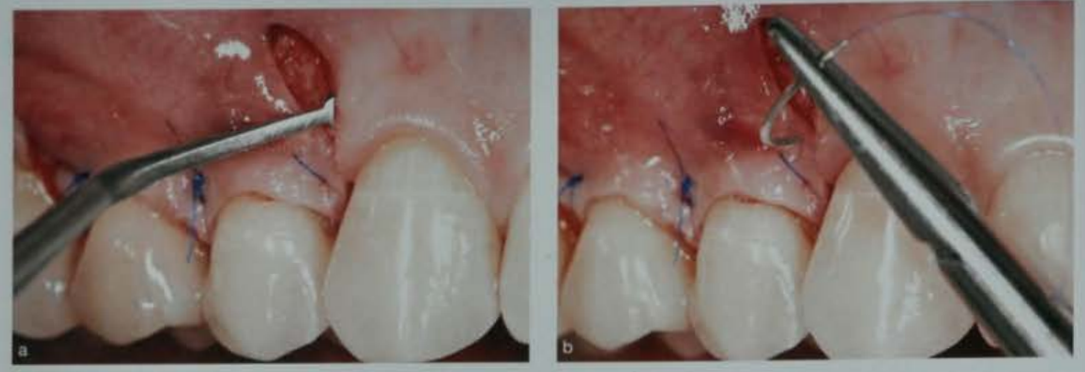


Fig 4-13 (a and b) Clinical example of an interrupted suture used to close a vertical incision. As a preparatory measure, a papilla elevator is used to carefully lift the immobile component of the flap from its bony base. The needle is inserted into the flap perpendicular to the surface.



Fig 4-13 (c and d) The mobile component is sutured to the immobile component of the flap. The needle is normally oriented perpendicular to the incision line. To prevent the sutures from tearing out of the tissue, the distance from the needle insertion site to the flap margin should never be less than 1 to 2 mm. Uniform bite size is crucial for optimal approximation of the wound margins. Therefore, the distances between the incision line and the needle insertion and exit sites on either side of the incision line must be as uniform as possible.

Wound closure sutures

The purpose of wound closure sutures is to precisely approximate the margins of the wound to achieve wound healing by primary intention.

Interrupted sutures

When interrupted sutures are used, uniform bite size is crucial for optimal approximation of the wound margins. Therefore, the *distances between the incision line and the needle insertion and exit sites* on either side of the incision line must be as uniform as possible (see chapter 2). *Soft tissues should be securely grasped* to prevent the sutures from pulling out of the soft tissue during knot tying or healing. Therefore, the stitches should be placed no less than 1 to 2 mm from the flap margin, depending on the flap thickness. The stitch may end within the flap or penetrate the entire flap.

The needle may be passed into and out of the tissue in one or two steps, depending on the accessibility and width of the wound. The needle should pierce the tissue at a *90-degree angle to the flap*. The needle is then inserted as far into the tissue as possible before the needle holder is opened to release the needle. At the exit site, the needle is grasped at midshaft with the needle holder and pulled completely through the tissue (Fig 4-13). To minimize soft tissue trauma during suturing, force should always be applied *in the direction of needle curvature* when the needle is passed through soft tissue. The needle must be *sharp*. The tip of the needle should never be grasped with the needle holder because this could blunt the needle. If the needle tip is damaged and blunted during suturing, new suture material should be used. When the flap margins are held with forceps during suturing, care should be taken to prevent crushing of the soft tissue by the forceps.



Fig 4-13 (e to j) After the needle is pushed through the tissue as far to the opposite side as possible, the needle holder is opened. The needle is then grasped by the middle shaft portion, the thread is pulled through the tissue, and a knot is tied.

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Fig 4-14 (a to c) Mattress sutures can also be used for wound closure in certain cases. Vertical mattress sutures are used to achieve precise approximation of the wound margins in the papillary region, for example, after esthetic crown lengthening procedures.

The needle is generally oriented *perpendicular to the incision line* when suturing is performed. However, when a repositioned flap with mobile and immobile components is sutured, the use of an angled needle path can be helpful when the flap is repositioned coronally or apically.

The smaller the number of stitches needed for precise approximation of the wound margins, the better for wound healing. Compared to continuous sutures, interrupted sutures have the advantage of not having the fate of the entire row of stitches being affected by the loosening of one knot. The disadvantage of the interrupted sutures is that they are more time-consuming to place.

Mattress sutures

When flap procedures are performed in the interdental area, it can be difficult to achieve precise approximation of the wound margins, especially if the papillae are completely intact. In fact, it can be impossible to achieve precise approximation with interrupted sutures. *Internal vertical mattress sutures* usually provide better results in these patients. In this suture technique, the needle is inserted buccally, near the tip of the papilla, and passed through the flap and interproximal soft tissue from buccal to palatal in the same vertical position. The needle is then passed back through the interproximal soft tissue and the buccal flap from palatal to buccal at a slightly more apical position. The suture is then tied over the first insertion site.

When properly placed, this suture should lie in a very coronal position. Therefore, tying of the suture results in slight compression. This promotes precise approximation of the wound margins and flap security. No additional interrupted sutures should be used in this case. Otherwise, sutures would pass over the tip of the papilla, resulting in additional trauma to that region (Fig 4-14). For a detailed description of the technique, see chapter 10.

Continuous sutures

A continuous suture is basically a series of multiple interrupted sutures that do not have to be tied separately. Consequently, a continuous suture is faster and easier to make than an equal number of single interrupted sutures. It is also very easy to remove continuous sutures. The disadvantage of continuous sutures is that the loosening of a single knot affects the entire row of stitches.

The *continuous locking suture with interlocking loops* has proved very useful in plastic periodontal and implant surgery. First, a normal interrupted suture is made at the

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Fig 4-15 Clinical case example of a continuous locking suture placed after a free connective tissue graft was harvested from the palate.

distal end of the incision, and only the short end of the suture is cut. While the second stitch is placed more mesially, the suture is held with the surgeon's left hand and a loop is formed. When the needle emerges at the exit site, it initially is not pulled out of the tissue completely. First, the needle is passed through the loop of the suture, and the suture is pulled to lock it. The loop can be turned 180 degrees to additionally stabilize the individual sutures. This procedure is continued until the final suture is tied off at the mesial end of the incision line. This is done by pulling the needle and thread through the tissue until only a small loop remains. This loop is used as the short end of the suture for knot tying (Fig 4-15).

For a detailed description of the suturing technique, see chapter 7. The smaller the number of stitches needed for precise approximation of the wound margins, the better for healing.

Tension-relieving sutures

Tension-relieving sutures are always used in combination with wound closure sutures. They relieve tension on the incision line before the actual wound closure sutures are placed to ensure tension-free approximation of the wound margins. The use of wound closure sutures alone results in narrow points of contact between the wound margins. When combined with tension-relieving sutures, broader and more intimate areas of contact between the wound margins can be established, even in deeper tissue layers. Tension-relieving sutures improve the precision and mechanical stability of suture closure. This is particularly helpful in situations where postoperative edema increases tension on the wound margins. Tension-relieving sutures are tied prior to suture closure. They relieve tension on the incision line to enable precise flap positioning during the actual process of suture closure. Tension-relieving sutures are strategically placed to precisely control the direction of pressure on the flap to invert or evert the flap margins, as needed. Because of the broad distribution of forces when the sutures are tied, the risk of sutures tearing out of the tissue is minimal.

Mattress sutures are the type of tension-relieving sutures most commonly used in plastic-esthetic periodontal and implant surgery. Mattress sutures may be vertical or

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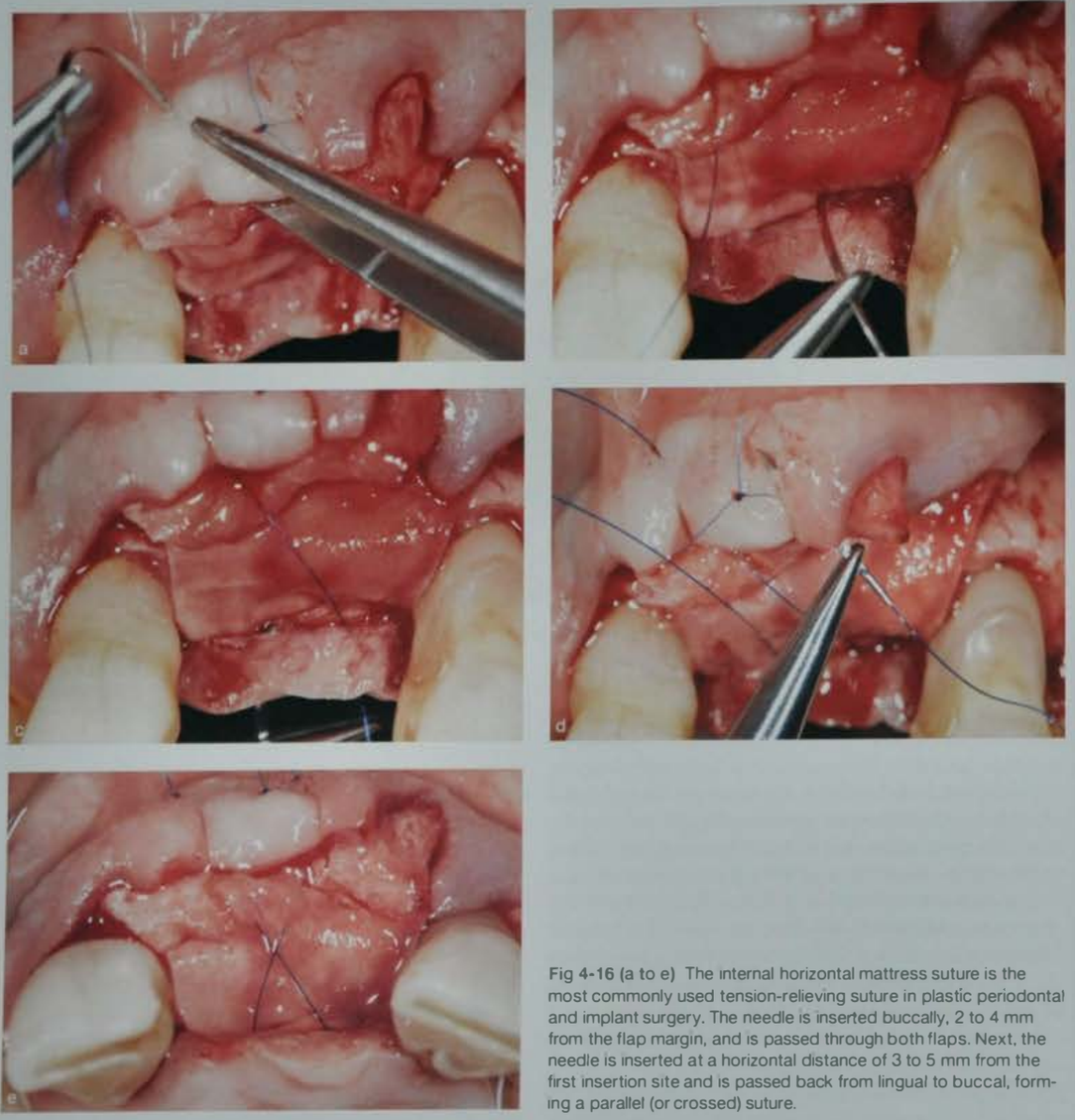


Fig 4-16 (a to e) The internal horizontal mattress suture is the most commonly used tension-relieving suture in plastic periodontal and implant surgery. The needle is inserted buccally, 2 to 4 mm from the flap margin, and is passed through both flaps. Next, the needle is inserted at a horizontal distance of 3 to 5 mm from the first insertion site and is passed back from lingual to buccal, forming a parallel (or crossed) suture.

horizontal, internal or external. The type best suited for relieving tension on the wound margins is the internal horizontal mattress suture. Internal horizontal mattress sutures result in eversion of the wound margins, which greatly simplifies closure with interrupted sutures or with one continuous suture. External mattress sutures often result in inversion of the wound margins, which complicates suture closure and promotes postoperative scar formation. Inverted wound margins can also complicate future scar correction.

For these reasons, the *internal horizontal mattress suture* is the type of tension-relieving suture most commonly used in plastic-esthetic periodontal and implant surgery. The needle is inserted 2 to 4 mm from the flap margin and passed through both flap segments. At a horizontal distance of 3 to 5 mm from the first insertion site, the needle is passed back in the opposite direction, forming a parallel suture. After the last stitch, the suture is tied. The number of mattress sutures needed depends on the length of the incision. The actual wound closure sutures are placed after the tension-relieving sutures are finished (Fig 4-16). For a detailed description of the procedure, see chapter 13.

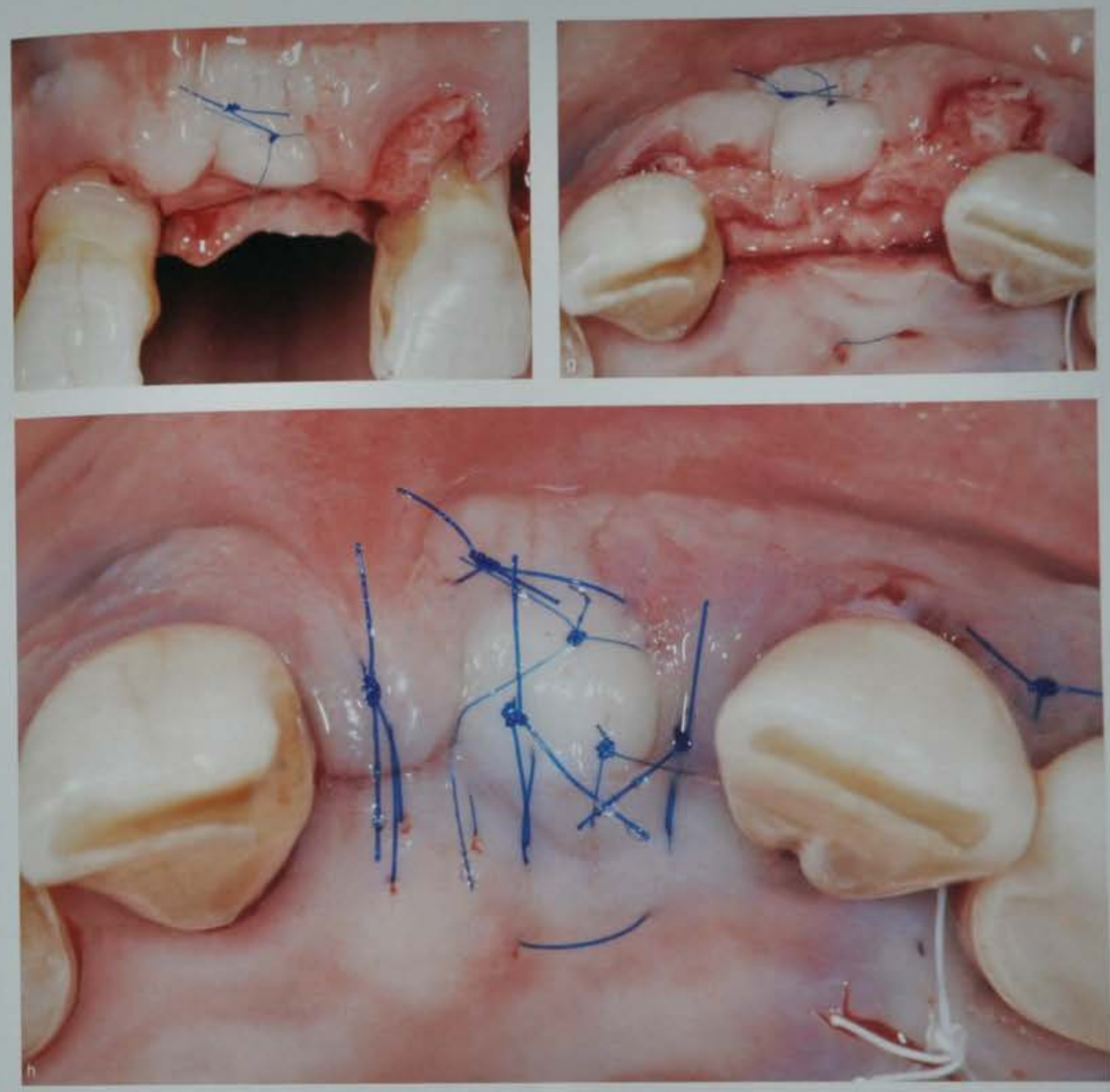


Fig 4-16 (f to h) Tension-relieving sutures facilitate tension-free approximation of the wound margins. When the knot is tied, the wound margins are everted, facilitating wound closure.

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Fig 4-17 (a to c) Clinical case example demonstrating the use of a double-sling suture in an inlay graft procedure for alveolar ridge augmentation using autologous connective tissue. The needle is inserted buccally, 3 to 4 mm from the flap margin, and is passed completely through both flaps in the buccolingual direction.

Combination sutures: Double-sling suture

The *double-sling suture* is a combination wound closure and tension-relieving suture.[14] It helps to achieve excellent flap approximation and stability with less effort. As with interrupted sutures, the needle is first passed completely through the flap at a distance of 3 to 4 mm from the incision line. Next, the needle is passed through the two parts of the flap again, in the same orientation but with a reduced bite size of 1 to 2 mm. Finally, the suture is tied. If the flap is thick enough, the second stitch should preferably be placed within the flap as well (Fig 4-17). For a detailed description of the procedure, see chapter 13.

Suspension sutures

In flap advancement procedures, suspension sutures can be used to secure the mobilized flap to its new position. The suspension sutures pass through an immobile anchor point to bring the movable flap segments into the desired position and secure them there. An adjacent tooth, the attached mucosa of the palate, or the periosteum can serve as the anchor point. Tension-free flap adaptation is crucial if suspension sutures are to be used safely and effectively.

Sling sutures

Sling sutures can be used to secure coronally advanced flaps in place. *Both horizontal and vertical sling sutures* are used in plastic periodontal and implant surgery. In addition to ensuring *coronal stabilization* of the flap, they achieve *compression of the wound*, which is beneficial to healing. This positive effect on healing is especially helpful when connective tissue autografts are used. Horizontal sling sutures are anchored about the circumference of an adjacent tooth. Vertical sling sutures use other structures as anchor points (eg, interproximal contact points splinted with composite material). To achieve both coronal stabilization and wound compression, vertical sling sutures must cross the interdental space twice. They are then referred to as double-crossed sutures[15] (Fig 4-18). For a detailed description of the technique, see chapter 9.

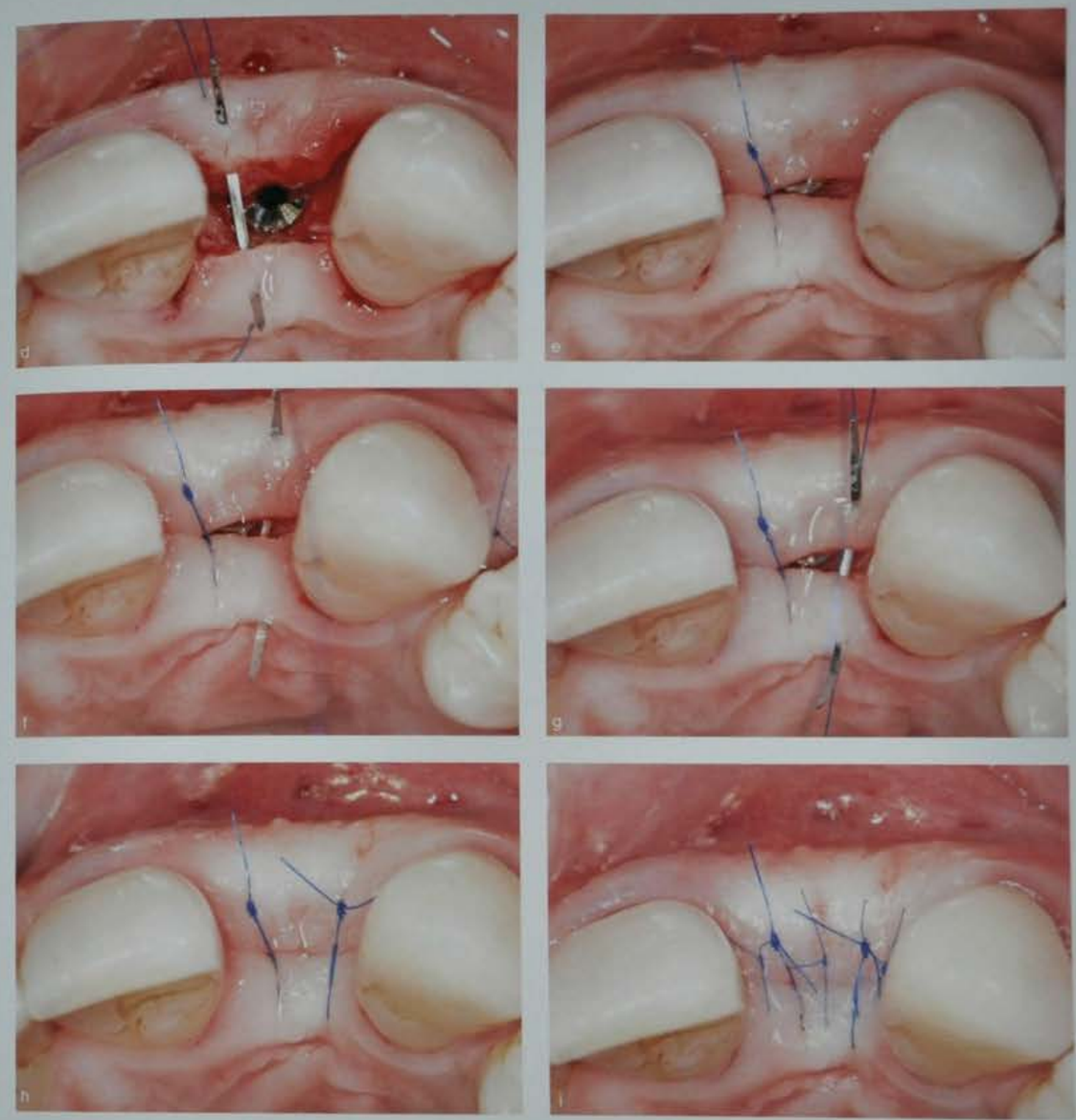
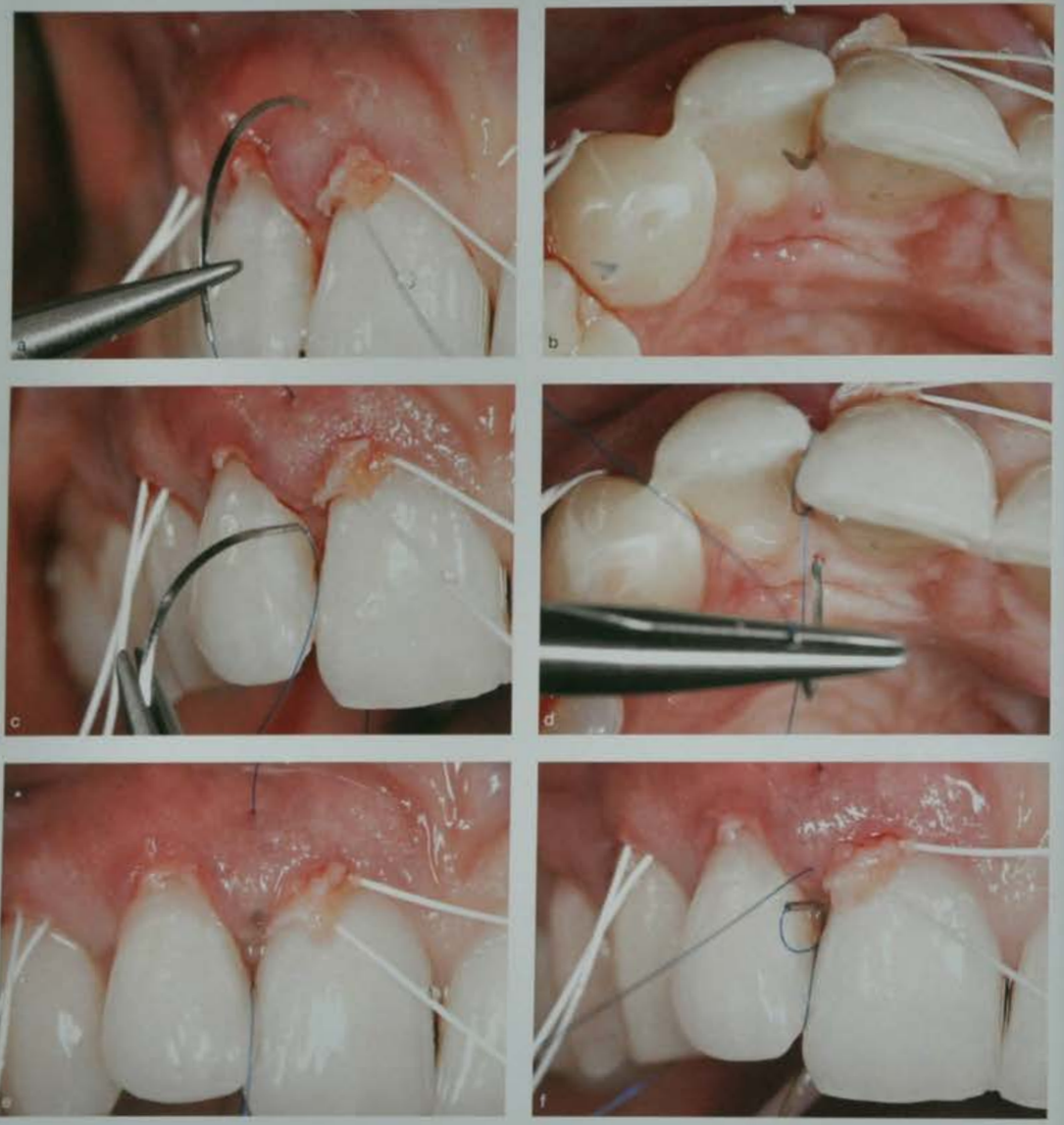


Fig 4-17 (d to i) The needle is passed through both margins of the flap again from buccal to lingual. The orientation is the same, but the bite size is smaller. The suture is then tied. The needle passes within the flap. The effect of the double-sling suture is comparable to that of tension-relieving and wound closure sutures combined.

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Horizontal sling sutures may have a *crossed* and/or a *parallel* configuration. They are most frequently used in flap procedures for treatment of gingival recession. Crossed horizontal sling sutures are used for fixation of connective tissue grafts (Fig 4-19). Parallel horizontal sling sutures are used to secure the flap to the exposed root surface (Fig 4-20). For a detailed description of the procedure, see chapter 9.

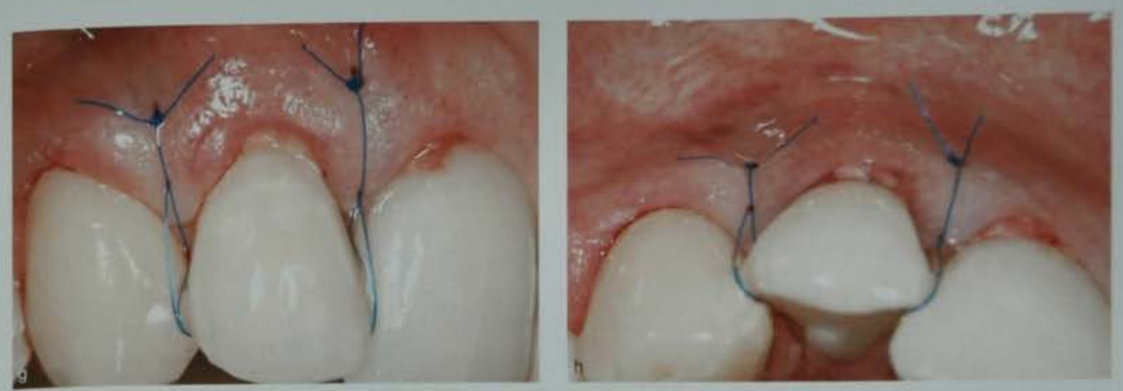


Fig 4-18 (a to h) Clinical case example of a double-crossed suture placed after coverage of gingival recession using the modified tunnelling technique. After placement of the double-crossed vertical sling suture, the flap "hugs" the graft. The resulting coronal stability of the soft tissue and compression of the flap and graft onto the root surface stabilize the wound and have a positive effect on the diffusion and supply of nutrients to the exposed parts of the connective tissue graft.

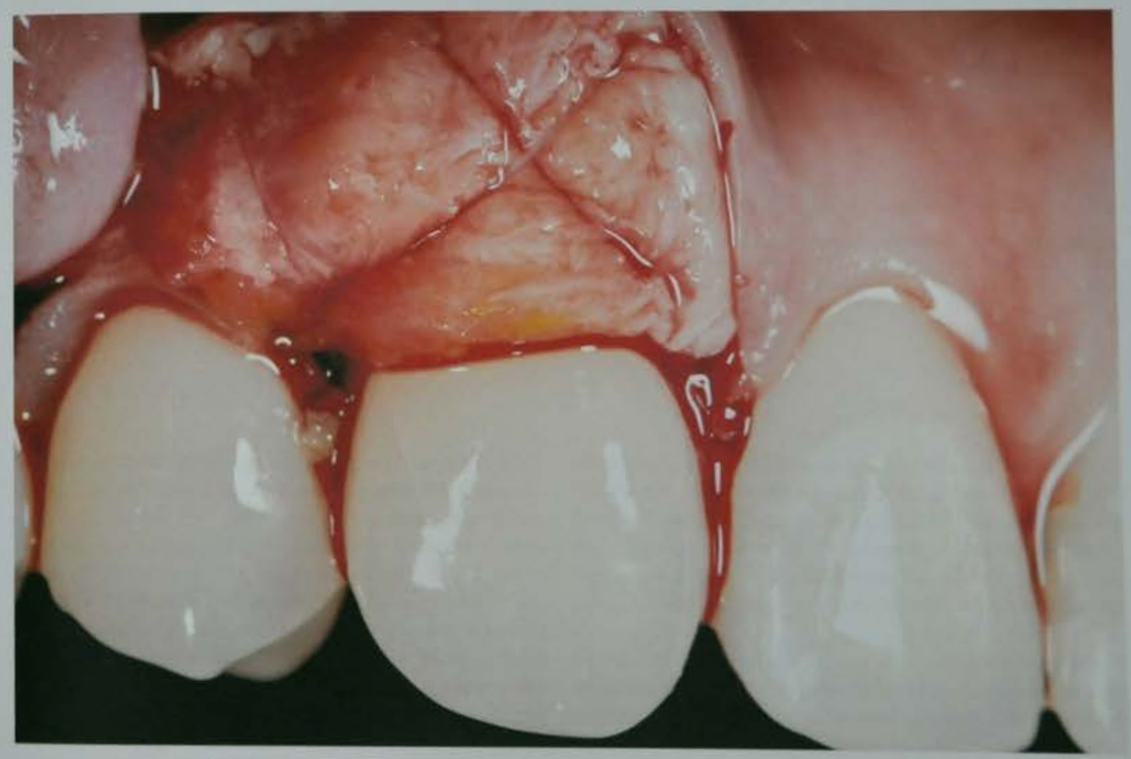


Fig 4-19 Clinical case example of a coronally positioned flap procedure performed for treatment of gingival recession. A crossed horizontal sling suture was used to secure the connective tissue graft.

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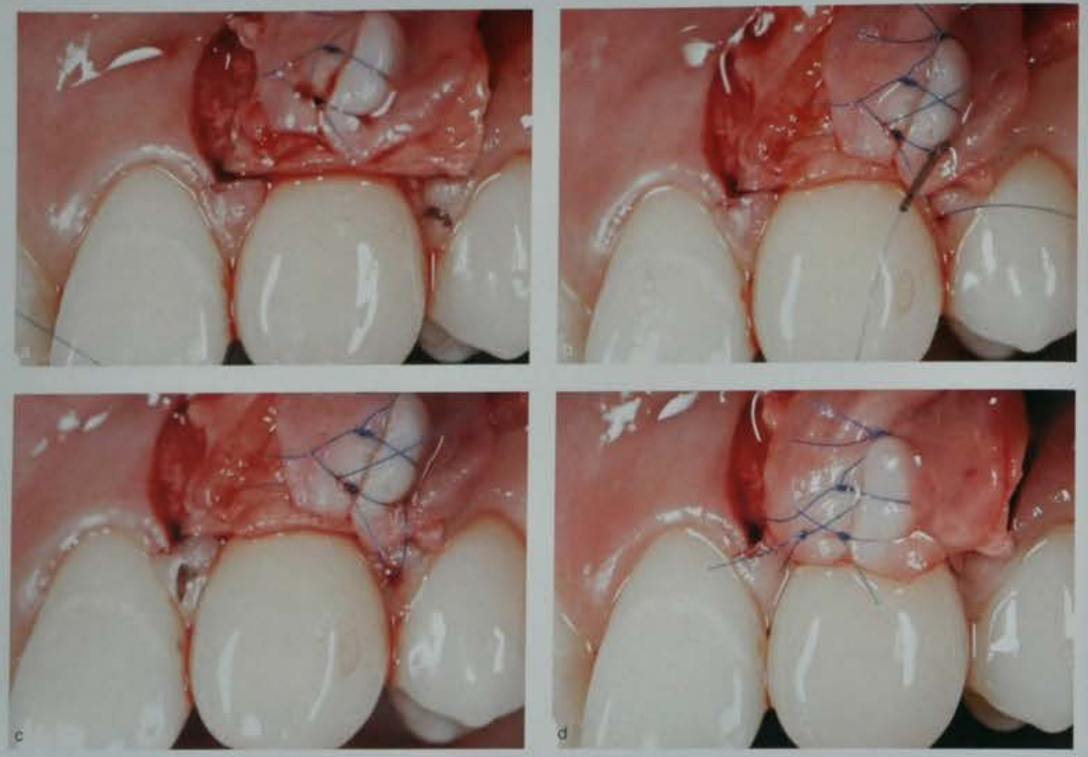


Fig 4-20 (a to d) Clinical case example of a double lateral bridging flap used for treatment of gingival recession. A parallel horizontal sling suture has been used to secure the flap and connective tissue graft to the root surface.

Horizontal sling sutures are also used to close the donor site of free connective tissue grafts harvested from the palate. The wound compressing effect of the horizontal sling sutures achieves effective hemostasis, which is particularly beneficial for healing (Fig 4-21). For a detailed description of the procedure, see chapter 7.

Periosteal sutures

Periosteal sutures are used to close apically repositioned flaps used for esthetic crown lengthening or subepithelial connective tissue grafts harvested from the tuberosity area. The elevation of a partial-thickness flap is an important prerequisite for the use of periosteal sutures. This ensures that the periosteum and supraperiosteal connective tissue needed for fixation of the sutures remain on the bone.

In periosteal suturing, the needle is inserted at the level of the mucogingival junction and is passed, from the outside in, through the buccal flap at the desired position and through the connective tissue and periosteum until it engages the bone. The needle is then rotated against the bone and made to exit the tissue along the flap margin, from the inside out. The needle is then passed below the contact point, back first, from buccal to lingual. The needle is then inserted vertically into the palatal tissue (apical to coronal) and passed back through the same embrasure from lingual to buccal, and the suture is tied above the first insertion site (Figs 4-22 and 4-23). For a detailed description of the procedure, see chapters 7 and 10.

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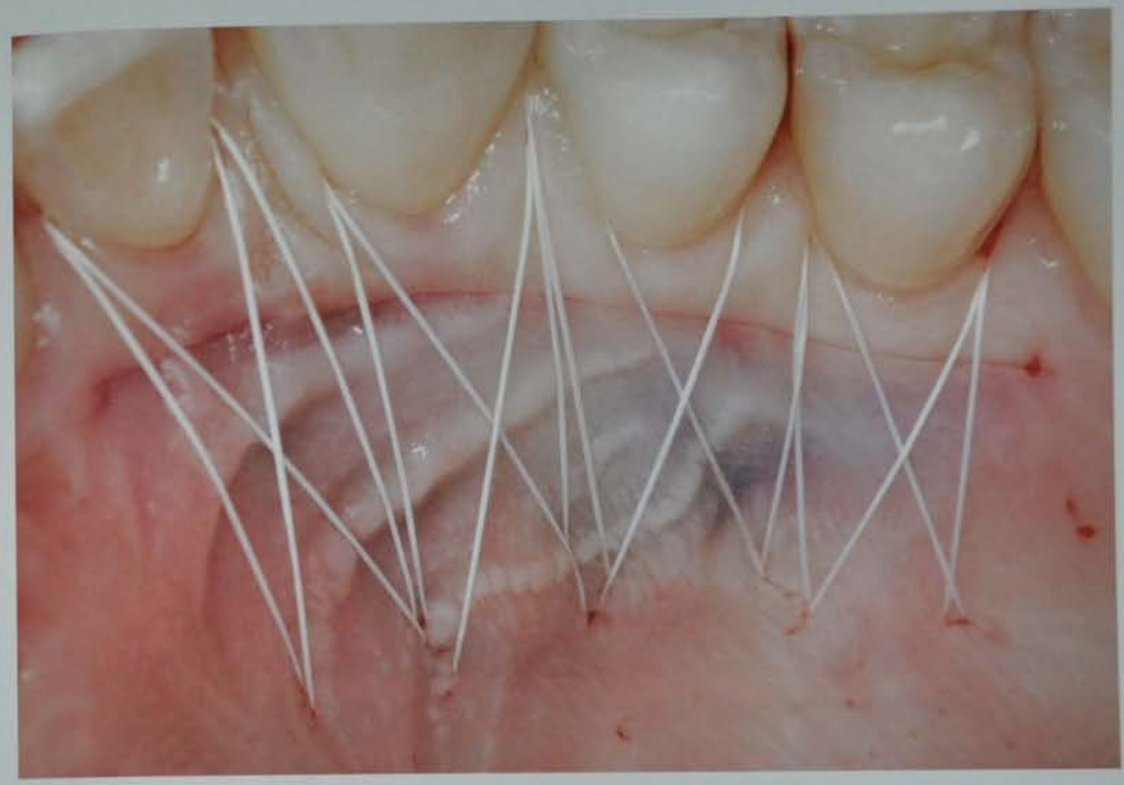


Fig 4-21 Clinical case example of parallel and crossed horizontal sling sutures used to close the surgical site after a subepithelial connective tissue graft was harvested from the palate.

Fixation sutures

In soft tissue augmentation with connective tissue grafts, fixation sutures are used to achieve precise fixation of the graft to the flap or undermined mucosa. The needle is inserted from the outside and is passed deep into the mucosa. The underlying graft is securely engaged, and the needle is made to exit not too far from the insertion site. The suture is then tied loosely. Excessive tension can compromise blood flow in this region and must be absolutely avoided. Fixation sutures may be either vertical or horizontal (Fig 4-24). For a detailed description of the procedure, see chapter 13. When a multilayer flap design is used, fixation sutures can also be used to position and stabilize the inner aspects of a pedicle flap.

Positioning sutures

Positioning sutures can be very helpful when tunnel techniques are used for placement of connective tissue grafts. The needle is inserted in the part of the tunnel distal to the augmentation site and passed through the tunnel. The needle is then inserted in the graft laterally and passed

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Fig 4-22 (a and b) Because the needle is inserted through the flap from the outside in and then through the supraperiosteal connective tissue, periosteal sutures ensure stable and reliable positioning and fixation of partial-thickness flaps.

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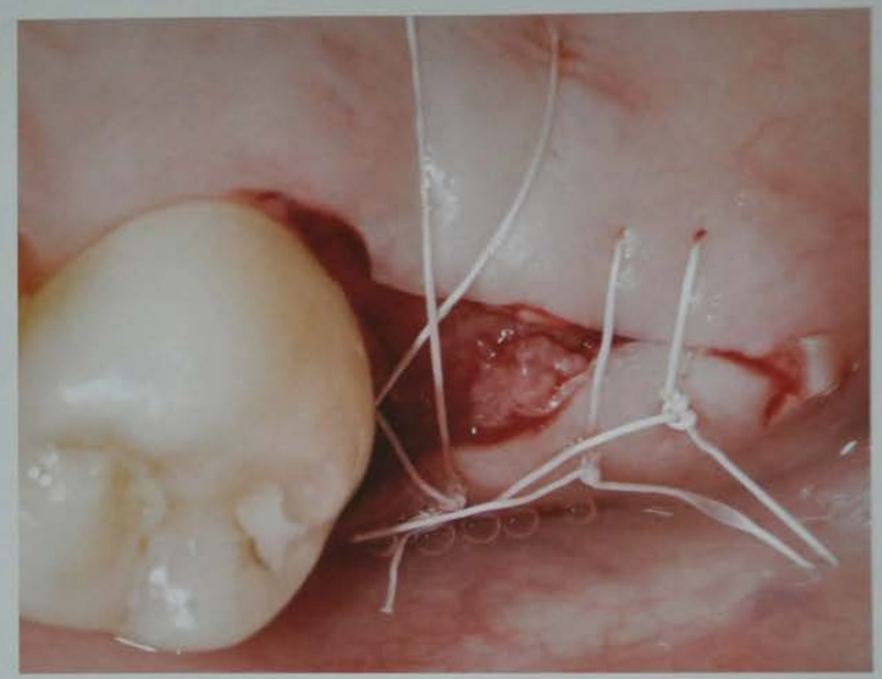


Fig 4-23 Clinical case example of a flap positioned apically and secured with periosteal sutures after a subepithelial connective tissue graft was harvested from the tuberosity area.

back through the tunnel by the same route. Pulling on the suture then allows the graft to be more easily inserted and precisely positioned in the tunnel (Fig 4-25). For a detailed description of the procedure, see chapter 9.

All suturing techniques presented in this chapter and used in the surgical procedures described in the later chapters of this book are summarized in Table 4-1.

Table 4-1

Overview of suturing techniques used in plastic-esthetic periodontal and implant surgical procedures

Wound closure sutures	Interrupted sutures Vertical mattress sutures Continuous sutures	
Tension-relieving sutures	Horizontal internal mattress sutures	
Combination sutures	Double-sling sutures	
Suspension sutures	Sling sutures Periosteal sutures	Vertical sling sutures Horizontal sling sutures
Fixation sutures		
Positioning sutures		

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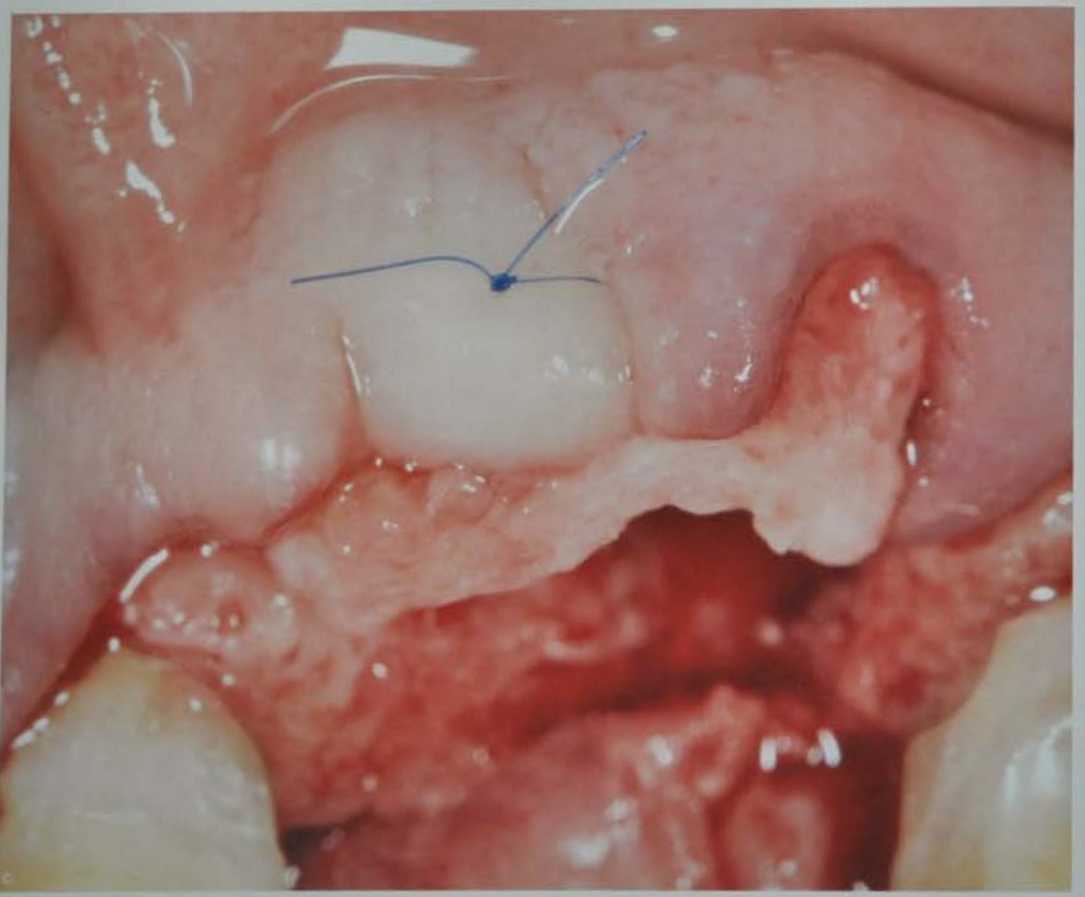


Fig 4-24 (a to c) Clinical case example of a fixation suture used for precise positioning of a free connective tissue graft during an implantation procedure with simultaneous hard and soft tissue augmentation.





Fig 4-25 (a and b) Positioning sutures can be very helpful when tunnel techniques are used for placement of connective tissue grafts. They facilitate insertion and precise positioning of the graft in the tunnel.

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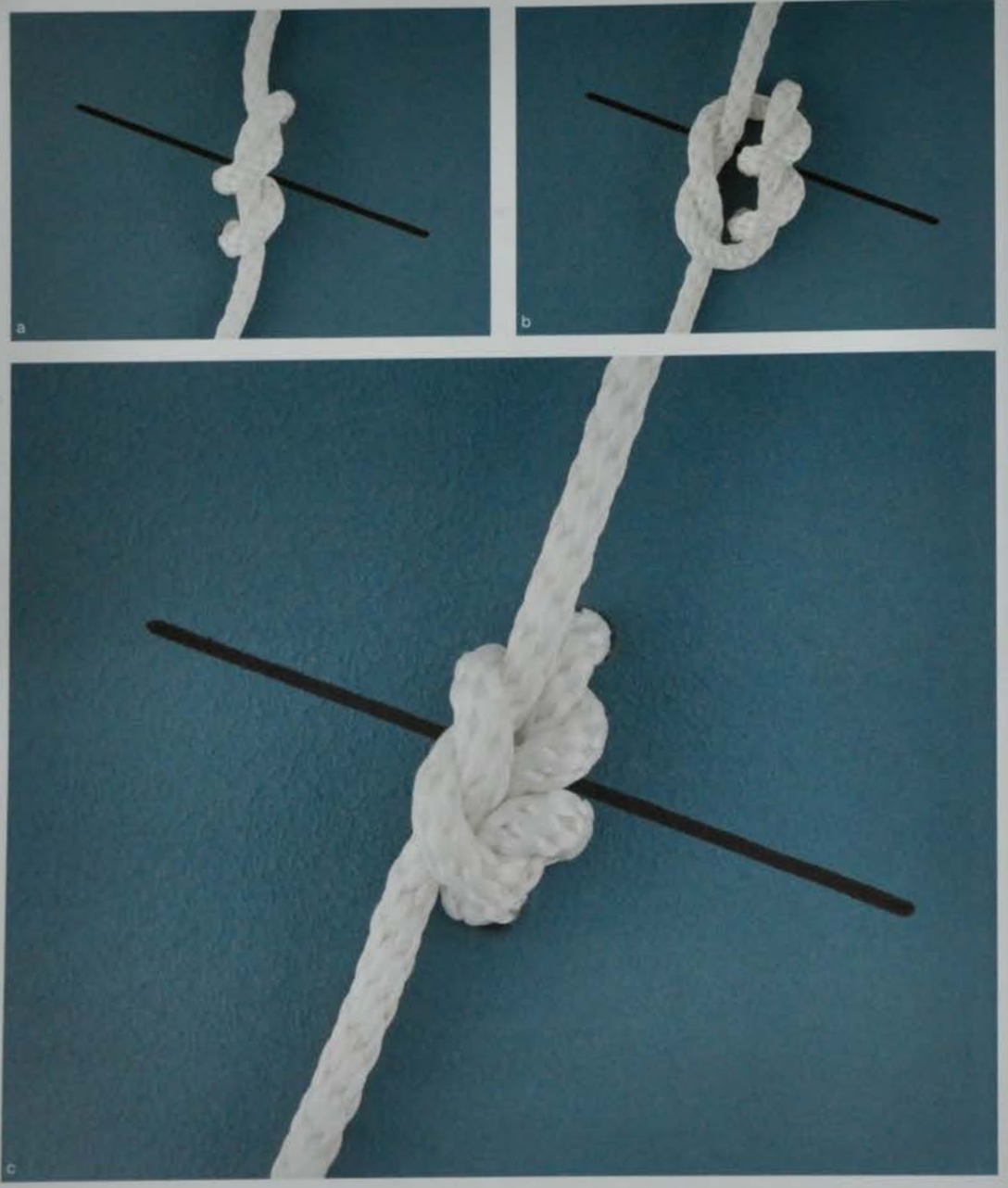


Fig 4-26 (a to c) Microsurgical suture materials can be tied with a simple surgeon's knot for adequate knot stability. A surgeon's knot consists of an initial double throw followed by a second single throw in the opposite direction.

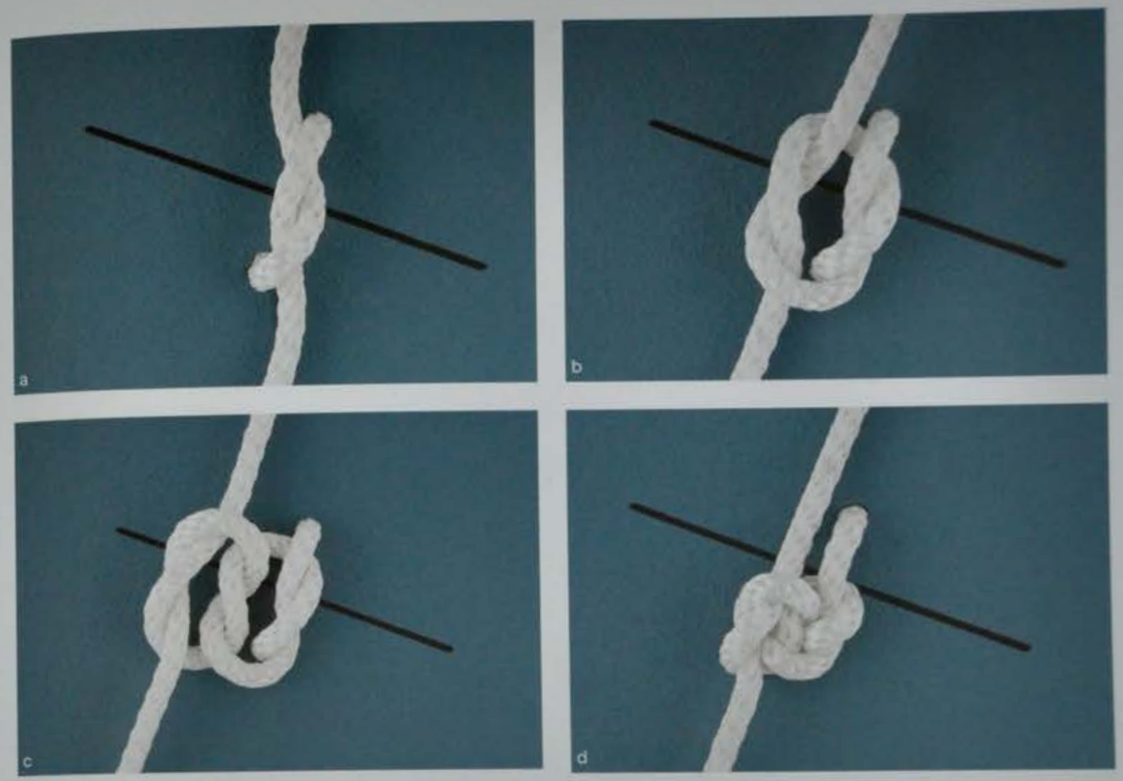


Fig 4-27 (a to d) Macrosurgical sutures made of e-PTFE should be tied with a square knot and an additional third throw to ensure adequate knot safety. The knot is constructed with three single throws, each in the opposite direction of the preceding throw.

4.3.3 Throws and Knots

To ensure sufficient knot stability, each suture knot consists of a number of throws. The first throw determines the position and tension of the suture and, thus, the exact position of the wound margins. The second throw and any additional throws secure the position of the first throw. All of the *microsurgical suture materials* described in this book can be used to tie a *simple surgeon's knot*, that is, a knot with an initial double throw followed by a second single throw in the opposite direction (see chapter 2).

Once the second throw has been made, it is not possible to tighten the first throw by pulling on the second. Therefore, it is important to ensure that the first throw is secure and precisely positioned before the second is made. After the first throw is completed, it can be helpful to rotate the suture ends 180 degrees before the second throw is made (Fig 4-26).

Macrosurgical sutures made of expanded polytetrafluoroethylene (e-PTFE) should be tied with a *square knot with an additional third throw* to ensure adequate knot safety. The knot is constructed with three consecutive single throws, each in the opposite direction of the preceding throw. Because of the excellent gliding capacity of e-PTFE, the first throw can still be tightened after the second throw has been made. The third throw is needed to ensure knot security (Fig 4-27).

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Fig 4-28 To prevent impairment of the healing process, the sutures should be removed as atraumatically as possible 5 to 7 days after the procedure.

To ensure that blood flow to the wound margins is not impaired during the healing period, sutures should not be tied too tightly.

For enhanced patient comfort, surgical knots should be as small as possible, and the cut ends ("ears") of the knots should never be longer than 3 mm. To avoid irritation of the wound margins and to minimize plaque accumulation in the wound area, the knots should not be placed on the incision line but rather lateral to the wound margins.

In plastic-esthetic periodontal and implant surgery, sutures are tied either completely with instruments (needle holder and forceps) or partly with instruments (needle holder and fingers). Instrument tying makes it easier to control the knot position, particularly when accessibility to the site is limited. For a detailed description of the procedure, see chapter 2.

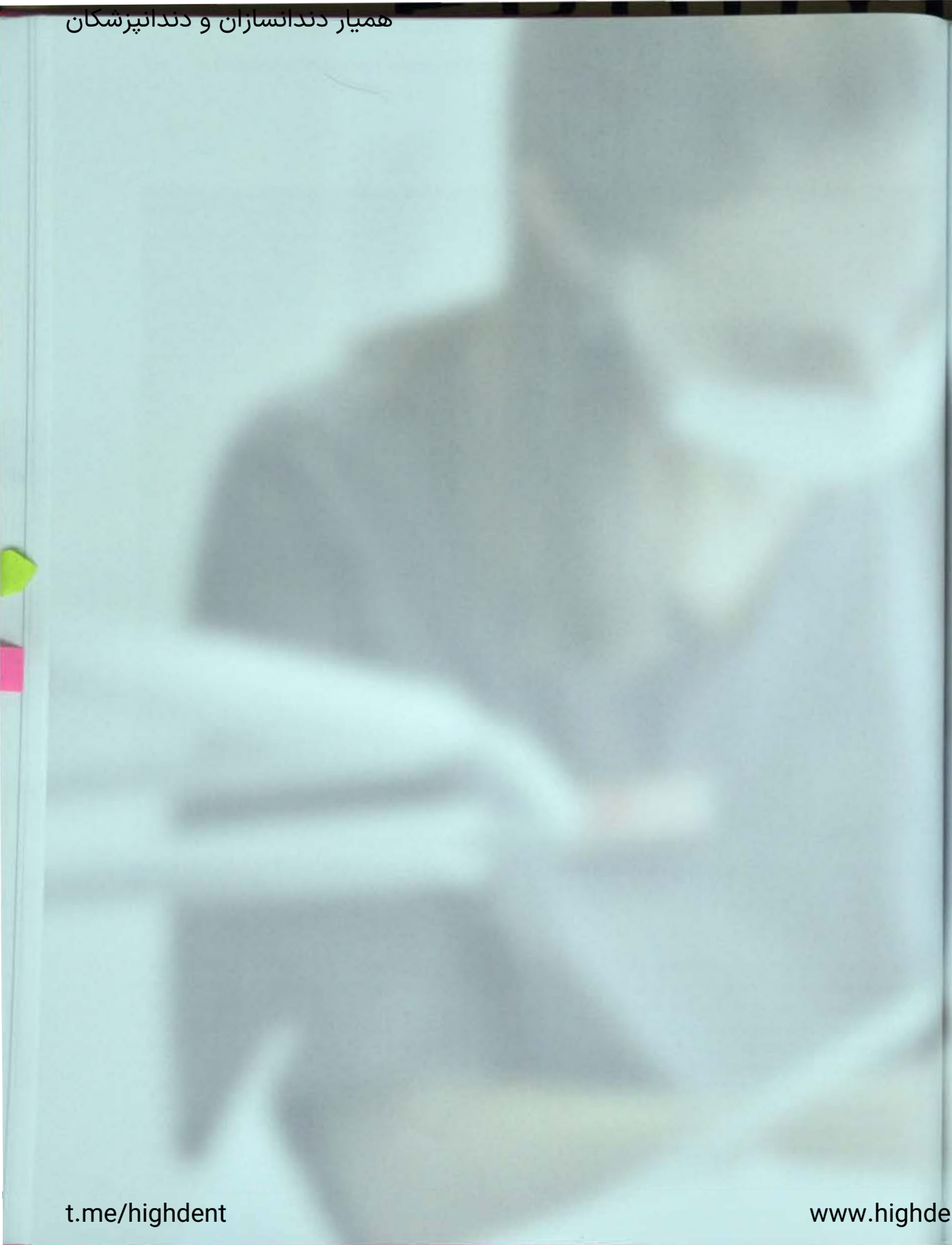
To prevent an unnecessary delay and impairment of healing, the sutures should be removed as atraumatically as possible 5 to 7 days after the procedure (Fig 4-28).

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CHAPTER 5

GINGIVAL ESTHETICS: CRITERIA, GUIDELINES, AND DIAGNOSTIC STRATEGIES

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The soft tissue framework around the teeth is an integral component of the overall dentofacial esthetics. Many individuals have gingival display in the maxillary anterior region and, less frequently, in the mandibular anterior region during function and smiling. If this is the case, then both the teeth and the gingival margin should ideally satisfy certain esthetic requirements. Perfect dental esthetics cannot compensate for deficiencies in gingival esthetics and vice versa. Because "red-and-white esthetics" is intimately related to the way in which people are perceived by themselves and by others, the appearance of the teeth and gingival tissues must be equally weighted during treatment planning to successfully create or restore balanced dentofacial harmony[1–3] (Fig 5-1).

It is often said that "Beauty is relative" and "Beauty is in the eye of the beholder," so the perception, assessment, and creation of beauty seem to be rather subjective and complex.[4,5] The many attempts to establish objective criteria and guidelines for the correction of esthetic problems in the dentofacial appearance of individuals seem futile to some, yet many guidelines and definitions for gingival and dental esthetics are now widely recognized and accepted by many dentists. As such, they provide useful tools for evaluating and treating patients with extensive gingival problems.[6,7]

This apparent contradiction can be explained by analyzing the results of experimental studies in psychology. In the field of research on attractiveness, a number of investigations have shown that the human perception of beauty is largely objective because it normally conforms to an average or general taste. Because an individual's concept of beauty largely corresponds to that of the general population, an objective core of "hard data" on esthetics can be extracted. In actuality, only a small portion of a person's perception of beauty is truly subjective and determined by personal preferences and environmental influences such as cultural background, education, and social trends.[8–10]

Even so, consistent and strict compliance with the established rules and principles of dental and gingival esthetics does not invariably guarantee the creation of dentofacial harmony and a naturally beautiful smile in every case.[11] A "perfect" smile is rarely typified by extreme perfection. A naturally beautiful smile is characterized by harmonious integration of the teeth into the framework of the surrounding periodontal structures, lips, and face. Based on these considerations, this chapter provides objective criteria to define a framework for the dentofacial harmony of a given patient. However, they are merely intended as guidelines. The diagnostic challenge is not to rigorously apply these criteria but rather to weigh and apply them according to the individual clinical condition. In addition to knowing and applying these criteria, the clinician must be able to produce a restoration that allows for natural variation and captures the personality and character of the individual patient in order to achieve a successful outcome. Due consideration of individual features such as malocclusion and facial asymmetry is of great importance in this context.[12,13]

Perception of gingival esthetics is more objective than that of dental esthetics. Nonetheless, an individual's perception of minor deviations from the "ideal" gingival margin can be subjective. While one person may be very bothered by mild gingival recession around a maxillary canine, another will hardly notice it.

Clear communication between the dentist and the patient during the entire planning and treatment period is key to successful dentofacial esthetic treatment that meets the expectation of the dentist and, more importantly, that of the patient. The typical patient presenting for smile enhancement is a layperson who finds it difficult to judge his or her own appearance and assess the capabilities and limitations of the proposed corrective measures. The clinician must include the patient to jointly develop a treatment plan.

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Fig 5-1 In patients with gingival display in the anterior region, particularly during a smile, both the teeth and the gingival margin must meet certain esthetic criteria to project an overall esthetic impression.

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Fig 5-2 Periodontal health is a basic requirement for gingival esthetics.



Fig 5-3 The alveolar mucosa is generally dark red and can be readily distinguished from the light pink gingiva.



Fig 5-4 The surface of the gingiva is firm, dull, and stippled like an orange peel, whereas that of the alveolar mucosa is shiny and smooth.

5.1 Esthetic Criteria

Generally recognized and established criteria for gingival esthetics in terms of an esthetic and harmonious gingival morphology and gingival margin are described in the following sections.[14–16]

5.1.1 Gingival Health

Gingival and periodontal health is a basic prerequisite for an esthetic gingival morphology. Gingival inflammation not only produces pathophysiologic changes in the marginal periodontium but also causes changes in the color and surface texture of the gingiva. Inflamed gingiva bleeds easily and has a red, swollen, plump, and shiny appearance.

Therefore, a proper assessment of gingival esthetics can only be performed under inflammation-free periodontal conditions. The continuous personal oral hygiene motivation and support accompanying initial and supportive periodontal therapies are important for oral health and gingival esthetics.[15] Any dental treatment having a negative impact on gingival health in terms of biology and esthetics must be absolutely avoided for the same reasons (Fig 5-2).

5.1.2 Anatomical and Morphologic Features

Color

Healthy gingiva is light pink in color. Variably intense brownish pigmentation of the gingiva is not uncommon in dark-skinned individuals.[16]

The alveolar mucosa has a dark red color, making it readily distinguishable from the gingiva (Fig 5-3). Its dark color is attributed to the strong blood supply to the subepithelial connective tissue under a nonkeratinized and thus relatively translucent epithelium.

Surface texture

The surface texture of the healthy gingiva is mainly determined by the supracrestal fiber attachment of the subepithelial connective tissue to the keratinized gingival epithelium (see chapter 1). The epithelial surface of the attached gingiva bound to underlying alveolar bone often displays stippling (orange peel texture).[16] Evidence suggests that stippling is more pronounced in individuals with thick gingival biotypes than in those with thin biotypes.[7] Keratinization gives the gingival epithelium a firm texture and a dull surface appearance.

The adjacent alveolar mucosa has a shiny and smooth appearance that stands out against the background of the gingiva (Fig 5-4).

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Fig 5-5 The papilla is the part of the gingiva that fills the interproximal space between the area of tooth contact of two adjacent teeth and the interdental bone septum.

Interdental gingiva

By definition, the *papilla* is the part of the gingiva that fills the interproximal space between the area of contact of two adjacent teeth and the interdental bone septum (see chapter 1). The contact point between the central incisors is in the most incisal position compared to the contact point between other teeth. For ideal gingival esthetics, the highest point of the interdental papilla should be located there, and the papillary height should decrease gradually from anterior to posterior[16] (Fig 5-5). The contour of the gingiva follows the geometry of the papillary soft tissue around the teeth, resulting in the typical scalloped architecture of the gingiva. The shape of the teeth (triangular or rectangular) determines the height of the papilla and the degree of scallop (high or low).[17,18]

Studies suggest that teeth with triangular morphology tend to be associated with a narrow band of keratinized gingiva.[18] It has been frequently proposed that the majority of patients with triangular teeth and high papillae have a thin gingival biotype and that most of those with rectangular teeth and low papilla have a thick gingival biotype. However, this hypothesis has yet to be confirmed[19] (see chapter 1).

The absence of papillae or interdental soft tissue results in so-called black triangles, which can have a negative impact on esthetics.[20]

Gingival zenith

The *gingival zenith* is defined as the most apical point of the gingival margin scallop when viewed buccally. The soft tissue outline in the zenith region is determined by the contour of the underlying tooth. The gingival zenith is usually located at the most convex and most buccal point on the buccal tooth surface.[12] The gingival zenith is often located slightly distal to the long axis of a tooth, but its position may vary depending on the position and geometry of the tooth (Fig 5-6).



Fig 5-6 (a to d) The gingival zenith is usually located at the most convex and most buccal point on the buccal tooth surface, which is generally slightly distal to the long axis of the tooth.

If the gingival zenith is located just distal to the long axis of the tooth, the shape of the *gingival margin profile* will be *trigonal*.[6] However, variations are common and do not necessarily impair the overall esthetic impression.[3] The zeniths of the lateral incisors are generally positioned centrally on the long axis of the tooth, resulting in a convex shape of the gingival margin profile.[14] In the maxillary central incisors, flattening or pitting occasionally causes a slight indentation on the labial surfaces in the mesial half of the cervical region. This results in a

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Fig 5-7 The shape of the gingival margin profile may be trigonal or convex, depending on the position of the gingival zenith. Occasionally, flattening or pitting may cause a slight indentation in the cervical region. When this occurs in combination with a distally positioned gingival zenith, the gingival margin will have an S-shaped profile.

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Fig 5-8 The gingival margin runs parallel to the cementoenamel junction. The cementoenamel junction rises coronally in the interproximal areas, resulting in the characteristic scallop of the gingival architecture.

slight indentation of the gingiva because the soft tissue follows the contour of the teeth. Slight coronal displacement of the gingiva can be seen in this region. When this occurs in connection with a distally positioned gingival zenith, the gingival margin will have an S-shaped profile (Fig 5-7). Because the position and height of the gingival zenith are determined by the underlying buccal tooth surface, orthodontic and restorative procedures are better suited to change these relationships than surgical corrective measures.

Gingival contour

The gingival margin follows the cementoenamel junction of the teeth (Fig 5-8). The individual architecture of the gingival margin can vary widely due to the wide range of individual variation in anterior tooth arrangement, morphology, and position. It is possible that each individual architecture with its own individual variation from the ideal gingival margin may be very esthetic and harmonious in the dentofacial framework of a given individual (Figs 5-9).

Based strictly on esthetic criteria, the maxillary gingival contour is considered ideal when the gingival margins around the lateral incisors are slightly more coronal than the gingival margins around the central incisors and canines. In the mandible, on the other hand, the gingival margins should ideally be slightly more apical around the canines than gingival margins around the central and lateral incisors.[14] The overall appearance of the gingival margin should be as balanced and symmetric as possible.[1] Also, the maxillary gingival margin should run parallel to the incisal edges of the teeth and parallel to the lower lip line when the individual is smiling (Fig 5-10).

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Fig 5-9 (a to f) Because the gingival margin follows the cementoenamel junction, the gingival contour is directly determined by tooth shape and position. Variation in anterior tooth arrangements and gingival contours can be esthetically pleasing in different patients.

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Fig 5-10 (a) In the maxilla, the gingival margins should ideally be slightly more coronal around the lateral incisors than at the central incisors and canines. (b) In the mandible, on the other hand, the gingival margins should ideally be slightly more apical around the canines than at the central and lateral incisors.

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5.1.3 Smile Types and Gingival Display

The aforementioned criteria for esthetic gingival margins apply regardless of how much of the teeth and gingiva is revealed when the patient is smiling.[21,22] The activity and dynamics of the individual muscles involved in smiling vary greatly from one patient to another. Investigators have attempted to classify different smile types to provide an objective basis for interpretation and verbalization of dentofacial problems in order to enhance communication between dentists and patients as well as amoung dentists.

Philips[23] established a smile classification scheme based on the three smile patterns identified by plastic surgeons: the *commissure smile*, the *cuspid smile*, and the *complex smile*. This classification system, based on neuromuscular criteria, considers the muscle groups involved in individual smile patterns and indicates the extent to which the maxillary and mandibular teeth and gingiva are displayed when the person is smiling. This type of classification system makes it clear that, although there is overlapping among the different smile patterns, the esthetic zones for gingival tissues vary widely and are unique to each individual. A full range of variation may be observed, from a smile with no gingival display to a "gummy" smile with gingival display extending as far back as the posterior teeth.[24,25]

Tjan and *Miller*[22] published another commonly used smile classification system distinguishing individuals with a *high*, *average*, or *low smile line* based on the amount of dental and gingival exposure during a natural full smile (Fig 5-11). According to their classification, a low smile line reveals less than 75% of the maxillary incisors, an average smile line reveals 75% to 100% of the maxillary anterior teeth along with the interproximal gingiva, and a high smile line reveals 100% of the anterior incisors and an abundant amount of the overlying gingiva. The high smile line, also known as a *gummy smile*, is the smile type of main esthetic concern.

After evaluating their study population of 454 subjects with age ranging from 20 to 30 years, the investigators found a low smile line in 20.5%, an average smile line in 69.0%, and a high smile line in 10.5% of subjects. The group with a high smile line contained twice as many women as men. The authors hypothesized that the reason for this significant gender-specific difference could be that women have a shorter upper lip than men,[22] but this assumption could not be confirmed in subsequent studies.[26] The *Tjan* and *Miller* smile classification system[22] does not take gingival display in esthetically relevant zones of the mandible into account. Mandibular gingival display tends to increase with age.

Two factors must be taken into account when gingival display is clinically assessed in routine practice. First, it is hard to get the patient to show a natural full smile on demand. Therefore, it is better to obtain the necessary information by observing the patient in relaxed, normal conversation over a longer period of time. Second, many patients with problems in the anterior region have trained themselves to restrict their lip movement when smiling to cover unattractive areas. This pattern of lip restraint often disappears on its own after successful restoration, which must be taken into account during the initial evaluation of smile esthetics and treatment planning.

Based on the maxillary smile line criteria described above, the esthetically ideal smile line is one in which roughly 1 mm of marginal gingiva is revealed during a natural full smile. Exposure of more than 3 mm of gingiva when smiling is perceived as unattractive by the majority of patients.[4] However, there are exceptions to every rule. Remember the individual nature of dentofacial harmony. Even a gummy smile can look very attractive on certain people.

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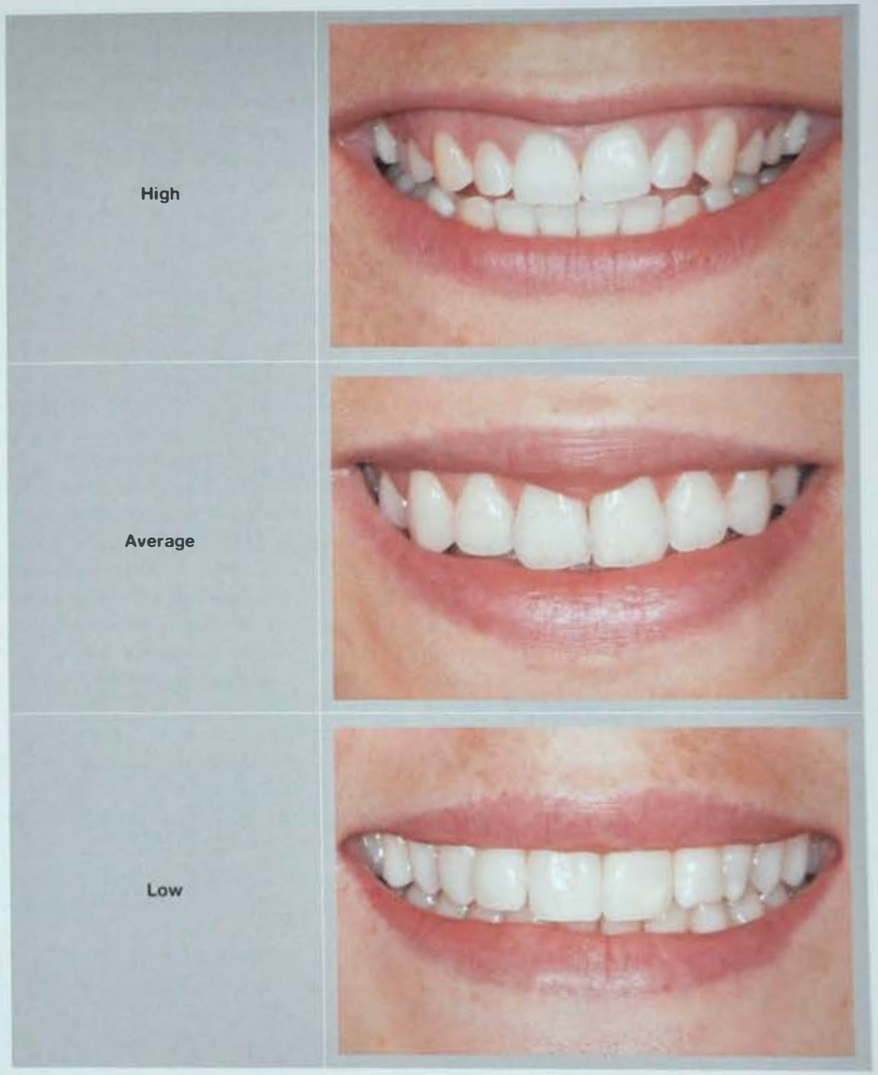


Fig 5-11 *Tjan* and *Miller* classification system[22] distinguishes high, average, and low smile lines.

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5.2 Indications for and Goals of Mucogingival Surgery

The following factors must be considered when surgical correction of gingival esthetics is being contemplated. If the motivation is purely cosmetic, it generally does not make sense to undertake this type of elective surgery unless the patient has an average or a high smile line resulting in maxillary gingival display during function and smiling. Second, the urgency of gingival correction is determined by the size and location of the problem zone. The gingival margin along the six maxillary anterior teeth is the most relevant area of esthetic concern.[2,27] Generally, the closer to the midline a gingival defect is located, the greater the chance of esthetic impairment. From an esthetic perspective, gingival recession around a maxillary central incisor, even if only slight, can be highly relevant, whereas the same amount of recession around a maxillary canine might present no esthetic problem at all.[2,27]

In complex cases requiring extensive surgical and restorative procedures for correction of dental and gingival esthetics around multiple teeth, greater deviation from the ideal gingival esthetics may be tolerable in some cases. The subtle illusion of natural roots, the selective correction of proportions such as the length-width ratio of the reconstructed teeth, and the creative use of ceramic shades can create illusions that can optically mask gingival imperfections to a certain extent. However, in esthetically demanding patients, even slight deviations from the ideal gingival margin will be of high esthetic concern, and this type of restoration design will not be acceptable. Cooperation between the patient and the dentist is needed to determine whether mucogingival surgery is indicated in the individual case. The dentist must assess the predictability, the biologic and surgical risks, and the long-term prognosis of the planned procedure and communicate this information to the patient as accurately as possible. Conversely, the patient must articulate and communicate his or her esthetic wishes and expectations to the dentist as completely and precisely as possible. The patient must understand which results can realistically be achieved and, above all, be able to accept technical limitations.

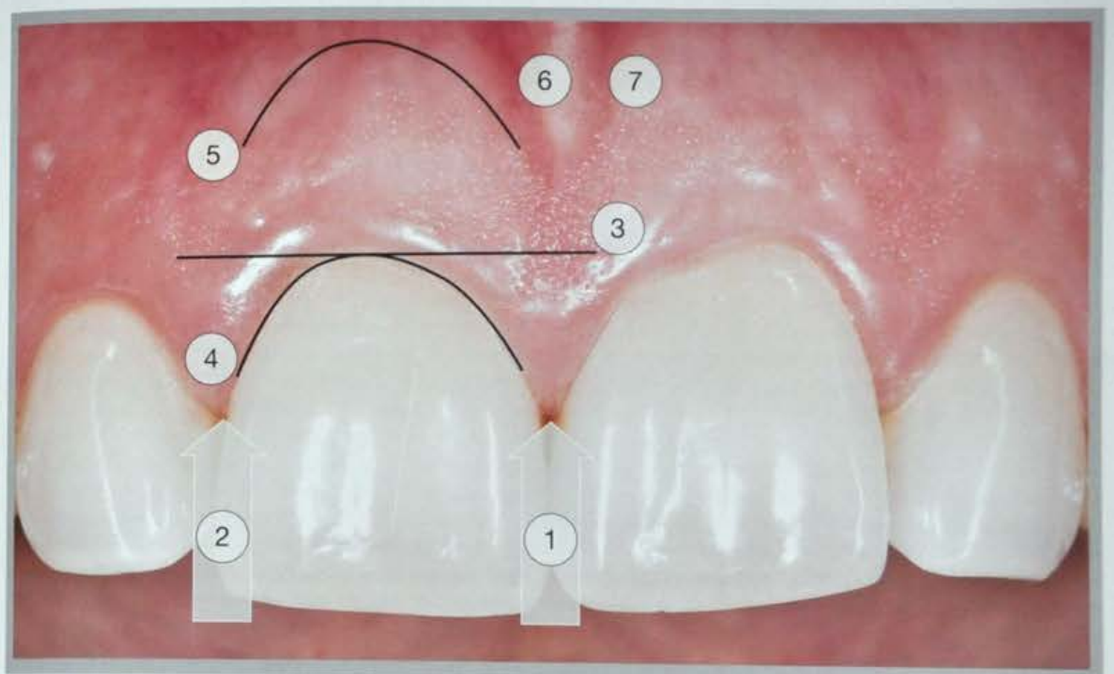
If the patient opts for surgical enhancement of gingival esthetics, the dentist must define the treatment objectives in *quantitative and qualitative terms*. The success of treatment does not hinge on any single factor alone. Quantitative objectives in terms of correcting existing defects (eg, gingival recession) must be achieved using predictable procedures with a good long-term prognosis. Qualitative goals must also be met. All or as many of the above-mentioned attributes of natural and healthy gingival esthetics as possible must be achieved because gingival corrective surgery is often performed for purely cosmetic reasons. The color and surface of the new reconstructed tissues must match those of the surrounding local tissues as closely as possible. Overcompensation and scar formation must be avoided.

These qualitative aspects have not received sufficient consideration in the past, particularly in scientific analyses and comparisons of different surgical methods. The first study investigating the qualitative outcomes of different plastic-esthetic periodontal and implant surgical procedures for correction of gingival esthetics were only recently published.[28] The Pink Esthetic Score (PES) developed by *Fürhauser* and coworkers[28] was originally used for assessment of soft tissue around single-tooth implants but can also be used to evaluate the outcome of gingival esthetic surgery. The PES can be considered the first system for objective and qualitative assessment of the esthetic outcome of mucogingival surgery (Table 5-1).

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Table 5-1

The Pink Esthetic Score developed by *Fürhauser* and coworkers[28] rates seven variables relating to gingival esthetics on a scale of 0 to 2, yielding a maximum score of 14 points.



① Mesial papilla
② Distal papilla
③ Level of the gingival margin
④ Marginal tissue contour
⑤ Alveolar process contour
⑥ Soft tissue color
⑦ Soft tissue texture

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5.3 Esthetic Analysis in Complex Cases

If mucogingival surgery is to be performed *without restoration* of the affected teeth, the analysis of gingival esthetics will be relatively straightforward and simple because the teeth provide intact landmarks for orientation. By applying the criteria and guidelines for gingival esthetics described earlier, the clinician can analyze the existing gingival margin in a very objective manner and establish a treatment plan based on the problems identified in the analysis.

If mucogingival surgery is to be performed in combination with *tooth restoration*, assessment of the gingival margin will be more difficult because intact landmarks, such as incisal edge position, will be either lacking or subjected to change. In the latter case, the analysis may still be relatively simple if intact natural landmarks such as the edges of the incisors or at least the cementoenamel junctions are still present at the start of treatment. However, it can be very complicated if the teeth are prosthetically restored or missing and, consequently, the dental landmarks needed for proper orientation are absent. The rule of thumb is: The smaller the number of natural dental landmarks at the beginning of treatment, the more difficult the esthetic analysis of the gingival margin (Fig 5-12).

In complex cases, the esthetic analysis must be performed as a step-by-step procedure. The first step is to determine the *incisal edge positions* and thus the tooth positions relative to the lips and face. Second, the patient is assessed for adequate *tooth length* relative to the *gingival margin*.[29] Proper interpretation and analysis of casts, radiographs, and old patient photographs are very important.

A procedure for esthetic analysis in complex cases with combined restorative and surgical problems is described in the following sections. Because this procedure selectively focuses on the harmony and esthetics of the gingival margin, it may be necessary for the reader to refer to more specific literature for details of a more complete and comprehensive esthetic analysis.[3]

5.3.1 Landmarks

Incisal edge position

Incisal edge position is the most crucial landmark for esthetic analysis of complex cases. Therefore, determination of incisal edge position is the first step of the analysis. First, the incisal edge position and incisal contour of the maxillary anterior teeth relative to the lips are assessed while the patient's *mouth is slightly opened* and the mandible is relaxed (Fig 5-13a). The teeth must be visible during the esthetic assessment. The degree of anterior tooth display can vary widely from case to case. *Vig* and *Brundo's* review of the literature[21] provides useful reference values for assessment of natural anterior tooth display. According to their study, maxillary central incisor exposure in women (3.40 mm) is greater than that in men (1.91 mm). Although maxillary central incisor exposure in women is twice as high as that in men, the reverse is true of mandibular central incisor exposure with the individual's mouth slightly open and the mandible relaxed. They also observed age-related differences: Maxillary central incisor exposure in young patients (3.37 mm) is greater than that in middle aged patients (1.26 mm). Their findings suggest that mandibular central incisor exposure increases with age relative to maxillary central incisor exposure. Ethnic differences also exist. For example, maxillary central incisor exposure in whites is generally greater than that in Asians and blacks.

In the next step of the analysis, the incisal contour of the maxillary anterior teeth is assessed in relation to the lower lip *during a smile* (Fig 5-13b). Ideally, the contour of the incisal edges should be convex and parallel to the curvature of the lower lip. This configuration is referred to as a *positive smile line*, which is present in most young people.[22] Depending on the position of the canines, the incisal edge contour may have a bow-shaped or a wing-shaped appearance. In approximately half of all individuals, the incisal edges touch the lower lip to some extent when the person is smiling. A gap between the incisal edges and lower lip can be seen in roughly one-third of all individuals, and the lower lip covers the incisal edges in approximately 16% of people.[22] A negative smile line (reverse smile line) is characterized by a straight or inverse incisal edge contour when the person is smiling and is generally considered unattractive.[30]

Because age- and gender-specific differences exist, there is a certain degree of variation in evaluation and definition of the correct incisal edge position. The main thing is to respect the patient's wishes and expectations as far as technically possible. Phonetic tests, such as having the patient say the letters F, V, and S, can be very helpful when incisal edge position is assessed. Dental and skeletal type differences result in certain differences in labial phonemes, which must be taken into account.[31]

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Fig 5-12 In this patient, the analysis of gingival esthetics is complicated by the clinical situation at baseline. During the course of the proposed treatment, the existing restorations will not be preserved but replaced. The current landmarks will change after the old restorations have been replaced. Consequently, reliable natural landmarks are lacking.

Tooth length

After incisal edge position, tooth length is the next variable needed for assessment of the gingival margin. The lengths of intact natural anterior teeth do not vary much from one patient to another.[32] Studies suggest that there is a certain degree of gender-specific difference but no significant correlation between stature or height and tooth size[33] (Table 5-2). Therefore, it is relatively easy to determine tooth length compared to other esthetic parameters. However, the subjective preconceptions of the patient must also be taken into account.

Gingival margin

In complex cases, the last step of the esthetic analysis is to evaluate the gingival margin using the incisal edge position and tooth length data obtained.

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Fig 5-13a The first step of the esthetic analysis is to evaluate the incisal edge position while the patient's mouth is slightly opened and the mandible is relaxed. The teeth must be visible during this assessment. The extent of tooth display during a smile is determined by the sex and age of the patient.



Fig 5-13b The next step is to evaluate the contour of the incisal edges relative to the curvature of the lower lip during a smile. Ideally, the contour of the incisal edges should be convex and parallel to the curvature of the lower lip.

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Table 5-2

Mean clinical crown length (in mm) of intact, periodontally healthy maxillary anterior teeth*

	Maxillary central incisor	Maxillary lateral incisor	Maxillary canine
Men	10.19 ± 0.94	8.70 ± 0.78	10.06 ± 1.02
Women	9.39 ± 0.86	7.79 ± 0.99	8.89 ± 0.97

*Data from *Sterrett* et al.[33]

5.3.2 Mock-ups and Diagnostic Provisional Restorations for Intraoral Evaluation of Esthetics

Mock-ups and diagnostic provisional restorations are valuable tools for intraoral evaluation of potential esthetic outcomes. They can be particularly helpful in complex cases. Mock-ups and diagnostic provisional restorations are used to test the proposed incisal edge positions and tooth lengths for esthetics and function and adapt them as needed prior to surgical correction of the soft tissue margin.

More importantly, the use of provisionals makes it possible to ensure that the proposed restoration meets the esthetic demands of the dentist and the patient. Provisional restorations can be corrected and adjusted as often as needed until both the dentist and the patient are satisfied with the esthetic and functional results.[34] Patients generally do not rate the final treatment outcome as a success unless their own esthetic expectations have been met. As was stated at the beginning of this chapter, success in complex cases depends on good communication between the dentist and the patient during the diagnostic process as well as during treatment planning. Unlike planning casts, wax-ups, digital image processing and imaging systems, provisional restorations provide a more practical and realistic basis for engagement in a constructive dialogue with the patient in routine practice. Diagnostic provisionals are thus a key factor in achieving a predictable esthetic result.[1,12,35]

However, *diagnostic provisionals* represent an irreversible form of treatment because the teeth must be prepared before the provisional restorations are fabricated. Therefore, the use of provisional restorations is indicated only if the patient has already committed to a restorative procedure in which preparation of the teeth is justified and necessary. If less invasive composite resin or labial veneer restorations have been planned or if the patient has not committed to having the restorative procedure performed, *mock-ups* may be a suitable alternative.

Mock-ups

Mock-ups are fabricated either *directly* (in the patient's mouth) or *indirectly* (in the dental laboratory). If the mock-up is to be prepared according to the direct technique, the use of a diagnostic wax-up is recommended. A vacuum-formed template or silicone stent prepared from the diagnostic wax-up ensures the reliable transfer of the model into the patient's mouth. Modern composite materials enable a wide range of possibilities for fabricating very esthetic mock-ups that blend nicely into the anterior tooth region (Fig 5-14).

Removable mock-ups are generally fabricated by the indirect technique, that is, in the dental laboratory, based on a diagnostic wax-up. The advantage of a removable mock-up is that the patient can take it out to judge the difference between the existing anterior tooth situation and the proposed changes. This is a useful aid in decision making. A removable mock-up will not be feasible unless the teeth provide an adequate degree of anchorage. Therefore, they are mainly used when multiple teeth are to be corrected. Removable mock-ups can be fabricated using polymethyl methacrylate or composite resin materials.

If it is possible to design a mock-up that thins out toward the edges, a good color match between the synthetic material and the natural tooth can be achieved. This effect can be enhanced by having the patient apply petroleum jelly or a similar substance between the synthetic material and the tooth.

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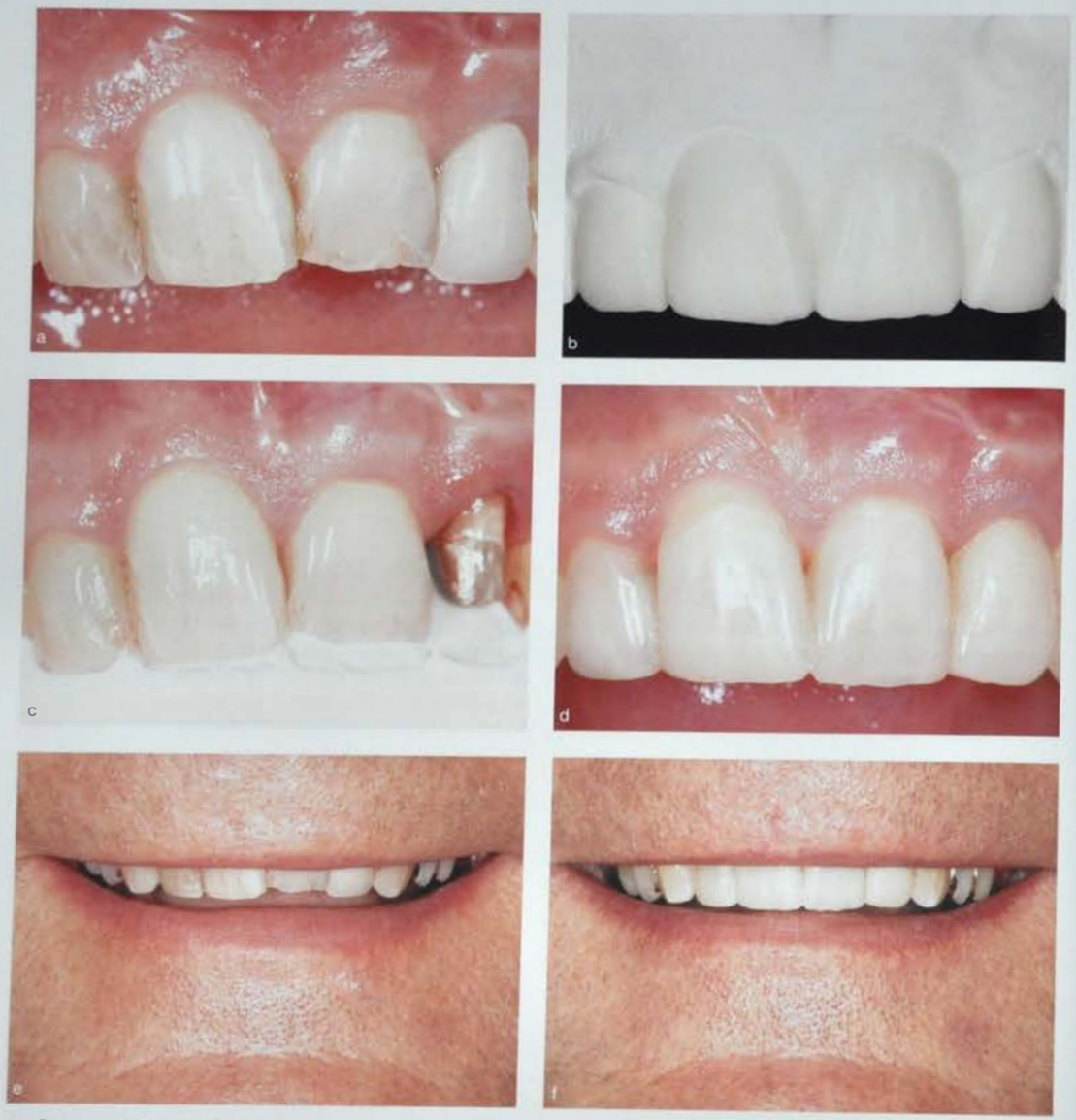


Fig 5-14 (a to f) Direct fabrication of a mock-up. A silicone stent prepared from the diagnostic wax-up is used to fabricate the mock-up as a direct composite resin buildup in the patient's mouth (Dental technician: *Uli Schober*, Seehausen, Germany.)

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Fixed mock-ups are another option. If the patient has already committed to restorative therapy, then the mock-up can be adhesively bonded to the teeth with no need for concern. If the mock-up is to be used as a tool for deciding whether or not to go ahead with a proposed restoration, then the mock-up should be placed without phosphoric acid etching or full adhesive bonding to the teeth, regardless of whether direct or indirect fabrication of the fixed mock-up is planned. Application of unfilled resin to the previously cleaned tooth surface and light curing will suffice. This provides sufficient adhesive power for try-in, but the mock-up can still be easily removed. If the entire tooth surface were etched and bonded, it would not be possible to remove the mock-up without damaging the underlying tooth surface, if at all, and this removal would be very time-consuming (Fig 5-15).

Diagnostic provisional restorations

Diagnostic provisional restorations must be designed to ensure that their quality of marginal fit, surface texture, and three-dimensional configuration are conducive to gingival health and allow adequate oral hygiene and plaque control by the patient. Only under these conditions can a reliable analysis of the gingival status and predictable execution of surgical corrections be accomplished.

Reinforcement fibers or metal frames are sometimes used to enhance the stability of provisional restorations, depending on the clinical situation. Provisional restorations are frequently used to shape and condition the soft tissue, especially in the context of plastic periodontal and implant surgery. Such reinforcements must be designed to ensure that composite material can be either added to or removed from the denture base.

Direct provisional restorations can be fabricated with relatively little effort. With the aid of a vacuum-formed template, the wax-up can be transferred to the patient's mouth as an immediate provisional restoration. The vacuum-formed template should have adequate stability and should remain securely in place when positioned in the mouth to prevent transfer errors. Direct provisional restorations can also be individualized and characterized with esthetic details in accordance with the skill of the person processing them.

Shell provisional restorations are a second option. The time and effort required to make acrylic resin shells and the esthetic results achieved range between those of direct and indirect provisional restorations. Basically, the dental technician uses the wax-up to make an acrylic resin shell, which the clinician can securely position and reline in the patient's mouth via a vacuum-formed template. All finishing and polishing is restricted to the relined areas. The successful use of acrylic resin shells requires excellent communication between the dentist and dental technician as well as the use of systematic and structured clinical and laboratory procedures. Immediate provisional restorations can be fabricated according to the same technique. Relatively little time and effort are needed to make a high-quality shell provisional restoration that provides an excellent basis for communication among the patient, dental technician, and dentist (Fig 5-16).

The fabrication of *indirect provisional restorations* requires a great deal of time and effort because impressions of the prepared teeth must be made and sent to the laboratory, where the restorations are prepared using the appropriate modeling techniques. An immediate provisional restoration must also be fabricated. This second restoration is used to bridge the interval between tooth preparation, impression making, and insertion of the provisional restoration constructed by the laboratory. Indirect provisional restorations provide the highest-quality temporary restorations in terms of stability, precision, surface texture, and esthetic reproduction of detail. Because they are well suited for extended use, they are particularly recommended when the provisional restoration is to be worn for long periods (Fig 5-17).

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Fig 5-15 (a to f) Indirect fabrication and bonding of a mock-up. In this case, unfilled resin was applied without prior etching for temporary bonding (Dental technician: *Uli Schober*, Seehausen, Germany.)

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Fig 5-16 (a to h) Relatively little time and effort are needed to make a high-quality shell provisional restoration. After the teeth are prepared, the shells are relined in the mouth and can be placed immediately after the relined areas have been finished and polished (Dental technician: *Uli Schober*, Seehausen, Germany.)







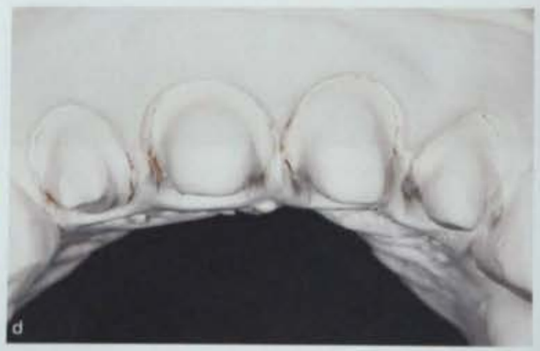














Fig 5-17 (a to j) Indirect provisional restorations constructed by the laborato ryare the most time-consuming but highest-quality type of provisional restoration (Dental technician: *Uli Schober*, Seehausen, Germany.)

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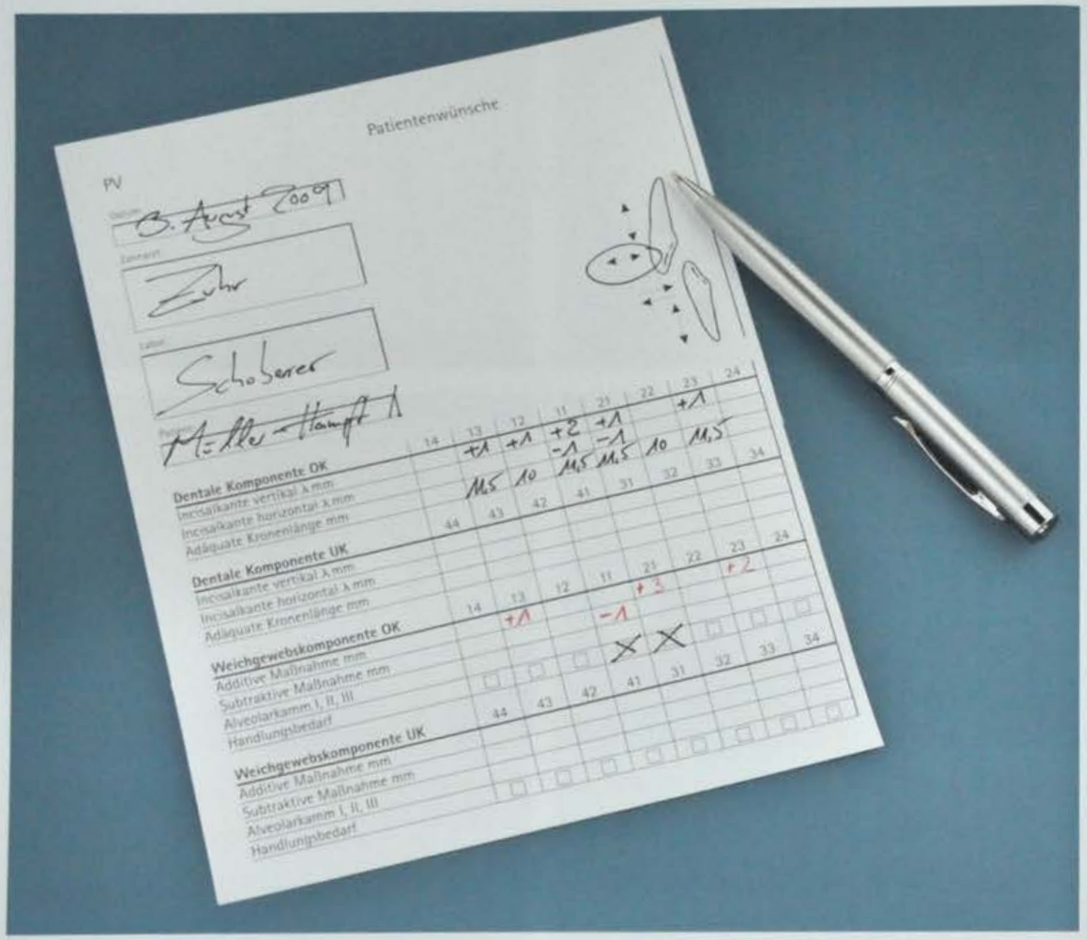


Fig 5-18 Sample esthetic analysis form used to evaluate gingival esthetics in complex cases.

5.3.3 Esthetic Analysis Form

In complex cases, it can be helpful to use a standardized esthetic analysis form (Fig 5-18). It not only provides a means of case documentation but also serves as an aid to communication among the dentist, the dental laboratory team, and all other persons involved in the treatment process.

Planned changes in incisal edge position in the vertical and sagittal planes and specific information about desired tooth length can be noted on the form. Any deviation from the ideal gingival margin can be analyzed based on this information. If any corrective action is needed or if surgical correction of the gingiva around the affected teeth is planned, the necessary information can be added in an additional field.

The most important steps in the esthetic analysis of complex cases involving combined dental and gingival esthetic defects are illustrated by the case example presented in Fig 5-19.

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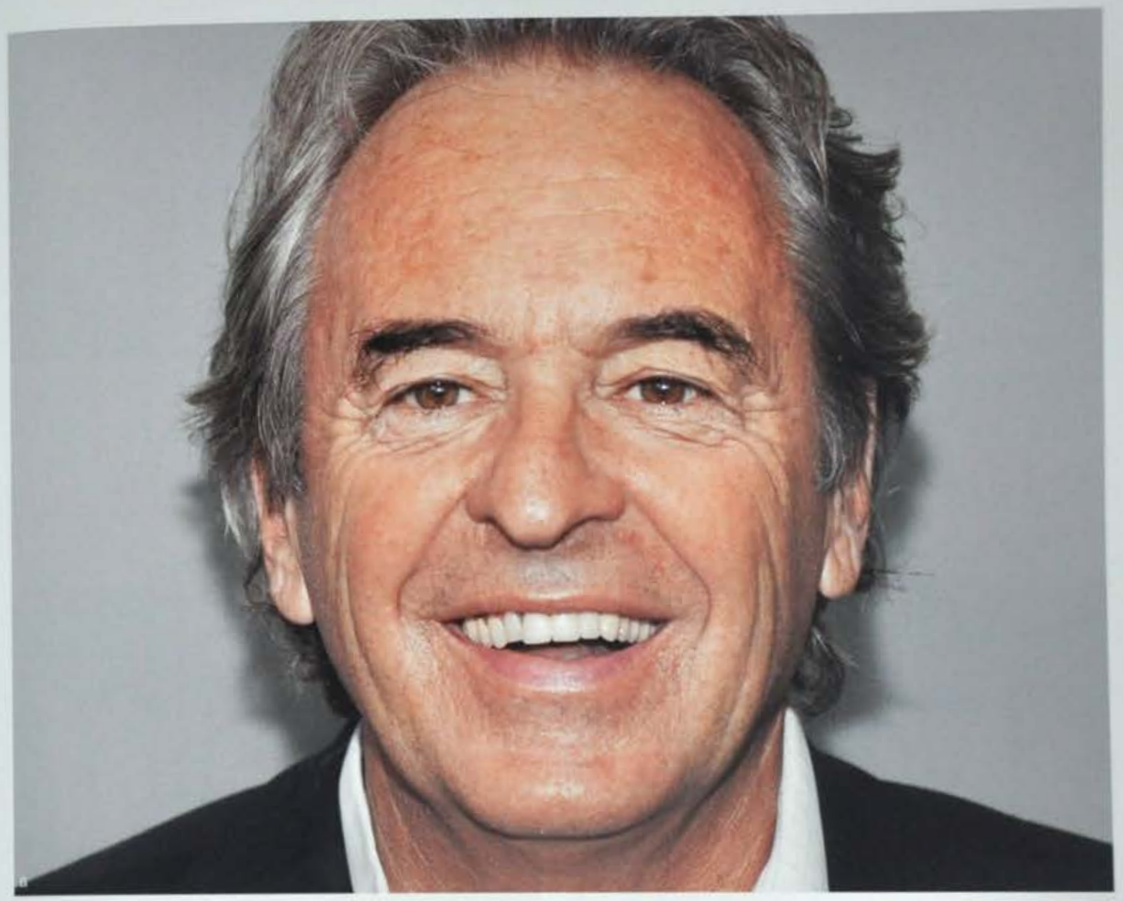






Fig 5-19 (a to c) Pretreatment clinical and radiographic images showing a patient with complex esthetic problems involving the teeth and gingival margin. The natural landmarks needed for reliable assessment of the existing gingival margin are absent. Therefore, a diagnostic provisional restoration is needed to allow correct planning of the incisal outline of the proposed restoration.

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Fig 5-19 (d and e) Pretreatment occlusal views of the maxillary and mandibular arches.









Fig 5-19 (f to i) To ensure a high degree of reliability during fabrication of the laboratory-made indirect provisional restoration, wax crowns are first tried in and repeatedly adapted in the patient's mouth until both the patient and dentist are satisfied that an optimal result has been achieved in terms of the incisal outline.

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Fig 5-19j Clinical situation after placement of the long-term provisional restoration fabricated in the laboratory. Reliable determination of the ideal gingival margin position can now be achieved based on the planned incisal outline and tooth lengths.

Fig 5-19k In this patient, the presence of *Miller* Class III gingival recession over the left central and lateral incisors has to be taken into account in the treatment plan for surgical correction of the gingival margin. The treatment plan calls for root coverage procedures for the left central incisor and the two lateral incisors and canines as well as surgical crown lengthening of the right central incisor. The treatment plan established based on the results of the esthetic analysis can be documented on the esthetic analysis form.

Maxillary Dental Components	14	13	12	11	21	22	23	24
Vertical incisal edge (mm)					+1	+1	+1	+1
Horizontal incisal edge (mm)								
Crown length		11,5	9,5	11	11,5	10	11,5	10,5
Mandibular Dental Components	44	43	42	41	31	32	33	34
Vertical incisal edge (mm)								
Horizontal incisal edge (mm)								
Crown length								
Maxillary Soft Tissue Components	14	13	12	11	21	22	23	24
Additive measure (mm)		+2	+1		+1	+1	+1	
Subtractive measure (mm)				-1				
Alveolar ridge I, II, III								I
Need for action	☐	X	X	X	X	X	X	X
Mandibular Soft Tissue Components	44	43	42	41	31	32	33	34
Additive measure (mm)								
Subtractive measure (mm)								
Alveolar ridge I, II, III								
Need for action	☐	☐	☐	☐	☐	☐	☐	☐

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Fig 5-19 (l to r) The individual steps of the periodontal surgical procedures performed to achieve a harmonious gingival margin are shown.



Fig 5-19s Clinical situation with provisional restorations 5 months after the surgical correction.

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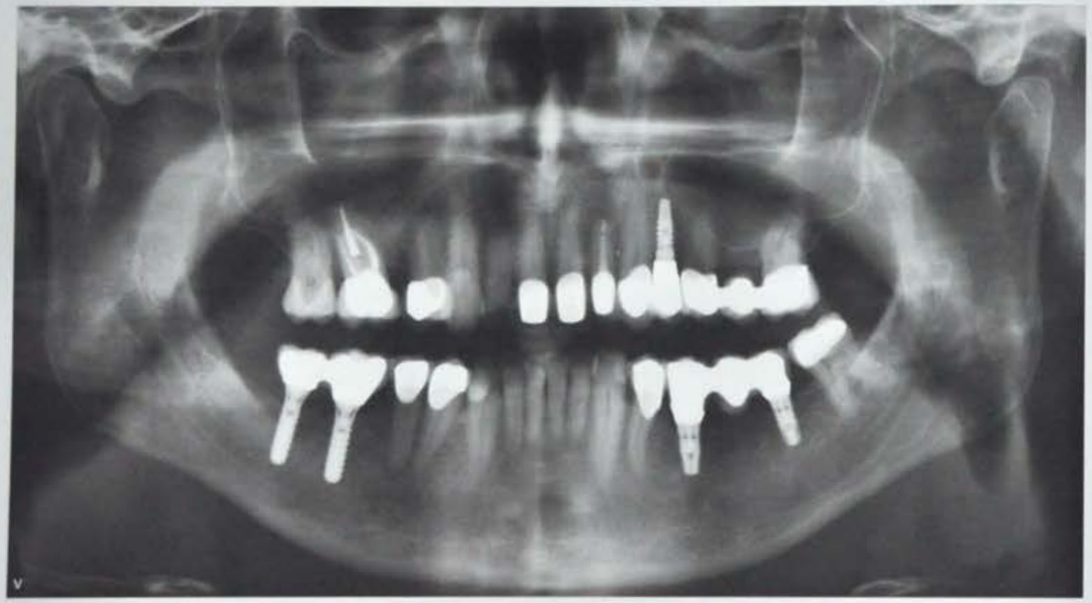












Fig 5-19 (t to aa) Posttreatment clinical and radiographic images reveal that harmonization of the gingival margin has been achieved with the treatment plan formulated based on the esthetic analysis.

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CHAPTER 6

PATIENT MANAGEMENT

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6.1 Informed Consent Process

Plastic-esthetic periodontal and implant surgery are elective procedures. In other words, the patients are free to choose between different treatment options and to decide when to have the desired procedure performed. This is the basic difference between elective surgery and emergency surgery (eg, for acute abscess), which must be performed without delay.[1] Likewise, there are differences in the scope of information the dentist is obligated to provide to ensure informed decision making by the patient in the two situations. While patients must receive very detailed information about elective procedures, especially when esthetically motivated, more basic information will suffice for informed consent before emergency surgery.

6.1.1 Legal Background

Whenever a patient consents to a treatment procedure, the dentist and the patient have entered into contract for services on the basis that the dentist is obligated to endeavor to preserve the health and welfare of the patient according to the rules of good practice. Legally, all interventions can be classified as bodily injury to the patient, defined as "a breach of integrity of the exterior surface of the human body or a disturbance of its internal vital processes." Consequently, any intervention that is not legally justified by a valid declaration of consent by the patient constitutes unlawful bodily injury, even if malpractice did not occur.

The statutory legitimation for the dentist to perform a surgical intervention therefore rests on two separate pillars: medical indication and patient consent. This is the background on which the dentist's obligation to provide the patient with comprehensive information about the risks and consequences of a planned procedure is based. The only way for dentists to perform surgical procedures without civil and criminal consequences is to fulfill their obligations to inform the patients and to obtain their legally valid informed consent before performing the procedures.[2,3] The age at which a patient con consent to treatment will depend on applicable law.

6.1.2 Content and Scope of the Informed Consent Process

In order to give informed consent, the patient must fully understand what he or she is consenting to. Therefore, the patient must receive a full explanation of the proposed surgical procedure and its potential consequences in a personal consultation with the clinician. The extent and scope of the proposed intervention must be explained in a manner that is clearly comprehensible to the patient. All explanations must be formulated for easy comprehension by non–medical professionals and adjusted to the intellectual level of the patient.

The clinician should start the informed consent process by informing the patient of the diagnosis, the nature of the disease, and the nature and purpose of the proposed intervention. The general and specific risks associated with the proposed procedure should then be explained. The patient should be informed about the specific consequences and complications of the proposed procedure and how they can impact his or her personal situation. Conversely, the consequences of not undergoing the proposed procedure should be explained to give the patient the information needed to make an informed decision.

The scope of information is determined not only by the frequency of complications but also and in particular by the personal and medical constitution of the patient. Therefore, the patient must also be informed about less common and more severe risks and side effects of the proposed procedure, especially if they can affect the private or professional life of the patient.

The clinician is not legally obligated to inform the patient about potential risks and consequences of a proposed procedure that can be managed by medical treatment (eg, arterial bleeding).[4,5] However, it is advisable to explain these potential complications to the patient and the measures used to treat them during the course of the informed consent process. Postoperative instructions for the patient can also be briefly described during this briefing, but the exact postoperative instructions will be given after the procedure.

Although it is not mandatory to document the information and consent in writing, both verbal and written documentation of the informed consent process is advisable. If a liability dispute should arise later, the documents can be submitted as evidence and can prompt the memory of the clinician who provided the information. Standardized forms can be used, but they must be individualized (Fig 6-1); that is, the blanks for the date, patient's name, special details, and explanatory sketches must be filled in. Written information leaflets and forms alone are no substitute for personal communication between the doctor and the patient.

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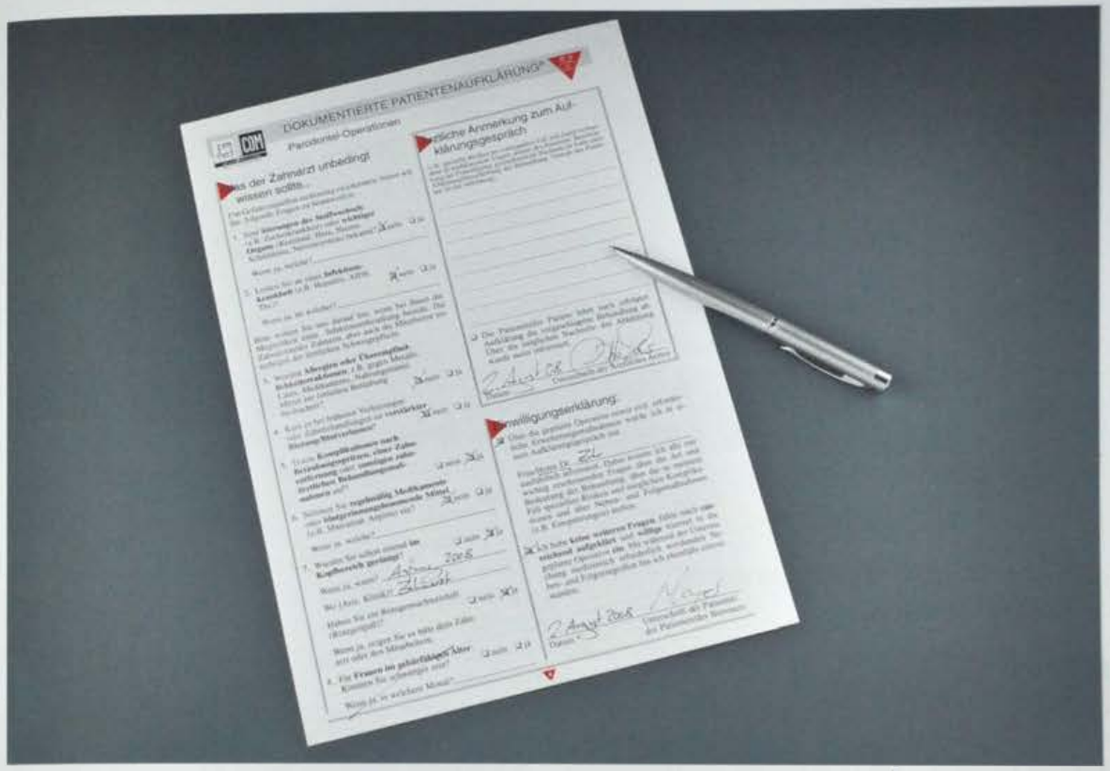


Fig 6-1 It is advisable to use written forms to document the informed consent process. The forms must be individualized; the blanks for the date, patient's name, special details, and explanatory sketches must be filled in.

Failure to give the patient adequate information on which to base an informed consent to the proposed procedure constitutes malpractice, for which the clinician can be held liable for any and all consequences of the procedure, even if the procedure was carried out "according to the rules of the art" and deemed to be in the objective interest of the patient.[5]

6.1.3 Timing of the Informed Consent Process

The informed consent process must be completed in a timely manner. The patient must be fully capable of comprehending the information and making a decision and must be allowed adequate time to consider the decision before a planned intervention. The concrete time frame varies depending on the individual circumstances, but, generally, informed consent should be obtained at least 1 day before the procedure. For elective procedures such as periodontal and implant surgery, it is both advisable and possible to provide the information needed for informed consent much earlier.[4]

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Table 6-1

Most important points to be covered in the informed consent process before elective surgery

Fundamental principles	• The less urgent the surgery, the more comprehensive the informed consent process. • The informed consent process should ideally be conducted verbally and in writing using a standardized form.
Content and scope of information	• Diagnosis. • Proposed treatment and alternatives. • Typical risks associated with the proposed treatment in the patient's specific case. • Postoperative instructions. • General risks associated with surgery.
Time of informed consent	• At least 24 hours before surgery.
Postoperative instructions	• No physical exertion the first week after surgery. • No special diet. • Avoid alcoholic and caffeinated beverages. • No smoking. • Instructions for treatment of postoperative swelling.

6.1.4 Delivery of Postoperative Instructions

The postoperative instructions should be briefly discussed during the preoperative informed consent process and explained in detail in the immediate postoperative period. The data should include information on the postoperative medication and strict instructions for correct postoperative behavior that are necessary to ensure the success of the procedure.

For example, the patient should be instructed to avoid physical exertion and rapid head and neck movement after periodontal and implant surgery because this movement can lead to complications such as bleeding, severe swelling, and suture dehiscence. For the same reasons, the surgical site should only be cleaned with lukewarm (not hot) water during the first few days after surgery. Visits to the sauna or similar activities are not permitted.

Patients often eat less or eat only certain kinds of food after oral surgery. This change in diet may be intentional or unintentional, but the resulting nutrient deficiency can weaken the immune system and reduce the body's healing capacity. The patient should be made aware of the importance of proper nutrition and be encouraged to continue eating the same foods as usual, even if they have to be pureed.

Conversely, the consumption of alcoholic and caffeinated beverages should be minimized during the first postoperative week, but, if necessary for the patient's well-being, they may be permitted in moderation. Smoking, on the other hand, is strictly prohibited.

To prevent unnecessary anxiety, the patient should always be told to expect swelling and bruising after periodontal and implant surgery. Postoperative edema reaches a peak approximately 24 to 48 hours after surgery. In most cases, the swelling subsides quickly after reaching this peak. Anti-inflammatory drugs and physical treatments can substantially reduce the severity of postoperative swelling.[6] The patient should apply an ice pack to the treated area several times a day for the first 3 days after surgery to reduce swelling.[7] A warm wet compress can be applied after the ice pack to stimulate circulation in the region. During the first week after surgery, toothbrushing in the surgically treated area is prohibited to prevent mechanical trauma to the wound.

In the immediate postoperative period, patients are often unable to fully absorb and comprehend all of the postoperative instructions. Therefore, the instructions should be explained to both the patient and a family member or accompanying person if possible. The patient should also be given a postoperative instruction sheet containing the most important information. For added reassurance, it is advisable to provide a phone number to call in case of emergency (Fig 6-2).

Table 6-1 provides a summary of the most important points to be covered in the informed consent process before elective surgery.

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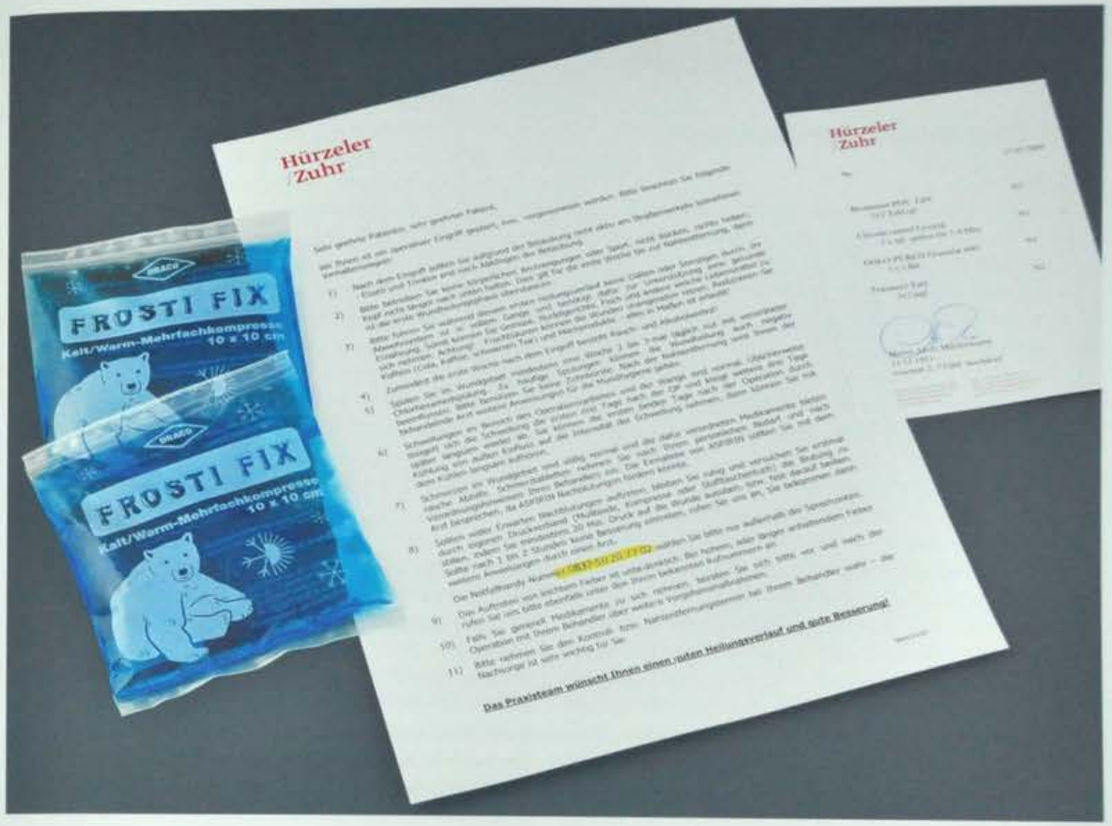


Fig 6-2 It is advisable to issue the patient a postoperative instruction sheet with an emergency phone number in addition to a cold pack and a prescription for the required medications.

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6.2 Preoperative and Postoperative Management

6.2.1 Preoperative Management

Principles

Oral surgery is performed in an environment with a high microbial load. It is not possible to sterilize the oral cavity completely either before or after surgery. An optimal pretreatment regimen that effectively reduces microbial contamination to the lowest possible levels is the key to successful oral surgery.

One basic rule is that surgery should never be performed on inflamed tissues because inflammatory changes have a negative impact on wound healing and affect the accuracy and precision of the surgical technique. Especially in high-risk patients, inflammation is associated with an increased risk of systemic infection, which can result in severe and potentially fatal complications. Therefore, local or systemic inflammatory processes should be adequately treated before the patient has surgery.[8,9]

Healthy periodontal tissues contain more collagen fibers and are thus more robust and resistant than inflamed tissues.[6,8,10] Inflammation-free periodontal conditions are absolutely necessary for precise microsurgical incision and flap technique. The larger number of collagen fibers in healthy soft tissue significantly improves the precision and stability of suture closure and makes it much easier to achieve primary approximation of the wound margins, which is crucial for optimal wound healing. Also, there is less intraoperative bleeding in the absence of inflammation. This improves the surgeon's view of the surgical field and ability to maneuver the surgical instruments and manipulate the tissues safely and precisely.

Periodontal pretreatment

If signs of marginal periodontitis are detected, periodontal pretreatment must be performed to eliminate the inflammation before surgical intervention. Adequate plaque control by the patient significantly reduces bacterial counts in the oral cavity and is fundamental to the success of plastic-esthetic periodontal and implant surgery (Fig 6-3). Therefore, the oral hygiene of the patient must be evaluated, and adequate personal oral hygiene must be established before surgery if necessary.

The patient may need a number of treatment sessions with a dental hygienist or an appropriately trained prophylaxis assistant, who should not only perform professional tooth cleaning but also enlighten, motivate, and instruct the patient in adequate personal oral hygiene. Periodontal pretreatment should also include the removal of overhanging restorations and restoration margins, which attract plaque and can impede adequate oral hygiene.[11] In addition to periodontal pretreatment, systemic infection prophylaxis and surgery are required for some patients with severe periodontitis in which inflammation has spread beyond the gingival tissues.

Plaque and bleeding indices are used to evaluate and monitor the status of periodontal inflammation. Simplified Plaque Index (PI) systems such as that of *Ainamo* and *Bay*[12] and simplified bleeding indices such as the Papillary Bleeding Index (PBI) according to *Saxer* and *Mühlemann*[13] are commonly used today. When recorded at each visit, plaque and bleeding scores are effective instruments for case monitoring and patient motivation. The prerequisite for plastic periodontal or implant surgery is a PI score of less than 20% and a PBI score of less than 5%. When these conditions are met, the clinician can safely assume that the periodontal tissues are virtually free of inflammation and have a high collagen content.

If a palatal soft tissue graft is to be used, a surgical stent will be needed for coverage of the palatal donor site and should be made before graft harvesting. Surgical stents are used to apply pressure to the palatal soft tissues to facilitate postoperative hemostasis and to protect the donor site during the first few days after surgery (see chapter 7).

Immediate preoperative patient preparation

A brief preoperative talk gives the clinician the opportunity to reassure the patient and answer any final questions the patient may have. Before entering the operating room, the patient should be asked to remove all constrictive and uncomfortable clothing and to cover or remove the shoes. Once the patient is comfortably positioned on the operating chair, some final preparations can be completed under nonsterile conditions. For example, interproximal contact points can be splinted with composite resin, if necessary, for suture anchorage. Local anesthesia should be administered before the patient is draped to allow adequate time for it to take effect.

Split sheets that completely cover the patient up to the perioral region are used as sterile drapes. The drapes are applied and secured, and the operating chair is adjusted to the correct position. The perioral and intraoral tissues



Fig 6-3 Effective plaque control by the patient is essential to the success of plastic-esthetic periodontal and implant surgery.

are swabbed with 0.1% chlorhexidine solution for approximately 60 seconds to achieve the best possible reduction of the resident and transient skin flora.[14–16]

Before surgical hand disinfection, the surgeon and surgical assistant should cover all of their hair with a hair covering, don a surgical mask, and put on a loupe or safety goggles. All rings, watches, and other jewelry must be removed from the hands and forearms. Surgical hand disinfection is a two-step procedure. First, the hands and forearms are cleaned up to the elbows with a soap-free liquid cleanser for approximately 1 minute.[17] A sterile nail brush is used under running water to clean and rinse the fingernails and skin around the edges of the nails.[17] Then the hands are dried with a sterile or virtually germ-free disposable towel. Second, an appropriate disinfection solution is applied to the hands and forearms up to the elbows with continuous rubbing motion for 2 to 5 minutes. After the hands are dried and scrubbed, a sterile gown and gloves are donned. The surgical procedure can now begin[17,18] (Fig 6-4).

National guidelines for hand hygiene in health care settings vary from one country to another. Clinicians should refer to their country's specific guidelines for dental practice.

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Fig 6-4 Before surgery, the patient is covered with sterile split sheet drapes (a), and the perioral and intraoral tissues are swabbed with 0.1% chlorhexidine solution (b and c). After scrubbing and donning a sterile gown and gloves (d), the surgeon can begin the procedure.

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Fig 6-5 After suture removal, thorough supragingival cleaning of the surgical site is performed with a rubber cup and chlorhexidine gel.

6.2.2 Postoperative Management

Principles

Postoperative management consists of providing the patient with adequate medication, postoperative instructions, and postoperative care designed to ensure optimal wound healing.

Postoperative medication and oral hygiene instruction

After surgery, the patient is prescribed postoperative medication with a spectrum of analgesic, anti-inflammatory, and anti-infective activity, which will be described in detail later. The postoperative instructions should be explained to the patient and, ideally, to a family member or accompanying person after surgery. In addition to medication, physical measures for reduction of swelling (application of ice packs) are also recommended.

The patient should also receive instructions for oral hygiene during the postoperative healing phase. No mechanical oral hygiene practices with a manual or powered toothbrush should be performed during the first 2 weeks after the surgery. Instead, the patient should rinse the mouth with 0.1% chlorhexidine mouthwash for 1 minute three times daily.

Follow-up wound inspection and suture removal

The sutures are removed and the wound is inspected 7 days after surgery, but an earlier appointment for wound inspection (4 days postoperatively) may be advisable after extensive procedures. After suture removal, thorough supragingival tooth cleaning is performed with a rubber cup and chlorhexidine gel applied at low speed to remove all plaque and food residue in the surgical region (Fig 6-5).

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Fig 6-6 After reconstructive periodontal or implant surgery, the patient is instructed to gently clean the treated area using an extra soft toothbrush and chlorhexidine toothpaste three times daily from the third to sixth postoperative weeks.

Aftercare

The modified postsurgical cleansing protocol ecommended by *Heitz* and coworkers[19] should be performed 7 days after the surgery because the patient's capacity to perform oral hygiene in the treated area is significantly limited during the first week after surgery. This 1-week postoperative appointment should consist of supragingival tooth cleaning with a rubber cup and chlorhexidine gel as well as cautious interproximal cleaning with Super Floss and chlorhexidine gel.

The patient is then given new oral hygiene instructions for the remaining postoperative period. Patients who underwent esthetic crown lengthening or other procedures with an uncomplicated course of healing are instructed to resume normal oral hygiene procedures according to the modified *Bass* technique, including interproximal cleaning. However, those who underwent reconstructive surgery (eg, root coverage) must continue the strict oral hygiene regimen because mechanical tooth cleaning could traumatize the treated tissues and impair the wound healing process. From the third postoperative week on, these patients should clean the treated area according to the modified *Stillman* technique 3 times daily for the next 4 weeks using an extrasoft toothbrush and chlorhexidine toothpaste[20,21] (Figs 6-6 and 6-7).They may also use dental floss or Super Floss for interproximal cleaning of teeth not adjacent to the surgical site. Patients are instructed to discontinue chlorhexidine mouth rinsing at this time.

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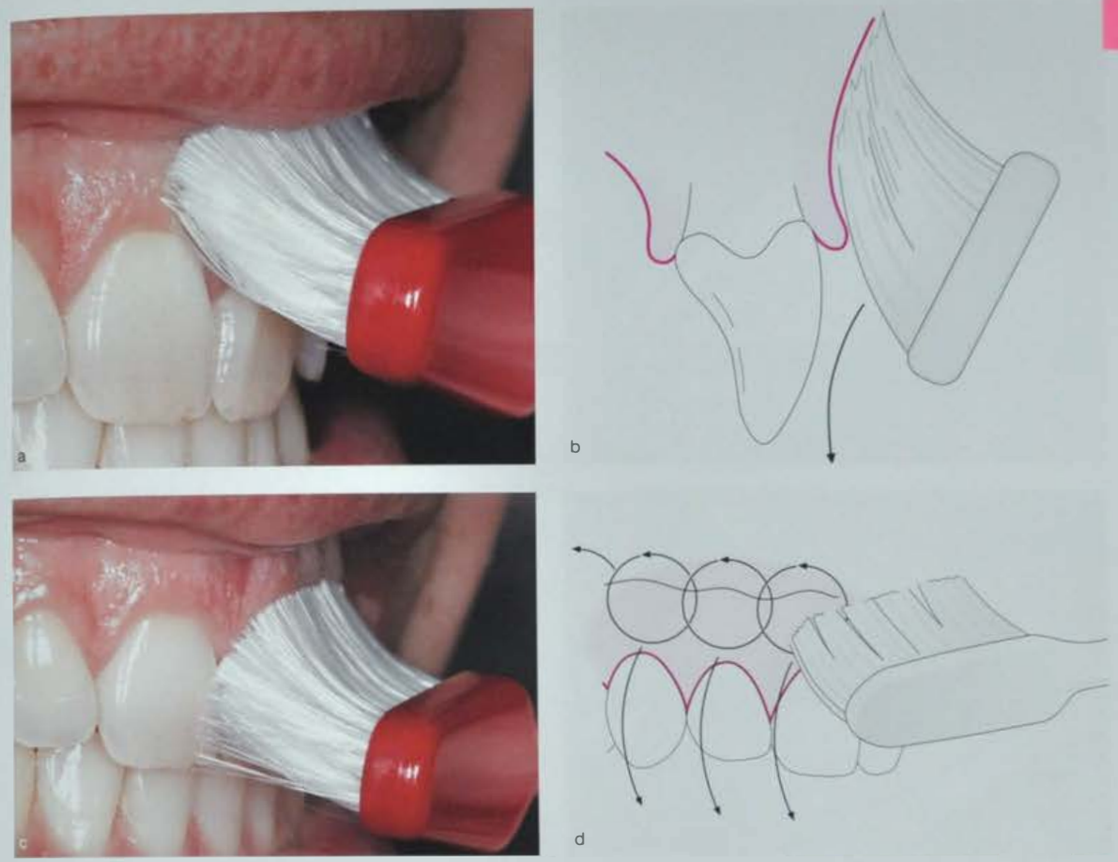


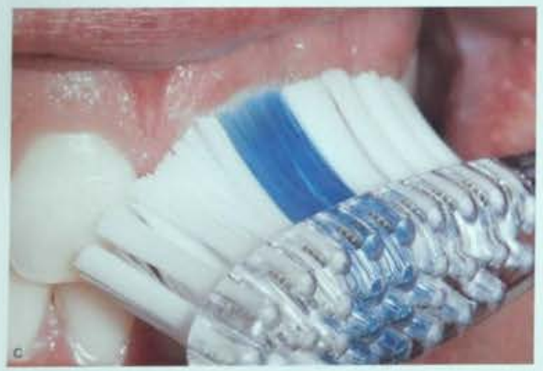
Fig 6-7 Modified *Stillman* technique of toothbrushing. (a and b) First, the toothbrush is placed with the bristle ends on the gingiva with the sides of the bristles resting against the teeth at a 45-degree angle to the long axis of the tooth. (c and d) Using small circular or jiggling movements (depending on his or her manual dexterity), the patient gently moves the toothbrush in a coronal direction to promote the stimulation and drainage of the gingiva.

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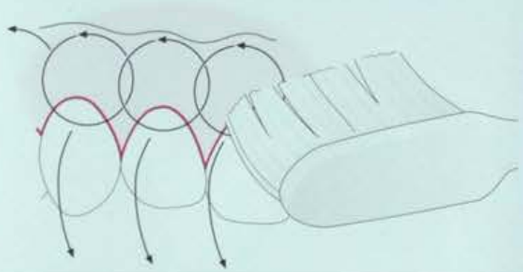
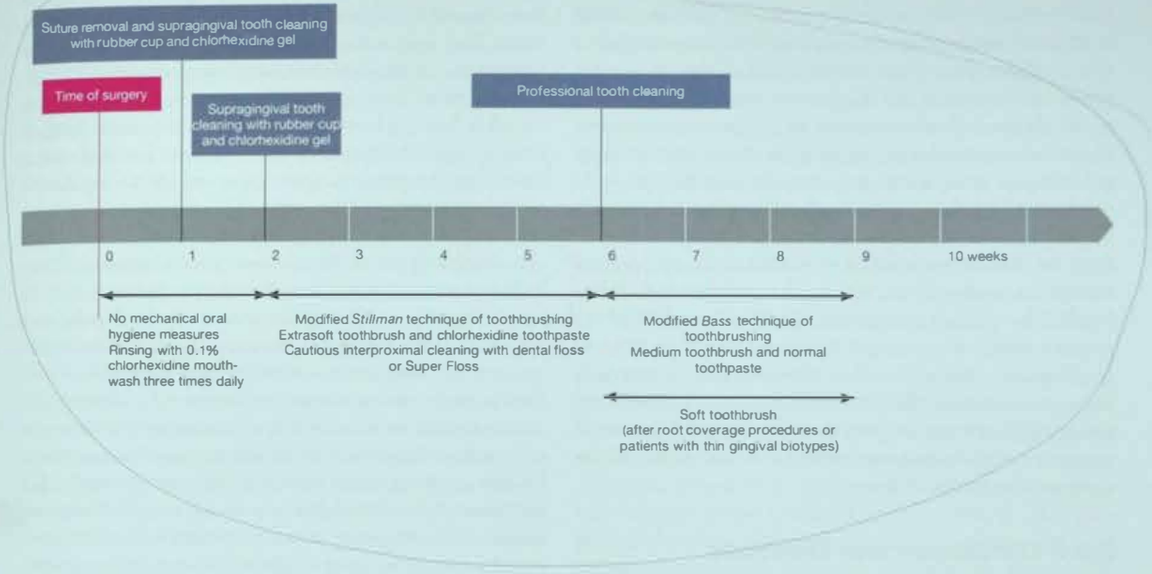


Fig 6-8 The modified Bass method can be used for complete-mouth tooth cleaning starting from the seventh postoperative week. (a and b) The bristle ends of the toothbrush are inserted into the sulci with the brush held at a 45-degree angle to the long axis of the tooth until the bristles bend under slight pressure to ensure cleaning of interproximal embrasures. (c and d) By turning the toothbrush along its long axis, the patient performs short circular vibratory movements of the brush in a coronal direction. Most patients are allowed to use a medium toothbrush and normal toothpaste at this time. However, patients who have undergone root coverage procedures or who have thin gingival biotypes should permanently switch to a soft toothbrush.

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Table 6-2

Oral hygiene regimen following reconstructive plastic-esthetic periodontal and implant surgery



Six weeks after surgery, the surgical site is reinspected and professional supragingival tooth cleaning of all teeth is performed. Most patients are allowed to resume normal oral hygiene procedures in the entire mouth using a medium toothbrush and normal toothpaste at this time. However, patients who have undergone root coverage procedures or who have thin gingival biotypes should permanently switch to a soft toothbrush. At this appointment, these patients are instructed to switch from the modified *Stillman* technique to the modified *Bass* technique[22] (Fig 6-8).

The most important points of the oral hygiene regimen following reconstructive plastic-esthetic periodontal and implant surgery are outlined in Table 6-2.

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6.3 Risk Factors

6.3.1 Principles

In modern dental practice, clinicians more frequently treat patients with medical conditions that put them at risk of surgical complications. Plastic periodontal and implant surgery are elective procedures. When patients with surgical risk factors are treated, it is crucial to weigh the expected benefits of an elective procedure against any potential injury it might cause. All necessary precautions must be taken to ensure that the patient is not harmed by the surgery itself or complications resulting from the intervention.

Surgical risk factors must be identified during the patient history or, at the latest, during the preoperative evaluation. The patient should be specifically asked about current medical treatment, previous surgeries, current medications, and all medical diseases and disorders. If there is any doubt, the dentist should consult with the patient's physician or specialist. Forensically, failure to recognize or give due consideration to risk factors can be construed as malpractice.[2]

6.3.2 Cardiovascular Diseases

In patients with cardiovascular diseases, complications following plastic periodontal and implant surgery could be related to the disease itself or, more frequently, to the anticoagulants the patients are taking.

Arterial hypertension

It is generally safe to treat patients with well-managed blood pressure. However, if a patient has severe untreated arterial hypertension (blood pressure of 180/115 mm Hg), no surgical treatments should be performed before the patient has consulted an internal medicine specialist and received appropriate treatment.[23]

Even if the patient has well-managed blood pressure, it is frequently recommended that a local anesthetic with a low vasoconstrictor concentration or no vasoconstrictor be used. However, this may trigger the release of endogenous surges of adrenaline, resulting in inadequate pain suppression. The impact of this stress-related effect should not be underestimated. Likewise, epinephrine-impregnated retraction cords and epinephrine-based hemostatic solutions should not be used in hypertensive patients.[24,25]

Coronary artery disease and angina pectoris

Coronary artery disease is a chronic form of heart disease characterized by relative or absolute blockage of the coronary arteries. In most cases, the problem is caused by the buildup of atherosclerotic plaques in the walls of the affected blood vessels. Eventually, the diminished blood flow may cause chest pain (angina pectoris), the hallmark symptom of coronary artery disease. The attacks of chest pain occur when not enough oxygen-rich blood is flowing to an area of the heart muscle. Angina attacks can be triggered by physical or emotional stress, including the stress or pain experienced during dental treatment.

It is important to distinguish between the two pathophysiologic types of the disease: stable angina and unstable angina. In stable angina, the attacks occur only in stress situations, exhibit the same pattern of pain, and respond well to treatment measures, such as calming exercises and medication. Cardiovascular complications rarely occur during dental treatment of patients with stable angina, especially if the patient has no history of myocardial infarction. However, all unnecessary stress on the cardiovascular system should be avoided. This includes treatment-related adrenaline surges. Therefore, local anesthetics with a low epinephrine concentration should always be used in these patients. Intraoperative measures such as general medical and/or anesthesiologic monitoring and concomitant administration of drugs to reduce endogenous epinephrine production should be carried out as needed. The same recommendations apply to patients who had a myocardial infarction in the distant past but are stable at the time of surgery.

Unstable angina is characterized by sudden change in pain symptoms due to a sudden interruption of blood flow to the heart muscle. The attacks are characterized by an increased duration and intensity of pain, and they also occur when the person is resting or asleep. Unstable angina is associated with a very high risk of myocardial infarction. These patients require immediate medical attention. Patients with unstable angina should not receive dental treatment unless absolutely necessary.[24,26]

Cardiac arrhythmias

Cardiac arrhythmia is a heart condition characterized by a change in the normal heart beat pattern due to abnormal generation and propagation of electrical impulses in the myocardium. Cardiac arrhythmias are classified and named according to their anatomical site of origin in the electrical conduction system. The different types defined according to heart rate are bradycardia (low heart rate), tachycardia (high heart rate), and dysrhythmia (irregular heartbeat). In patients with a known history of cardiac arrhythmia, precautions should be taken before surgery, and the patient's primary care specialist, internal medicine specialist, or cardiologist should be consulted before any surgical procedure is performed. Intraoperative monitoring with concomitant medication as needed is often helpful and necessary.

Most problems that arise are related to the use of local anesthesia. Relative contraindications include severe cardiac conduction defects such as atrioventricular block and severe bradycardia. In these cases, local anesthetics must be used cautiously and in low doses. Because epinephrine prolongs and intensifies the effects of local anesthetics, it may be helpful to use an anesthetic with a higher vasoconstrictor concentration.

Conversely, endogenous surges of adrenaline or exogenous administration of epinephrine can dangerously intensify tachycardia. Therefore, only anesthetics with low doses of epinephrine should be used in these patients. Epinephrine-impregnated retraction cords should not be used at all. These patients should be treated in a calm and relaxed environment to prevent anxiety and to reduce endogenous epinephrine production. A sedative premedication can be administered if needed.

The dentist should also be aware that many patients with cardiac arrhythmias are taking anticoagulants.[24,26] For this and other reasons, the dentist should consult with the patient's cardiologist before starting any treatment procedures.

Heart failure

Heart failure, or cardiac insufficiency, is defined as the inability of the heart to supply sufficient blood flow to the body due to an acquired cardiac dysfunction. This may be due to pathologic impairment of myocardial pump function (systolic dysfunction) or impaired filling of the heart in the presence of normal pump function (diastolic dysfunction). Three types of heart failure are distinguished according to location: left-sided heart failure (shortness of breath and angina), right-sided heart failure (cyanosis, peripheral edema, and jugular venous distention), and global heart failure (symptoms of left- and right-sided heart failure combined). If a patient with compensated heart failure has few or no clinical symptoms and if the disease is well controlled, periodontal surgery can generally be performed after prior consultation with the patient's doctor. Untreated heart failure, decompensated heart failure, and all types of acute heart failure are absolute contraindications to plastic periodontal and implant surgery.[24]

Endocarditis

Infective endocarditis is a life-threatening condition caused by inflammation of the endocardium, the innermost layer of tissue lining the chambers of the heart. It is usually caused by bacterial biofilms and, infrequently, by fungal pathogens. Endocarditis can occur as a complication of bacteremia associated with certain dental procedures. The recommendations of the German Society of Dental, Oral & Craniomandibular Science for endocarditis prophylaxis in dental practice are based on the interdisciplinary recommendations of the American Heart Association (AHA) published in 1997.[27,28] The latest guidelines regarding the use of antibiotics to prevent infective endocarditis are based on a revised version of the 2007 AHA guidelines established according to evidence-based criteria. They focus on the definition of high-risk patients, high-risk interventional procedures, and suitable antibiotic prophylaxis regimens for infective endocarditis.[29] The new guidelines state that endocarditis prophylaxis is not necessary except in high-risk patients, ie, those with artificial heart valves, a history of bacterial endocarditis, certain congenital heart conditions, or a heart transplant that develops a problem in a heart valve.

Patients with any of the aforementioned diseases must receive antibiotic prophylaxis prior to any periodontal or implant surgical procedure. Because peak bacteremia rates generally occur within 30 minutes of a surgical procedure, the administration of a single high dose of antibiotics 1 hour prior to the procedure should provide sufficient prophylaxis.[29] The generally recommended regimen is 2 g amoxicillin for patients not allergic to penicillin or 600 mg clindamycin for patients allergic to penicillin.

In addition to carefully evaluating the patient's history, the clinician should consult with the patient's cardiologist, particularly if the patient has a congenital heart defect.

Anticoagulant therapy

Anticoagulants are often indicated for thrombosis prophylaxis in patients with a number of cardiovascular conditions, including arterial disorders (eg, peripheral artery occlusive disease), venous disorders (eg, throm-

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bophlebitis, phlebothrombosis), and heart disease (eg, cardiac valve disease, history of myocardial infarction, history of cardiac surgery). Anticoagulant therapy is also indicated in patients undergoing hemodialysis.

Aspirin, warfarin and other coumarin derivatives, heparin, and modern platelet aggregation inhibitors such as clopidogrel are most commonly used. Anticoagulants may be administered alone or in combination with other drugs. Laboratory parameters for monitoring of anticoagulant therapy include platelet count, platelet aggregation, partial thromboplastin time, and prothrombin time. The prothrombin ratio (PR) is calculated as the patient's prothrombin time relative to a control prothrombin time. The International Normalized Ratio (INR) is used for international normalization and standardization of the results. The INR is inversely proportional to the PR. Thus, the INR, coagulation time, and bleeding tendency increase as the PR decreases. An INR of 1.0 and a PR of 100% (normal plasma) are considered normal.

The optimal therapeutic range for the PR (15% to 25%) ensures adequate anticoagulation without the risk of bleeding complications.[30,31] The corresponding therapeutic range for INR is 2.0 to 3.5. Minor surgical procedures such as simple tooth extraction can be performed in patients with a PR of roughly 25% or an INR of less than 3.5. Periodontal and implant surgical interventions should not be performed unless the laboratory parameters have been regulated to a PR of approximately 40% or an INR of 1.5 to 2.0.

Adjustment of PR and INR levels must always be performed in collaboration with the patient's physician and should never be carried out by the dentist alone. Particularly when considering elective procedures, the dentist must be aware that even a short discontinuation of the anticoagulant medication can lead to serious consequences for these high-risk patients. Heparin replacement is indicated in some cases, and concomitant antibiotic prophylaxis may also be necessary.[31,32]

6.3.3 Organ Transplants

The number of kidney, heart, liver, lung, bone marrow, stem cell, and combined organ transplantations performed around the world is steadily increasing. Transplant recipients require lifelong immunosuppressive therapy to prevent transplant rejection and to preserve transplant function. Consequently, dentists are seeing more and more pharmacologically immunocompromised patients.

Periodontal and implant surgery generally should not be performed within the first 3 months of organ transplantation. Subsequently, all dental procedures may be performed under antibiotic coverage once transplant function has been established and stabilized. When immunosuppressed patients are treated, the risk of streptococcal and anaerobic bacteremia must be excluded. If an increased anaerobic bacterial burden is suspected, antibiotic prophylaxis should be administered as follows:

- Amoxicillin (2 g) and metronidazole (400 mg) 1 hour prior to the procedure in patients not allergic to penicillin.[33]
- Clindamycin (600 mg) 1 hour prior to the procedure in patients allergic to penicillin.

6.3.4 Pulmonary Disease

Chronic bronchitis, pulmonary emphysema, and bronchial asthma are the most important types of pulmonary disease to be aware of in dental practice. All treatment measures with respiratory-depressant effects (sedation, rubber dam, and supine patient position) should be avoided in patients with pulmonary diseases. If major dental surgery must be performed, external low-dose oxygen administration is often helpful. Bilateral nerve block (inferior alveolar nerve and greater palatine foramen) should not be performed because this could cause gagging and choking in the patient. Asthma patients should not receive prophylactic doses of nonsteroidal anti-inflammatory drugs (NSAIDS) such as aspirin, diclofenac, ibuprofen, and naproxen because they may induce asthma attacks. Acetaminophen (paracetamol) is the analgesic of choice for these patients.[34,35]

6.3.5 Impaired Liver Function

As the central metabolic organ of the body, the liver has a number of important functions such as the uptake, storage, and distribution of nutrients; the production of bile; the excretion of metabolites, drugs, and toxics substances; and the synthesis of essential proteins, including coagulation factors. The ability to perform dental surgery for patients with acute or chronic liver disorders is therefore limited.

All types of dental procedures are contraindicated in patients with acute hepatitis. Chronic liver diseases may be associated with coagulation disorders and impaired drug elimination. Therefore, tests for coagulation factors produced in the liver or in the coagulation cascade itself should be performed before surgical interventions in patients with a known history of chronic liver disease. In addition, drugs metabolized in the liver should not be used; these include acetaminophen (paracetamol), codeine, and diazepam.

The local anesthetic articaine is almost completely hydrolyzed into nontoxic metabolites in the tissue, so it does not accumulate, even in patients with severe liver failure. Consequently, articaine does not induce toxic side effects and is thus the local anesthetic of choice in patients with liver disease. No dose adjustment is required. Conversely, lidocaine and all other local anesthetics of the amide class are eliminated in the liver in the first step of metabolism, and repeated injections of these are associated with a risk of accumulation and intoxication. Therefore, they should not be used in patients with a known history of liver disease unless absolutely necessary and, if so, only in significantly reduced doses.

When patients with any form of viral hepatitis are treated, strict compliance with all infection-control requirements is mandatory because such patients are potentially infectious.[36]

6.3.6 Impaired Renal Function

Electrolytes, metabolites, and toxic substances are filtered from the blood into the kidneys and eliminated in the urine. The kidneys regulate the water, salt, and acid-base balance via a complex hormonal feedback control system and are involved in long-term regulation of blood pressure. In addition, hormones needed for short-term regulation of blood pressure are produced by the kidneys. These include renin and erythropoietin, which initiates red blood cell production in hematopoietic tissues of the bone marrow.

Hemodialysis and kidney transplantation are the sequelae of chronic renal failure with the greatest impact on dental treatment. Periodontal or implant surgery must not be performed in these patients before the doctor treating the condition is consulted. Antibiotic prophylaxis is always required for patients with kidney transplants (immunosuppression) and renal dialysis (arteriovenous shunt). Dialysis patients are treated with anticoagulants and therefore have an increased bleeding tendency. Because heparin is administered during hemodialysis, dental treatment should not be performed on the day of hemodialysis; the best time for treatment is the day after dialysis.[37] As the progressive loss of renal function may result in the development of renal hypertension, these patients are at an increased risk of cardiovascular complications.

In addition, there is an increased risk that metabolites of local anesthetics and other drugs may accumulate in the blood of patients with renal failure. Articaine is the local anesthetic of choice because of its nearly complete hydrolysis into nontoxic metabolites in the tissue and high plasma protein- binding capacity. No dose adjustment is required.

6.3.7 Endocrine Disorders

Diabetes mellitus

Diabetes mellitus is a metabolic disorder caused by an absolute or relative deficiency of insulin, the hormone that regulates blood glucose levels and the glucose balance. Two basic types of diabetes are distinguished: juvenile-onset diabetes and adult-onset diabetes. Juvenile-onset diabetes (type 1) is the much less common form. Type 1 diabetic patients develop irreversible damage to the insulin-forming β cells of the pancreas and are unable to produce any endogenous insulin. This is referred to as an *absolute insulin deficiency*. Patients with type 1 diabetes require lifelong insulin therapy for replacement of the missing endogenous hormone. Curative treatment is still not available.

Patients with adult-onset diabetes (type 2) have become insulin resistant; that is, endogenous insulin is produced but no longer has a sufficient effect on its targets (various effector cells). This is referred to as a *relative insulin deficiency*. In addition to genetic predisposition, obesity has been identified as a main cause of type 2 diabetes.[34]

Some typical diabetic complications can result in problems during surgical interventions. Microangiopathies and macroangiopathies result in decreased blood flow to the tissues, thereby impairing local immunocompetence. Consequently, the risk of impaired wound healing and necrosis is high in diabetics, particularly when the disease is poorly managed.[38,39] Preoperative antibiotic prophylaxis may be advisable, even in patients with well-managed diabetes.

Diabetic patients also have an increased risk of medical emergencies. Hypoglycemia is one of the most common intraoperative complications in patients with diabetes. It is most commonly caused by overdose with insulin

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or other glucose-lowering medications but may also result from the long period of fasting before a surgical procedure. Symptoms range from increased endogenous epinephrine secretion with extreme cravings for food to severe neuronal deficits and unconsciousness. The former is an adrenergic counterregulatory mechanism characterized by increased tremor, heart rate, blood pressure, and nervous tension. A sugary beverage should be kept on hand for this type of emergency.

Hyperglycemia may develop if a diabetic receives too little or no insulin and endogenous or exogenous epinephrine levels are increased by surgical stress or local anesthetics. The condition can progress into a life-threatening diabetic coma. Therefore, local anesthetics with a low concentration of epinephrine should always be used in patients with a known history of diabetes. Acetone breath, fatigue, lack of appetite, nausea, vomiting, excessive thirst, and frequent urination may be early warning signs of diabetic coma. Emergency medical services should be called immediately at the first signs of diabetic coma.[40,41]

Diabetes is frequently associated with arterial hypertension and an increased risk of cardiovascular complications. Therefore, precautions should be taken to keep endogenous and exogenous epinephrine levels as low as possible.

Hyperthyroidism

Hyperthyroidism is characterized by increased sensitivity of adrenergic receptors to endogenous and exogenous epinephrine and excessive functional activity of the thyroid gland. The affected individuals exhibit adrenergic symptoms such as restlessness, nervousness, tremor. tachycardia, increased blood pressure amplitude, and hypertension.

During periodontal or implant surgery, it is crucial to keep endogenous and exogenous epinephrine levels—which are affected by surgical stress and local anesthetics, respectively—as low as possible to avoid aggravating the existing symptoms or inducing severe cardiovascular complications. Only anesthetics with low doses of epinephrine should be used in these patients. It may be advisable to consult with the patient's physician before any major surgical intervention.

6.3.8 Infectious Diseases

Infectious hepatitis

Viral pathogens are by far the most common causes of infectious hepatitis. The classic forms of viral hepatitis are caused by hepatitis A, B, C, D, E, F, and G viruses. After recovering from the acute stage of hepatitis, patients may develop chronic forms of the disease. Elective dental surgical procedures should not be performed in patients with acute hepatitis. Progression to chronic forms of the disease most commonly occurs in hepatitis B, C, and D. As chronic hepatitis can result in cirrhosis of the liver, these patients are at an increased risk of liver impairment, which can complicate any planned surgical procedure. The complications with the most relevant impact on dental surgery are impaired or delayed coagulation and impaired elimination of certain drugs and toxic substances. Therefore, the dentist should always consult with the patient's physician before performing any major surgical intervention.

Because hepatitis B, C, and D can be transmitted by parenteral routes, dental personnel have an increased risk of infection during surgery. Infection may occur if staff members are exposed to the blood and saliva of a patient with infectious hepatitis or if they injure themselves during surgery. The use of personal protective equipment (eg, goggles, face shield, gloves) and strict compliance with all applicable infection-control requirements are therefore mandatory. Hepatitis B immunization is mandatory for dental personnel; it also protects against hepatitis D.

HIV and AIDS

Human immunodeficiency virus (HIV) is shed in the bodily fluids of individuals infected with the disease and is transmitted by mucous membrane contact and by parenteral routes. There are four main stages of HIV infection. The incubation period is followed by an acute stage, which can last for several weeks and produces flulike symptoms. The acute stage is followed by a symptom-free latency phase, which can last for several months to several years. Its duration is also determined by whether the patient receives treatment. Full-blown acquired immune deficiency syndrome (AIDS) occurs when the number of $CD4^+$ T cells in the blood decreases to fewer than 200/μL. Typical AIDS-related diseases such as opportunistic infections and neoplasms then occur.

Periodontal surgical and implant procedures are contraindicated after the outbreak of AIDS. The same rule applies during the acute phases of HIV infection but is hardly feasible in practice because patients with acute HIV infection do not exhibit any characteristic symptoms and they may not have undergone a positive HIV test documenting that they have the disease. Periodontal and implant surgery may be performed during the latency phase of HIV infection. However, the physician managing the patient with HIV should always be consulted to determine the optimal timing of surgery. These patients require antibiotic prophylaxis due to their impaired immunocompetence. Strict compliance with all relevant infection-control requirements is mandatory to ensure the protection of these patients and the dental personnel treating them.[42]

6.3.9 Pregnancy and Lactation

As a rule, elective procedures such as plastic periodontal and implant surgery should not be performed when the patient is pregnant.

If a patient is breastfeeding, the dentist should be aware that some medications (such as macrolides and codeine) pass into the breast milk and should not be prescribed to nursing women. Nursing mothers should receive local anesthetics with the lowest possible toxicity, that is, those with active substances characterized by rapid metabolism, high plasma protein-binding capacity, and low lipid solubility. Articaine is the local anesthetic of choice.[24]

Risk factors for dental surgery and the most important measures and precautions to be considered are summarized in Table 6-3.

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Table 6-3

Risk factors for dental surgery and the most important measures and precautions to be considered

Hypertension	• The patient's physician should be consulted. • Untreated hypertension must be brought under control before surgery. • Surgery is possible in patients with well-managed hypertension. • Surgery should be performed in a stress-free manner using an anesthetic with the lowest possible concentration of vasoconstrictor additive.
Coronary artery disease and angina pectoris	• The patient's physician should be consulted. • Unstable angina is an absolute contraindication to elective surgery. • In patients with stable angina, surgery is possible but should be performed in a stress-free manner, using an anesthetic with the lowest possible concentration of vasoconstrictor additive and with a physician on call as needed.
Cardiac arrhythmias	• The patient's physician should be consulted. • Cardiac conduction defects/bradycardia: The local anesthetic is administered in a low dose or an anesthetic with a higher epinephrine concentration is used, as needed. • Tachycardia: Surgery should be performed in a stress-free manner using an anesthetic with the lowest possible concentration of vasoconstrictor additive; a sedative premedication can be helpful. • History: The patient must be asked specifically about anticoagulant use.
Heart failure	• The patient's physician should be consulted. • Surgery is possible in patients with no clinical symptoms and well-managed heart disease. • Untreated or acute heart failure is an absolute contraindication to elective surgery.

Endocarditis	• The patient's physician should be consulted.
	• Endocarditis prophylaxis is indicated only for high-risk patients.
	• High-risk patients are those with:
	  • Artificial heart valves.
	  • History of bactenal endocarditis.
	  • Certain congenital heart conditions.
	  • Heart transplant that develops a problem in a heart valve.
	• Regimen:
	  • 2 g amoxicillin 1 hour before surgery.
	  • 600 mg clindamycin 1 hour before surgery (for patients with penicillin allergy).

Anticoagulant therapy	• The patient's physician should be consulted. • Periodontal surgery can be performed after the patient's PR (Quick-test) is boosted to approximately 40%, equivalent to an INR of 1.5 to 2.0.

Organ transplants	• The patient's physician should be consulted.
	• Periodontal and implant surgery generally should not be performed within the first 3 months of organ transplantation.
	• Periodontal and implant surgery should always be performed under prophylactic antibiotic coverage using either:
	  • 2 g amoxicillin and 400 mg metronidazole 1 hour before surgery.
	  • 600 mg clindamycin 1 hour before surgery (for patients with penicillin allergy).

Pulmonary disease	• The patient's physician should be consulted. • Treatment measures with respiratory-depressant effects should be avoided. • Low-dose oxygen should be administered during the procedure. • Bilateral nerve block should not be performed. • NSAIDS should not be administered to asthmatics.

Impaired liver function	• The patient's physician should be consulted.
	• Acute hepatitis is an absolute contraindication to elective surgery.
	• Surgery is possible in patients with chronic hepatitis under the following conditions:
	  • Preoperative control of coagulation factors is achieved.
	  • Drugs metabolized in the liver (acetaminophen, codeine, diazepam) should not be used.
	  • Articaine is the local anesthetic of choice.
	  • Compliance with infection-control requirements and the use of personal protective equipment are mandatory.

Impaired renal function	• The patient's physician should be consulted. • There is an increased risk of cardiovascular complications. • Dialysis patients are on anticoagulant therapy. • Kidney transplant and dialysis patients always require antibiotic prophylaxis for prevention of infection. • Articaine is the local anesthetic of choice in patients with chronic renal failure.
Diabetes mellitus	• The patient's physician should be consulted. • Surgery can be performed in patients with well-managed diabetes. • Preoperative antibiotic prophylaxis is advisable. • There is an increased risk of medical emergencies (hypoglycemia or hyperglycemia). • There is an increased risk of cardiovascular complications: Surgery should be performed in a stress-free manner using an anesthetic with the lowest possible concentration of vasoconstrictor additive.
Hyperthyroidism	• The patient's physician should be consulted. • There is an increased risk of cardiovascular complications: Surgery should be performed in a stress-free manner using an anesthetic with the lowest possible concentration of vasoconstrictor additive.

Infectious hepatitis	• The patient's physician should be consulted.
	• Acute hepatitis is an absolute contraindication to elective surgery.
	• Surgery is possible in patients with chronic hepatitis under the following conditions:
	  • Preoperative control of coagulation factors is achieved.
	  • Drugs metabolized in the liver (acetaminophen, codeine, diazepam) should not be used.
	  • Articaine is the local anesthetic of choice.
	  • Compliance with infection-control requirements and the use of personal protective equipment are mandatory.

HIV and AIDS	• The patient's physician should be consulted. • Acute HIV disease and outbreak of AIDS are absolute contraindications to periodontal and implant surgery. • During the latency period, surgery can be performed under antibiotic prophylaxis. • Compliance with infection-control requirements and the use of personal protective equipment are mandatory.
Pregnancy and lactation	• Pregnancy is an absolute contraindication to elective surgery. • Nursing mothers should not be given drugs that can pass into breast milk. Articaine is the local anesthetic of choice in these patients.

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6.4 Preoperative and Postoperative Medications

For patients undergoing plastic-esthetic periodontal and implant surgery, preoperative and postoperative medications may be required in addition to local anesthesia in order to facilitate a procedure or to limit its local or systemic effects. Pharmacologic principles and clinical recommendations for the administration of preoperative and postoperative medications are described in the following sections.

6.4.1 Sedation

Principles

Local anesthesia is sufficient for most periodontal and implant surgical procedures. However, if the patient is very anxious or nervous, a preoperative medication can be administered orally or intravenously to relax and calm the patient before and during the procedure. In these cases, premedication can make the procedure much easier for the patient and the dentist.

Sedation is a pharmacologically controlled state of reduced and subdued yet maintained consciousness. Sedated patients are responsive and cooperative, and their circulatory functions and protective reflexes are not impaired. The transition from superficial sedation to general anesthesia is fluid and defined only by the respective state of consciousness of the patient. The dentist must be fully aware of the effects and side effects of the administered medications and know exactly which measures to take in case of complications. A careful and complete history and informed consent process are prerequisites for all treatments requiring sedation.

If anesthesiologic assistance is not available, superficial sedation using oral sedatives is the only viable option. However, these drugs can induce dose- and patient-dependent respiratory-depressant effects, so it is advisable to have a standby anesthesiologist in the background. The use of intraoperative patient monitoring equipment is also advisable. Pulse oximetry is an established method that provides an adequate standard of care.

The presence of appropriate monitoring equipment and personnel during surgery is mandatory for moderate or deep sedation, which is generally achieved by intravenous administration of anesthesia.[43]

Drugs used

Benzodiazepines are the drugs most commonly used for oral premedication in dental surgery today. Barbiturates were popular in the past but are now obsolete because they have a narrow therapeutic range and induce severe respiratory depression rather frequently. Benzodiazepines, on the other hand, do not have any negative effects on the respiratory and blood pressure regulatory centers of the autonomic nervous system when administered at therapeutic doses.

As they belong to the group of tranquilizers, benzodiazepines have anti-anxiety, sedative, and hypnotic effects and, at high doses, central muscle relaxing effects. The effects of benzodiazepines are mediated in the central nervous system by binding to γ-aminobutyric acid (GABA) receptors. GABA, the most important inhibitory neurotransmitter in the central nervous system, decreases the excitability of the target cells via GABA receptors. Benzodiazepines can bind to GABA receptors at other sites and increase the sensitivity of the receptors for GABA via protein structure changes. This leads to a preponderance of inhibitory mechanisms in the central nervous system, resulting in the desired sedative effects. There are now a number of other members of the group of benzodiazepines to choose from. They differ in terms of pharmacologic variables including, in particular, their profile and duration of action. An appropriate benzodiazepine is selected based on the indication-specific (duration and extent of surgery) and patient-specific conditions (age, weight, history of prior diseases, incompatibilities, and current medications). Because all benzodiazepines induce respiratory depression, they should not be used in individuals with obstructive pulmonary diseases such as asthma unless strictly indicated. The same applies to patients with severe liver disease because the enzyme-mediated conversion of these drugs into active metabolites is initiated in the liver. Absolute contraindications include known hypersensitivity to benzodiazepines; alcohol, drug, or medication abuse; myasthenia gravis; pregnancy; and lactation. The most important preoperative and postoperative medications used in dental surgery are described in the following sections.[44]

Diazepam

Diazepam, one of the oldest benzodiazepine derivatives, has a wide therapeutic range. Because of its very long half-life, diazepam can still be detected in plasma up to 48 hours after administration, resulting in a strong "hangover effect" that lasts for several hours after surgery. Nevertheless, in view of the long history of diazepam use with few reported side effects, the drug can be recommended for clinical practice. The usual dose for preoperative medication is 0.15 mg/kg.[45]

Midazolam

Midazolam is a benzodiazepine derivative with a short half-life, making it well suited for use in dental practice. The drug has a relatively rapid onset of action (10 minutes), with its peak effect occurring within approximately 30 to 60 minutes. Midazolam is two to three times more potent than diazepam. When administered as a preoperative medication, midazolam often produces anterograde amnesia. This dose-dependent effect is beneficial in terms of patient comfort and almost always occurs when the drug is administered intravenously. The usual dose for preoperative medication is 0.10 mg/kg.[45]

Clinical recommendations

When used as oral premedication, diazepam and midazolam should preferably be administered to patients with an empty stomach, 30 minutes to 1 hour prior to the procedure (Fig 6-9).

Patients must be monitored for least 2 hours after completion of outpatient procedures. In addition, patients must be informed that benzodiazepines impair their ability to drive. In elderly individuals, these drugs may significantly impair the patient's psychomotor skills, resulting in unsteady gait. Therefore, arrangements should be made for someone to take the patient home after the procedure.

Sedation

- Oral diazepam: 1 tablet (5 mg) 1 hour before surgery.
- Oral midazolam: 1 tablet (5 mg) 30 minutes before surgery.
- A standby anesthesiologist should be available as needed.
- Arrangements should be made for someone to take the patient home after the procedure due to impairment of driving and walking ability.
- Absolute and relative contraindications exist.



Fig 6-9 Diazepam and midazolam are very effective sedative premedications.

6.4.2 Local Anesthesia

Principles

Local anesthesia refers to the reversible and temporary local inhibition of the conduction of impulses along a peripheral nerve. Local anesthetics work by blocking neural sodium channels that mediate the generation and conduction of electrical impulses (action potentials) via the inflow of extracellular sodium ions into the nerve cells. All local anesthetics have basically the same mechanism of action because, when locally injected into tissue, they must penetrate the cell membranes of nerve fibers to reach the binding sites of the sodium channels inside the nerve cells. Therefore, all drugs used as local anesthetics are amphiphilic substances with a common basic chemical structure. An intermediate chain separates a hydrophobic or lipophilic end of the molecule (aromatic ring) from a hydrophilic end (amino group); this determines whether the local anesthetic belongs to the ester or amide class. Chemical modifications in the remaining groups of this basic structure affect the lipid solubility, water solubility, and protein-binding capacity of the respective drug, thus defining its pharmacologic properties such as the local anesthetic efficacy, onset of effect, duration of local anesthetic effect, systemic toxicity, and allergenic potential.

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Because peripheral axons in the autonomic nervous system and sensitive nociceptive nerve fibers are unmyelinated fibers lacking myelin sheaths, they are also blocked by local anesthetics. Blood vessels in the anesthetized region become dilated because of a decrease in vessel tone, which is controlled by the sympathetic nerve. Vasoconstrictor agents are therefore added to local anesthetics to counteract their accelerated absorption and distribution in the vascular system and reduce the risk of the related systemic side effects. The addition of epinephrine at a ratio of 1:200,000 to 1:100,000 is regarded as standard practice in modern dentistry.

Because traditional ester-based local anesthetics of the first generation were found to induce an increased rate of allergic reactions, they are rarely used today (with the exception of tetracaine for topical anesthesia). They have been largely replaced by the amide-based local anesthetics described in the following sections. Amide local anesthetics are generally well tolerated. The only absolute contraindication is a known history of sensitivity to the respective drug. Relative contraindications include severe cardiac conduction defects such as atrioventricular block, severe bradycardia, and acute decompensated heart failure.

In addition to these restrictions on the use of the local anesthetics themselves, absolute and relative contraindications for the vasoconstrictors added to local anesthetics also exist and must be considered. Epinephrine is a commonly used vasoconstrictor additive. Severe tachycardia is an absolute contraindication to epinephrine. Relative contraindications include various cardiovascular diseases (eg, heart failure, coronary artery disease, unstable angina, arterial hypertension, and cor pulmonale secondary to chronic bronchitis), diabetes mellitus, hyperthyroidism, pregnancy, and concomitant medications that interfere with epinephrine. For these patients, the dose of exogenous epinephrine should be kept as low as possible.[44]

Drugs used

Lidocaine and articaine are the most commonly used local anesthetics in modern dentistry. Both belong to the group of amide local anesthetics.

Lidocaine

Lidocaine, the first amide local anesthetic, is widely used, particularly in North America. Compared to the reference substance procaine, it is four times as potent with only twice the systemic toxicity. Because of this favorable risk-benefit ratio, lidocaine has replaced procaine as the standard local anesthetic.

Cartridges of 1% to 3% lidocaine solution are used for dental injections. The maximum recommended dose of lidocaine with vasoconstrictor is 7 mg/kg. For a patient weighing 70 kg, this is equivalent to 15.3 mL or nine 1.7-mL cartridges of 3% lidocaine solution.[46]

Articaine

Articaine is the most modern and second most commonly used local anesthetic after lidocaine. It belongs to the group of amide local anesthetics but has a special position because of its metabolism. Due to an additional ester bond, articaine is quickly inactivated by nonspecific esterases in tissue. Therefore, only a small portion of the administered dose is eliminated by the liver, the usual route of elimination of amide local anesthetics. Articaine is characterized by low lipid solubility, a high protein-binding capacity, and excellent efficacy (good bone diffusion). It has the best efficacy-to-systemic toxicity ratio of all currently available local anesthetics. Compared to the reference substance procaine, it is 5x more potent with only 1.5x the toxicity.

Articaine is supplied as a 1%, 2%, or 4% local anesthetic solution. The maximum recommended dose of articaine with vasoconstrictor is 7 mg/kg. For a patient weighing 70 kg, this is equivalent to 12.5 mL or seven 1.7-mL cartridges of 4% articaine solution.[46]

Clinical recommendations

A topical anesthetic is often used to numb the injection site. Local anesthetics that diffuse through the intact mucosa to the terminal nerve fibers are used for this purpose. Lidocaine and tetracaine are two such agents with excellent tissue penetration properties. Because of the high toxicity and allergenic effect of tetracaine preparations, only lidocaine-based topical anesthetics should be used, if any at all. It is important to note that the administered dose of topical anesthetic must be added to the total maximum dose. Therefore, generous spraying of topical anesthetic on large areas of the oral mucosa is not recommended. It is better to spot apply small quantities of topical anesthetic gel preparations to the mucosa. The disadvantages of topical anesthetics outweigh nearly all of the benefits. This additional stress can be avoided by using a thin injection needle, a slow injection rate, and a careful injection technique.

A dental cartridge system should be used for better dose control of local anesthesia. Used cartridges should be collected by an assistant to optimally monitor the administered dose. Preparations containing 4% articaine with 1:100,000 vasoconstrictor have proved effective in periodontal surgery (Fig 6-10). All of the procedures presented in this book can be performed using conventional techniques of infiltration and conduction anesthesia.[46]

Local anesthesia

- Amide local anesthetics should be used (eg, lidocaine, articaine).
- Topical anesthetics are not recommended due to their high toxicity.
- Dental cartridge systems should be used for better dose control.
- The maximum recommended dose of 4% articaine with 1:100,000 vasoconstrictor is 7 cartridges.
- Absolute and relative contraindications exist.



Fig 6-10 Preparations containing 4% articaine with 1:100,000 vasoconstrictor have proved effective for local anesthesia in plastic-esthetic periodontal and implant surgery.

6.4.3 Analgesics and Anti-inflammatories

Principles

When the integrity of the tissue has been compromised, the body launches an inflammatory response—the necessary prerequisite to and first step of all subsequent healing processes. Periodontal and implant surgery challenges the body's healing capacity, and extensive postoperative swelling can occur in the region of the manipulated tissues. The feeling of tension associated with edema and the local release of inflammatory mediators in the scope of an inflammatory response can leave the patient in a great deal of pain and discomfort. Because the oral cavity is an environment characterized by microbial contamination and relatively low oxygen tension, bacterial pathogens can proliferate largely unimpaired if extensive edema occurs, resulting in an increased risk of superinfection. Adequate reduction of inflammatory symptoms for prevention of pain and swelling is therefore an important part of a standard postoperative medication after plastic periodontal or implant surgery.

Analgesics are distinguished from other pain medications such as narcotics and local anesthetics according to their biochemical mechanism of action. The two primary types of analgesics are opioid and nonopioid analgesics. Opioid analgesics (central analgesics) are highly potent agents that inhibit the conduction and central perception of pain stimuli. They are primarily used to treat severe acute pain (trauma) or chronic conditions (cancer) and thus play a minor role in dentistry. Nonopioid analgesics are the most important analgesic and anti-inflammatory drugs in dental practice. Because they are chemically heterogenous, the effects and side effects of these drugs vary widely. There are two different classes of nonopioid analgesics: acidic analgesics (eg, aspirin, ibuprofen, and diclofenac) and nonacidic analgesics (eg, acetaminophen). Both classes generally have analgesic and antipyretic properties. Acidic analgesics are particularly potent anti-inflammatory drugs that effectively reduce pain and swelling. NSAIDs such as aspirin, ibuprofen, and diclofenac also belong to this class of drugs while steroidal anti-inflammatory drugs of the glucocorticoid class do not.

The primary mechanism of action of acidic analgesics or NSAIDS is based on inhibition of cyclooxygenase, the key enzyme involved in eicosanoid metabolism in humans. Cyclooxygenase catalyzes the synthesis of eicosanoids from arachidonic acid. The group of eicosanoids includes prostaglandins, the messengers of inflammation, as well as other substances that perform different tasks in the body. Therefore, inhibition of cyclooxygenase can lead to a variety of different drug side effects.

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The exact mechanism of action of nonacidic analgesics is still unknown today. Unlike acidic analgesics (the classic cyclooxygenase inhibitors), central effects seem to play an important role in nonacidic analgesic action. The potent antipyretic effect of acetaminophen was shown to be due to inhibition of prostaglandin synthesis in the temperature-regulating center in the hypothalamus.
Nonopioid analgesics do not induce physical or mental dependency.[44]

Drugs used

Acidic analgesics/Nonsteroidal anti-inflammatory drugs

Aspirin (acetylsalicylic acid)
Aspirin (acetylsalicylic acid), the prototype cyclooxygenase inhibitor, has been used for more than 100 years. It has analgesic and antipyretic effects and, at high doses, anti-inflammatory effects. At low doses, irreversible inhibition of platelet aggregation can also be observed. Side effects of aspirin most commonly occur in the gastrointestinal tract because intake of aspirin results in a loss of the protective effect of prostaglandins on the stomach lining. The effective single dose of aspirin for analgesic effect in a healthy 70-kg adult is 500 to 1,000 mg. Because aspirin inhibits platelet aggregation, it is not suitable for postoperative pain management.[44,46]

Aspirin (acetylsalicylic acid)

- Its effects are very well studied.
- The effective single dose for analgesic effect in a healthy 70-kg adult is 500 to 1,000 mg.
- The anti-inflammatory effect occurs only at higher doses.
- Aspirin inhibits platelet aggregation and therefore is not suitable for postoperative pain management.
- Absolute and relative contraindications exist.

Ibuprofen
Ibuprofen is a phenyl propionic acid derivative with a marked anti-inflammatory effect in addition to antipyretic and analgesic effects. Short-term administration of the drug is very well tolerated. In contrast to aspirin, ibuprofen (like diclofenac) produces reversible inhibition of cyclooxygenase. The usual single dose for a healthy 70-kg adult is 600 mg. Because of its excellent spectrum of action and side-effect profile, ibuprofen is the standard drug for postoperative management of pain and inflammation.[44,46]

Ibuprofen

- It has a very good anti-inflammatory effect and good analgesic effect.
- The incidence of side effects is low and there is no anticoagulant effect.
- The effective single dose for analgesic effect in a healthy 70-kg adult is 600 mg.
- The standard regimen after periodontal surgery for a healthy 70-kg adult is ibuprofen, 600 mg three times daily for 4 days.
- Absolute and relative contraindications exist.

Diclofenac
Diclofenac is an acetic acid derivative with a marked anti-inflammatory effect. It is therefore a standard drug for treatment of rheumatic diseases. The usual single dose is 75 mg of diclofenac sodium. Gastrointestinal side effects are not uncommon. Therefore, diclofenac should not be used by patients with ulcers. Diclofenac can be prescribed after extensive surgery to prevent postoperative swelling but should not be used on a routine basis.[44,46]

Diclofenac

- It has a very good anti-inflammatory effect.
- Gastrointestinal side effects may occur.
- Diclofenac can be used instead of ibuprofen after extensive or lengthy surgery.
- The effective single dose for analgesic effect in a healthy 70-kg adult is 75 mg of diclofenac sodium.
- Absolute and relative contraindications exist.

Nonacidic analgesics

Acetaminophen (paracetamol)
Acetaminophen is an aniline derivative with good analgesic and antipyretic effect but a weak anti-inflammatory effect. When used on a short-term basis, acetaminophen is one of the best-tolerated drugs. The single dose for a healthy 70-kg adult is 500 to 1,000 mg. Because of its weak anti-inflammatory effect, acetaminophen is not a first-line postoperative medication. However, it is the standard analgesic medication for pregnant women, children, adolescents, asthmatics, and individuals with gastrointestinal disorders.[44,46]

Acetaminophen (paracetamol)

- It is very well tolerated.
- The anti-inflammatory effect is weak.
- Acetaminophen is the standard medication for pregnant women, children, adolescents, asthmatics, and individuals with gastrointestinal disorders.
- The effective single dose for analgesic effect in a healthy 70-kg adult is 500 to 1,000 mg.
- Absolute and relative contraindications exist.

Glucocorticoids

Glucocorticoids are another group of drugs with potent anti-inflammatory effects. Glucocorticoid preparations consist of endogenously produced hormones or synthetic compounds. When administered in high nonphysiologic concentrations, glucocorticoids suppress all phases of the inflammatory response, from exudation and proliferation to scar formation. However, they also suppress nonspecific and specific immune responses to infection and other noxious agents. This immunosuppressive effect is based on a number of molecular biologic effects characterized by the increased expression of immunomodulatory proteins.
A single intravenous dose (250 mg) of the glucocorticoid prednisolone can effectively reduce swelling that obstructs swallowing and breathing following major jaw surgery. Direct subcutaneous injection of glucocorticoids into the surgical site is not recommended because this may impair wound healing and promote the spread of infection. Because the anti-inflammatory effect of acidic analgesics is usually sufficient for periodontal surgery, additional glucocorticoid treatment generally is not necessary.[45]

Glucocorticoids

- They have a good anti-inflammatory effect.
- Glucocorticoids suppress immune response (immunosuppressant).
- A single intravenous dose of 250 mg prednisolone may be administered after prolonged surgery if necessary.

Herbal and homeopathic medications

Traumeel
Traumeel is a homeopathic compound preparation that consists of a number of different herbal active substances. It is said to curb inflammatory response by stimulating the production of protective cytokines by immune cells. A number of studies have demonstrated the efficacy of this medicinal product in reducing swelling.[47,48]

Traumeel

- Traumeel is a homeopathic medication.
- It has an anti-inflammatory effect.
- Few side effects are to be expected.
- The standard regimen for Traumeel as a postoperative medication is two tablets three times daily for 4 days.

Bromelain
Bromelain, a highly concentrated mixture of enzymes extracted from the stem of the pineapple plant, is reported to have anti-inflammatory effects. These enzymes are said to accelerate the degradation of protein complexes and their breakdown products, thereby improving wound healing.[49–51]

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Bromelain

- Bromelain is a homeopathic medication.
- It has an anti-inflammatory effect.
- Few side effects are to be expected.
- The standard regimen for bromelain as a postoperative medication is two tablets three times daily for 4 days.

Clinical recommendations

The rule of thumb for analgesic therapy is to use the lowest dose needed to achieve the desired effect. To minimize side effects, single-agent preparations should be preferentially used instead of combination preparations containing additional active substances such as hypnotics, codeine, or caffeine.[52]

Preoperative administration (approximately 1 hour prior to the procedure) and/or postoperative administration (directly after the procedure) of analgesics can be very helpful for sensitive patients or after extensive surgery. This provides timely alleviation of postoperative pain before the local anesthetic wears off.

Clinical experience has shown that ibuprofen achieves excellent analgesic and anti-inflammatory effects with an excellent side effect and tolerability profile. Evidence suggests that the use of ibuprofen granules ensures a more rapid onset of action. For optimal reduction of swelling, a regimen of 600-mg ibuprofen granules three times daily for 4 days is recommended.

In addition, a homeopathic product such as Traumeel S (two tablets three times daily) or bromelain (two tablets three times daily) can be prescribed for prevention of swelling. Because they contain all-natural ingredients and have a low risk of side effects, patient acceptance of these products is very high. The combination of ibuprofen with both Traumeel and bromelain has proved to be very effective and well tolerated (Fig 6-11).

After extensive major periodontal and implant surgery, diclofenac can be used instead of ibuprofen, but the risk of side effects is higher, particularly in the gastrointestinal tract[44] (Fig 6-12).

Metamizole (preferably drops) can be used as a last resort if the aforementioned analgesics fail to achieve satisfactory relief of postoperative pain. However, the patient must be informed that metamizole will impair the ability to drive (Fig 6-13).

Standard postoperative medications

- Ibuprofen, 600-mg granules three times daily for 4 days
- Traumeel, two tablets three times daily for 4 days
- Bromelain, two tablets three times daily for 4 days

Postoperative medications if severe swelling is expected

- Diclofenac sodium, 75 mg two times daily for 4 days
- Traumeel, two tablets three times daily for 4 days
- Bromelain, two tablets three times daily for 4 days
- Intravenous glucocorticoid (250 mg prednisolone) as needed after consultation with the anesthesiologist

Second-line medication if ibuprofen or diclofenac provides inadequate pain relief

- Metamizole, 500 mg two times daily for 3 to 5 days

6.4.4 Antibacterial Prophylaxis

Chlorhexidine

Principles

Oral antimicrobial agents are rated according to their substantivity, that is, their capacity for retention on a substrate without loss of their antimicrobial activity. Chlorhexidine digluconate has a very high substantivity and is the gold standard for postoperative antibacterial prophylaxis following dental surgery. Chlorhexidine is available in the following forms: 0.1% to 0.2% mouthrinse, 1% gel, 10% concentrate, and 1% or 40% varnish.[53] Chlorhexidine adsorbs to negatively charged surfaces of oral tissues, including the teeth, and is then slowly released in antimicrobially effective form. This results in a depot effect in which the action of the drug lasts much longer than the actual rinsing time.

Because of its cationic nature, chlorhexidine has a high affinity for the negatively charged surfaces of bacterial microorganisms. After binding to their surfaces, it inhibits pellicle formation and induces structural changes in the microorganisms. The subsequent change in cell wall permeability disrupts the cellular osmotic balance, resulting in lytic destruction of the microorganisms.



Fig 6-11 One possible postoperative analgesic and anti-inflammatory standard regimen consists of 4 days of ibuprofen, 600 mg three times daily; Traumeel, two tablets three times daily; and bromelain, two tablets three times daily.



Fig 6-12 If severe postoperative swelling is expected, it may be better to use diclofenac instead of ibuprofen.



Fig 6-13 If neither ibuprofen nor diclofenac provides satisfactory pain relief, metamizole can be used as a second-line medication.

Chlorhexidine digluconate does have some undesirable side effects, including tooth discoloration, alterations in taste perception, and black hairy tongue. Reversible epithelial desquamation can also occur after long-term use. The development of resistant strains of bacteria has not been observed to date[44] (Fig 6-14).

Clinical recommendations

For infection prophylaxis following periodontal or implant surgery, the patient is instructed to rinse the mouth with 10 mL of 0.1% chlorhexidine mouthrinse three times daily for 2 weeks instead of the normal home oral hygiene regimen. The addition of alcohol to oral chlorhexidine rinses does not provide additional antimicrobial effects.

Chlorhexidine

- The patient should rinse with 10 mL of 0.1% chlorhexidine mouthrinse three times daily for 2 weeks.
- No mechanical oral hygiene measures should be performed in the surgical region for 14 days.
- Alcohol-free products are preferred.

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Fig 6-14 After surgery, the patient is instructed to use a 0.1% oral chlorhexidine mouthrinse for 2 weeks instead of the normal home oral hygiene regimen.

Antibiotics

Principles

Preoperative administration of antibiotics may be necessary for bacteremia prophylaxis in high-risk patients as well as for additional wound infection prophylaxis in certain cases. However, the routine use of antibiotics in plastic-esthetic periodontal and implant surgery should be viewed critically. Most studies of antibiotic prophylaxis have shown that it does not result in any significant reduction of postoperative complications such as pain and swelling.[54,55] Therefore, the routine use of antibiotics before surgery is not recommended. However, there are exceptions: Healthy patients should receive antibiotic prophylaxis prior to augmentation procedures involving bone autografts or xenografts with or without the use of membranes. Antibiotics may also be necessary for treatment of inflammatory postoperative complications (see chapter 17).

Drugs used

Aminopenicillins (amoxicillin)

Amoxicillin, a member of the group of aminopenicillins, has a broad spectrum of bactericidal activity against many gram-positive and gram-negative microorganisms. The drug is almost completely absorbed after oral administration. The absorption of amoxicillin is not affected by food intake. Amoxicillin has a low rate of gastrointestinal side effects. Allergic reactions occur in approximately 10% of patients receiving the drug. The oral daily dose for a healthy 70-kg adult is 1.5 to 3.0 g divided into three doses. In dentistry, amoxicillin is the antibiotic of first choice in nonallergic patients.[44,46]

Lincosamides (clindamycin)

Lincosamides inhibit protein synthesis in bacterial ribosomes. They have a broad spectrum of bacteriostatic activity against many gram-positive cocci and anaerobic gram-negative rods. Clindamycin can be administered orally or parenterally. After oral administration, clindamycin is well absorbed and exhibits excellent bone penetration. Reported side effects include allergic reactions and gastrointestinal disorders including pseudomembranous colitis, a severe but rare adverse drug reaction. The oral daily dose for a healthy 70-kg adult is 0.6 to 1.8 g divided into three to four doses.[44,46]

Nitroimidazoles (metronidazole)

Metronidazole is active against all obligate anaerobic bacteria but is not active against facultative anaerobic and aerobic bacteria. Metronidazole can be administered orally or parenterally. The most common side effects are gastrointestinal disorders such as nausea, vomiting, and epigastric pain. Neurologic disorders such as headaches, paresthesias, and vertigo may also occur. Alcohol intolerance has also been described. The daily dose for a healthy 70-kg adult is 400 mg orally three to four times daily or 500 mg intravenously.[44,46]



Fig 6-15 Standard antibiotic prophylaxis regimens for inflammatory postoperative complications: amoxicillin, 500 mg 3 times daily for 7 days, for patients not allergic to penicillin, or clindamycin, 300 mg 3 times daily for 7 days, for patients allergic to penicillin.

Clinical recommendations

With the exception of bacteremia prophylaxis in high-risk patients, there are very few indications for antibiotic prophylaxis in plastic-esthetic periodontal surgery. As was mentioned earlier, the use of antibiotics for wound infection prophylaxis is advisable only before augmentation procedures involving bone autografts or xenografts, membrane procedures, and lengthy and extensive soft tissue interventions. Amoxicillin has proved to be an effective drug for this purpose. The recommended regimen is 500 mg amoxicillin three times daily for 7 days in patients not allergic to penicillin or 300 mg clindamycin three times daily for 7 days in patients allergic to penicillin. Amoxicillin is also the antibiotic of first choice for treatment of postoperative bacterial infection (see chapter 17). The recommended regimen for this indication is 500 mg amoxicillin three times daily for 7 days in patients not allergic to penicillin or 300 mg clindamycin three times daily for 7 days in patients allergic to penicillin (Fig 6-15).

Antibiotic prophylaxis for bacteremia in high-risk patients

- Amoxicillin, 2 g, is administered 1 hour before surgery for patients not allergic to penicillin.
- Clindamycin, 600 mg, is administered 1 hour before surgery for patients allergic to penicillin.

Antibiotic prophylaxis before hard tissue augmentation or lengthy procedures

- Amoxicillin, 500 mg three times daily for 7 days, is prescribed for patients not allergic to penicillin.
- Clindamycin, 300 mg three times daily for 7 days, is prescribed for patients allergic to penicillin.

Antibiotic treatment of postoperative infections

- Amoxicillin, 500 mg three times daily for 7 days, is prescribed for patients not allergic to penicillin.
- Clindamycin, 300 mg three times daily for 7 days, is prescribed for patients allergic to penicillin.

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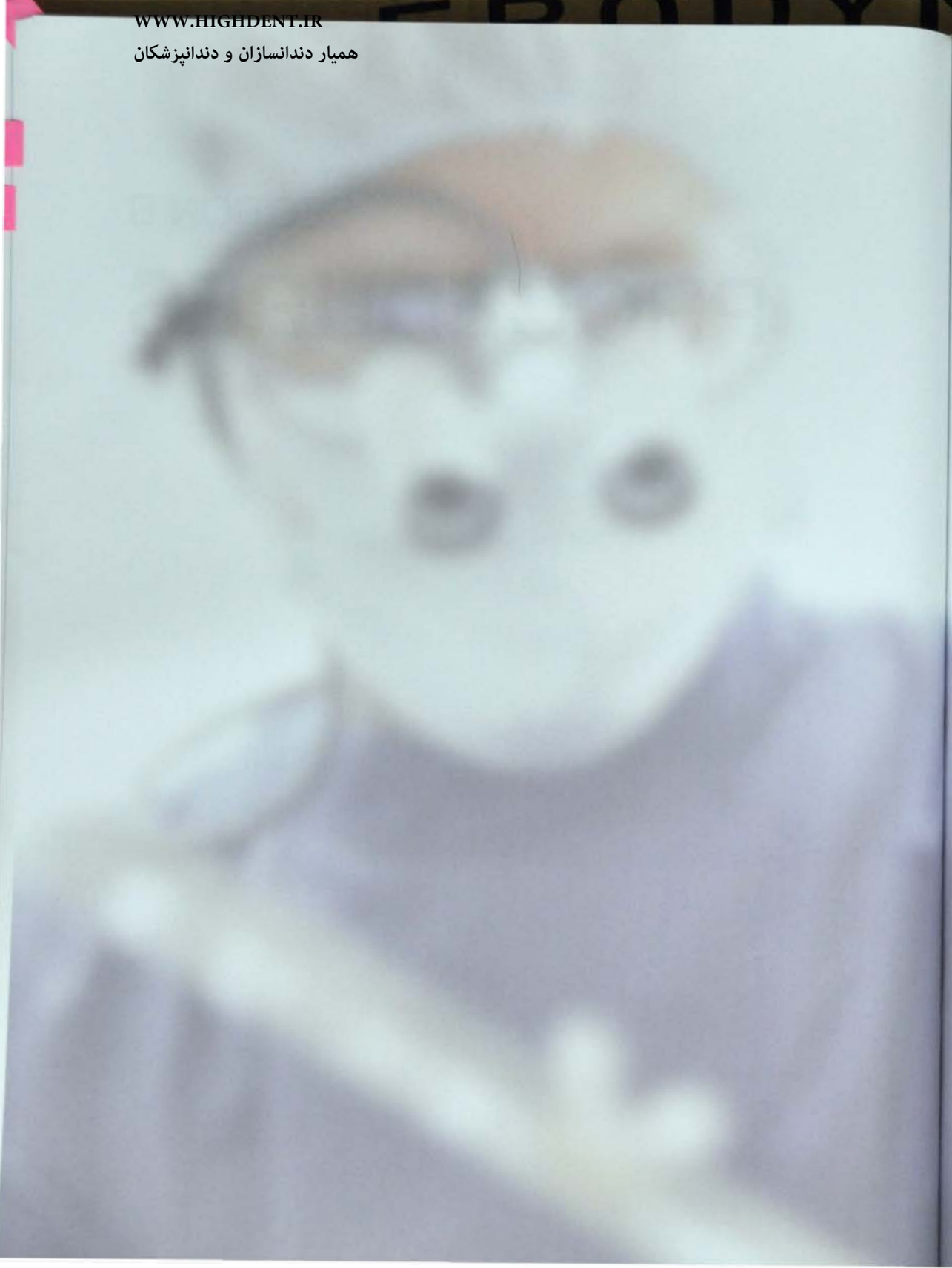
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SECTION B

PROCEDURES

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CHAPTER 7

AUTOGRAFT HARVESTING

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7.1 Theory

The vast majority of procedures performed in plastic-esthetic periodontal and implant surgery are reconstructive procedures that are generally performed using autogenous connective tissue and/or bone grafts. Autograft harvesting is therefore a common and frequent procedure.

7.1.1 Physiologic Principles of Free Tissue Transplantation

Transplantation is a collective term for all procedures involving the harvesting and replanting of organs, tissues, or cells from one part of the body to another in the same individual *(autotransplantation)*, from one individual to another of the same species *(allotransplantation)*, from one species to another *(xenotransplantation)*, or from inorganic sources into living tissues *(alloplasty)*. While *vascular* or *pedicle grafts* are connected to the arterial blood supply intraoperatively and have their own direct blood supply postoperatively, *free grafts* are *avascular* and have no direct blood supply. Because vascular graft procedures are often difficult or impossible to perform in reconstructive periodontal and implant surgery, they are of minor significance in this field. Consequently, this chapter will focus on the use of *free tissue grafts* in reconstructive plastic-esthetic periodontal and implant surgery.

During the immediate postoperative period, free grafts or the cells contained in them (in the case of autografts) are supplied exclusively by *diffusion*. Apart from their limited intracellular energy reserves, these grafts are entirely dependent on the influx of metabolites with the extracellular fluid by means of diffusion for survival. The driving force behind this diffusion process, also known as *plasmatic circulation*, is the concentration gradient between the native and the transplanted tissues. From the third to fourth postoperative day on, the mediator-stimulated ingrowth of capillaries from the recipient bed into the graft and the formation of anastomoses between blood vessels of the graft and the recipient bed begins, gradually reestablishing circulation to the graft (*revascularization*). The stages of wound healing that follow are dependent on these capillary proliferation processes, the end of which is characterized by a dense network of blood vessels extending beyond the preexisting graft margins.[1,2]

For optimal plasmatic circulation and revascularization, the graft should be adapted to the recipient bed as intimately as possible to minimize the diffusion distance and capillary proliferation length to be covered and to maximize the number of transplanted cells receiving an adequate supply of nutrients during the early postoperative period. Intimate and extensive contact between the graft and the well-vascularized recipient bed is crucial to graft survival. Heavy bleeding and the formation of a large blood clot between the graft and the recipient bed impairs the nutrient supply to the transplanted cells. The surgical techniques used to create the recipient bed and establish primary wound closure are also crucial to the success of grafting (Fig 7-1). For further details, see chapters 3 and 4.

These basic principles of graft integration generally apply to both autogenous connective tissue and bone grafts, but the great histomorphologic differences in the extracellular matrix structures of the bone and connective tissue result in differences in integration and healing of the grafts themselves and, in particular, of the cells they contain. Because connective tissue autografts have an organic extracellular matrix with relatively loosely arranged collagen fibers within the matrix, plasmatic circulation in the initial postoperative period and the subsequent revascularization process can start early and proceed relatively unimpeded. Furthermore, the chances that a large number of fibroblasts in the graft will receive an adequate supply of nutrients quickly enough and will therefore survive are relatively good. Autogenous bone grafts, on the other hand, have an inorganic or mineralized extracellular matrix, forming a barrier that is not easy to cross by diffusion and revascularization. The denser the autograft (ie, the higher the mineral content and the smaller the freely accessible surface area of the graft), the harder it is to achieve tissue revascularization and the smaller the number of cotransplanted osteoblasts capable of surviving in the endosteum of the bony canals and marrow spaces. Thus, the prognosis of osteoblasts in an autologous particulate bone graft or a soft cancellous bone block graft is different from that of those in a dense autologous cortical bone block.[3,4] *De Marco* and coworkers[5] demonstrated in a histomorphometric study in rats that resistance of autogenous bone blocks to revascularization can lead to the death of cells, particularly those located in the peripheral parts of the graft and therefore reducing the regenerative capacity. However, the cellular and molecular details of many biologic processes and interactions involved in healing and integration of the bone and connective tissue graft are still unknown despite intensive research efforts. For this reason, the potential effects of areas of devitalized bone in bone block grafts in which only the inorganic mineralized matrix is left after the organic components have died are just conjecture. Likewise, the potential effects on the mediator-guided interactions between the resorptive processes and integrative remodeling processes occurring during the graft healing and bone regeneration stages can only be speculated. However, it would seem that the reduced regenerative capacity in devitalized areas of autogenous bone blocks could at least partly explain the extensive resorption observed in the grafts.

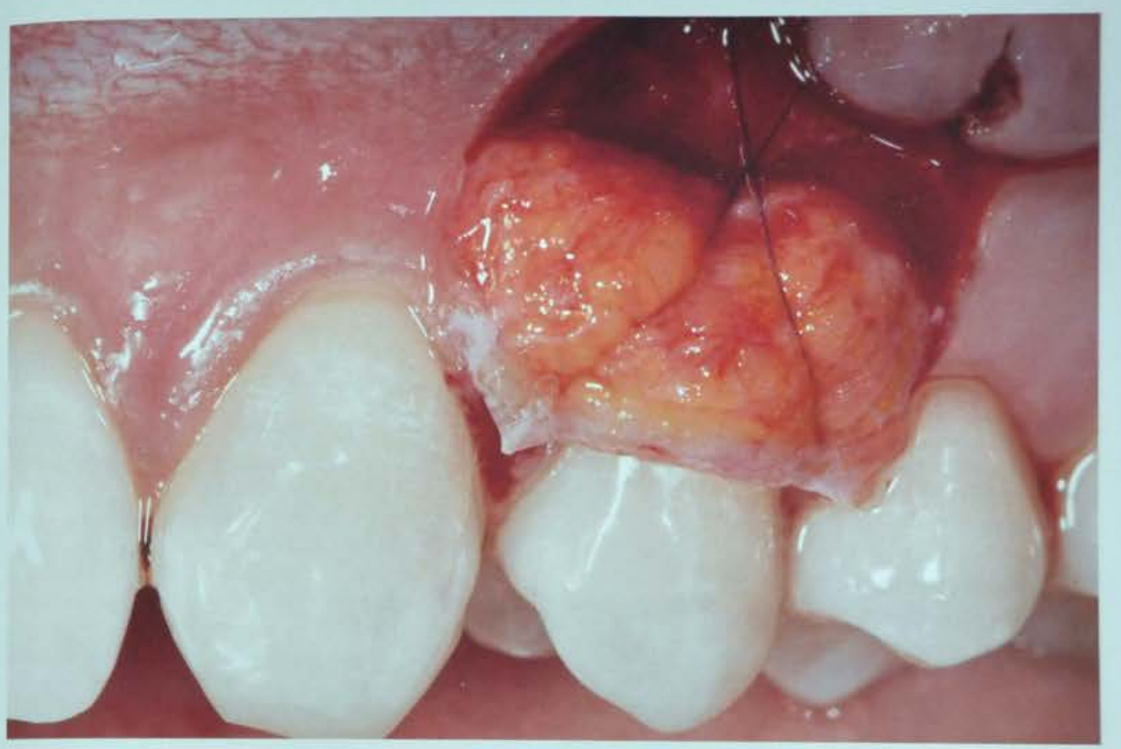


Fig 7-1 Intimate and extensive contact between the graft and the well-vascularized recipient bed is an important prerequisite for survival of the graft and the cells contained in it. Clinical case example: A free subepithelial connective tissue graft was harvested from the palate for treatment of gingival recession (root coverage). A crossed sling suture is used to establish intimate contact between the graft and the recipient bed, thus minimizing the diffusion distance and capillary proliferation length to be covered in order to achieve revascularization and graft survival.

The prognosis of osteoblasts transferred in soft cancellous bone block grafts is better than that of those in autogenous cortical bone block grafts, and the prognosis of those in autologous particulate bone grafts is even better. The extent to which facilitation of plasmatic circulation and revascularization (ie, osteoblast survival) in the graft is responsible for the increased regenerative capacity of these types of grafts cannot be explained in detail for the reasons described above. A particulate bone graft, which is organized like a blood clot, can heal and regenerate in an environment with a hematogenous healing capacity, particularly in the immedi-

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ate postoperative period. This could explain why this type of graft has a higher regenerative capacity than autogenous bone blocks. A main disadvantage of cancellous blocks and particulate bone grafts is the difficulty in achieving proper graft fixation and immobilization because the necessary fixation tools such as osteosynthesis screws do not hold well in the loose structure of cancellous block grafts. Another disadvantage of particulate grafts is their lack of a stable form. In addition to adequate blood supply, optimal graft fixation is another absolute requirement for bone healing and regeneration[6] (Fig 7-2). Volume-stable hard and soft tissue grafts should ideally be used for plastic periodontal and implant surgery in the esthetic zone. The impact of the survival of transplanted tissue-specific cells and degree of graft revascularization on the integration of hard and soft tissue grafts is still not clear. Also, there may be many other factors and processes that can influence the success of hard and soft tissue grafting.

7.1.2 Requirements for Free Tissue Grafts

There are five basic requirements for free tissue grafts:

1. A *sufficient amount* of graft should be available.
2. It should be possible to harvest the graft *without significant medical risks* and *with acceptable morbidity*.
3. The graft should contain *vital tissue-specific cells*.
4. The graft should have *tissue-conductive properties*.
5. The graft should also have *tissue-inductive properties*.

In the case of free autografts, the first two requirements are directly dependent on the selected donor site and the corresponding harvesting procedure, whereas the next three are directly related to the biologic and biofunctional characteristics of the graft material.

The survival of vital, tissue-specific cells in an autologous graft depends on an early and adequate supply of nutrients in the initial healing phase. The cells are nourished initially by the blood supply from the recipient bed by means of diffusion (plasmatic circulation) and, later, by means of revascularization of the graft.

The requirement to have as many surviving tissue-specific cells in the graft as possible is based on concepts of bone healing and bone regeneration first suggested by the German orthopedist *Wolff*[7] in Berlin during the 19th century and later expounded on by his colleagues *Axhausen*[8] and *Lexer*.[9] The so-called *osteoblast theory* expresses the idea that the "transplantation forces" from the largest possible number of surviving osteoblasts in a graft are responsible for bone regenerative capacity (*osteogenic property*).

Based on his microscopic observations, *Barth*[10] doubted this theory and later proposed an alternative hypothesis: After the death of the organic component, the remaining inorganic (mineralized) matrix serves as a conductor for osteoblasts migrating from the recipient site and thus promotes new bone formation originating from the graft bed. He coined the terms *creeping substitution* and *osteoconduction* to describe the *osteoconductive properties* of bone grafts.

In addition to the two aforementioned theories, a third theory of bone regeneration and bone formation, known as *osteoinduction*, has been discussed in the scientific literature recently. This term describes the ability of the mediators and proteins in natural bone to differentiate pluripotent mesenchymal stem cells into osteoblastic cells and to promote their proliferation and synthesis capacity (*osteoinductive property*).[11]

Although the terms *osteoinduction*, *osteoconduction*, and *osteogenesis* originate from concepts of bone regeneration and bone healing, the underlying concepts can also be used to describe the healing and regeneration processes associated with connective tissue grafting. The "ideal" graft material also exhibits an optimal potential for tissue-specific conduction and induction and contains the largest number of cotransplanted vital cells possible.

Autogenous bone grafts

In terms of having a bone graft with greatest possible osteoconductive, osteoinductive, and osteogenic potential, autogenous bone is the most ideal material currently available. The mineral architecture, pore arrangement, and pore size of autogenous bone should best promote the ingrowth of newly formed bone in the scope of conductor function (osteoconduction).

Autogenous bone also has great osteoinductive potential. Bone morphogenetic proteins (BMPs) are key mediators that induce local pluripotent mesenchymal stem cells to differentiate into osteogenic or osteoblastic cells and stimulate their proliferation and secretion.[12] Interestingly, cortical bone has a higher proportion of BMPs than spongy bone.[11] However, because cortical bone blocks have a low surface area and cannot release the

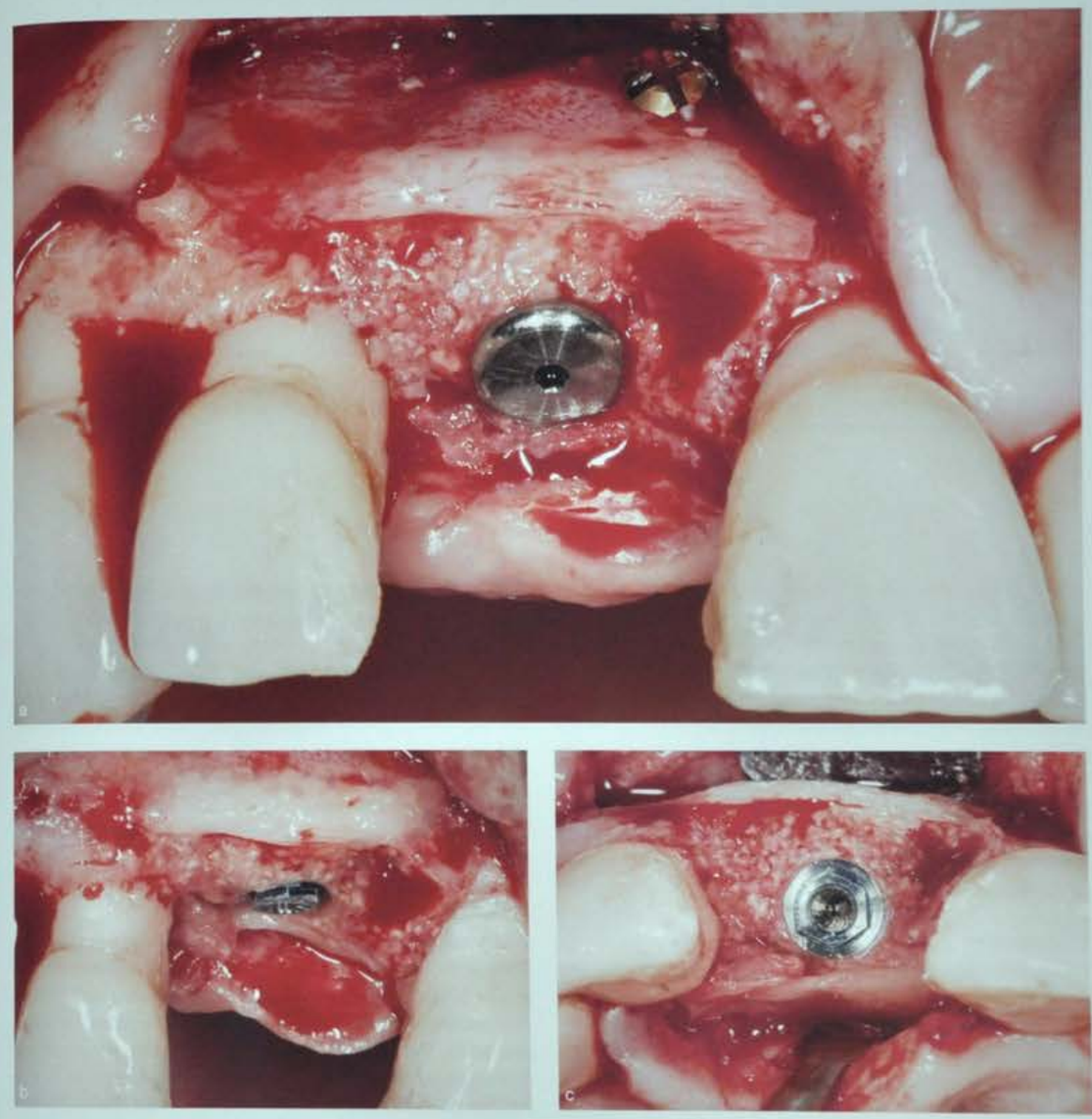


Fig 7-2 (a to c) Clinical situation on reentry 6 months after hard tissue augmentation with cortical bone block and simultaneous implantation according to the *Khoury* method: No change in the cortical bone blocks integrated in the local tissue can be observed, and the space between the two bone blocks, which was filled with a mixture of autologous particulate bone and bone substitute material at the time of hard tissue augmentation, exhibits all the clinical features of highly vital bone. This method seems to synergistically combine the high stability of autologous cortical bone blocks with the high regenerative and healing capacity of autologous particulate bone for optimal defect reconstruction and implant integration.

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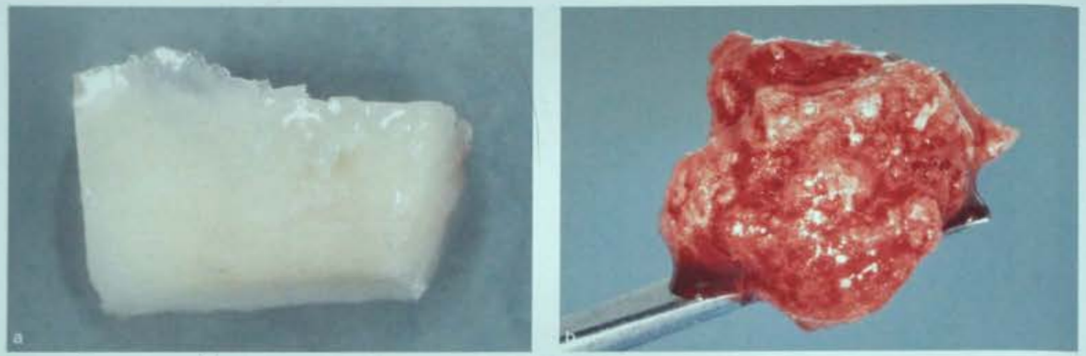


Fig 7-3 In terms of osteoinductive, osteoconductive, and osteogenic potential, autogenous bone grafts are the most ideal material for for hard tissue augmentation. Cancellous and particulate bone grafts (a) have obvious advantages over cortical bone grafts (b) in terms of their osteoinductive and osteogenic capacities.

BMPs they contain, it is better to grind the cortical bone block into smaller particles.

The number of endogenous osteoblasts (osteogenesis) transferred by transplantation varies from one bone autograft to another. The osteogenic potential stemming from these cells depends primarily on how many of these cells survive transplantation, ie, on plasmatic circulation in the initial period and on revascularization in the later period following transplantation. As already explained in detail, cancellous or particulate bone grafts are superior to cortical bone grafts for this reason (Fig 7-3).

Connective tissue autografts

Connective tissue autografts are ideal materials for the reconstruction of soft tissue defects. The organic extracellular connective tissue matrix can serve as a spaceholder and conductor for new ingrowing fibroblasts, ensuring smooth integration into the surrounding tissue. Tissue-specific endogenous proteins as well as specific connective tissue cells (fibroblasts) are transferred with the connective tissue autograft. The majority of these cells are well nourished by the blood supply from the plasmatic circulation in the initial period and from revascularization in the subsequent period following transplantation. Consequently, they have a good prognosis (Fig 7-4).

7.1.3 Potential Donor Sites and Harvesting Techniques

All of the techniques of plastic-esthetic periodontal and implant surgery described in this book can be performed using intraorally harvested hard and soft tissue autografts. For this reason and for reasons of clinical feasibility and practicability, this section will focus on potential donor sites within the oral cavity. However, the limited availability of intraoral autograft material is a significant disadvantage in some cases.

Autogenous bone grafts

Methods for harvesting avascular osseous autografts from different regions in the oral cavity have been described. One thing that all intraoral donor sites have in common is that they supply mainly cortical bone graft material; the proportion of cancellous bone material available from intraoral donor sites is always limited.

In the maxilla, the main intraoral donor sites for autogenous bone grafts are the maxillary tuberosity, the zygomatic process, and the region caudal to the anterior nasal spine. Those in the mandible are the retromolar region, the lateral body of the mandible (external oblique line at the junction between the horizontal and ascending part of the ramus), and the symphyseal region. The volume of bone that can be harvested from maxillary donor sites is very small. Therefore, intraoral



Fig 7-4 In terms of tissue induction, conduction, and genesis, connective tissue autografts are ideal materials for soft tissue augmentation for the same reasons that autogenous bone grafts are ideal for hard tissue augmentation.

autogenous bone graft material is preferentially harvested from the mandibular region.

The mandibular symphyseal region is probably the most commonly used donor site, and it can possibly provide the greatest volume of bone graft. When grafts are harvested from the symphyseal region, the risk of intraoperative complications (eg, mandibular incisor sensory impairment of variable severity) is significantly higher than that when grafts are harvested from other intraoral donor sites such as the lateral mandibular angle in the region of the external oblique line.[13,14] The external oblique line at the junction between the horizontal and ascending ramus of the mandible is the more ideal and preferred intraoral donor site for bone autografts. Bone harvested from this region consists primarily of cortical bone, which has a very low proportion of cancellous bone. Full-thickness cortical bone blocks as well as thin cortical bone plates and ground autogenous bone particles can be obtained. The use of the bone filter that collects bone particles during the drilling procedure can be used when an osteotomy is performed to harvest graft material in this region. However, bone filters should always be used very selectively to avoid the aspiration of harmful bacteria that could later contaminate the graft.[15]

As in surgical extraction of mandibular third molars, bone autograft harvesting requires elevation of a flap in the region of the lateral mandibular angle. Before the first incision is placed, the area distal to the last molar should be palpated to identify the ascending ramus of the mandible to ensure that the distal crestal incision along the ascending ramus is made in continuous contact with bone. This serves two purposes: first, to prevent deep soft tissue damage on the lingual aspect of the ascending ramus, which could result in severe bleeding, and, second and more importantly, to prevent lingual nerve damage (Fig 7-5).

Because the mandibular canal and inferior alveolar neurovascular bundle may be located close to the buccal cortical bone, particularly in the distal part of the lateral mandibular angle, the surgeon should take care to avoid performing the osteotomy too far distally and, more importantly, to avoid penetrating too far into the bone. Ideally, a penetration depth that safely ensures that the osteotomy does not extend too far beyond the compact bone and into the cancellous bone should be selected. In addition, the osteotomy should be performed by slow and controlled drilling and stopped immediately at the first signs of bleeding from the osteotomy site. Damage to the inferior alveolar nerve and the corresponding blood vessels is almost entirely preventable when these precautions are taken (Fig 7-6).

Connective tissue autografts

Several intraoral donor sites for connective tissue autografts have been described.[16] The most commonly

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Fig 7-5 When the crestal incision is made distal to the last molar, it is important to maintain continuous contact with bone for two reasons: (1) to prevent deep soft tissue injury and (2) to prevent lingual nerve damage on the lingual aspect of the ascending ramus. Palpating to identify the ascending ramus of the mandible before the incision is placed provides anatomical orientation for effective damage prevention.

used donor site is the palate, but the maxillary tuberosity area and the mandibular retromolar region are also used. Two types of connective tissue autografts can be distinguished: the *free subepithelial connective tissue graft* and the *full-thickness free mucosal graft*. The former is harvested without covering epithelium and consists mainly of a subepithelial collagen tissue matrix, whereas the latter contains all histologic tissue layers, including the covering epithelium.

There is little scientific data available on the thickness of the mucosa at the aforementioned donor sites.[17] *Studer* and coworkers[18] were the first to investigate the thickness of masticatory mucosa in the human hard palate and tuberosity area in dentate patients. They anesthetized the target regions and measured the thickness of the mucosa using a periodontal probe according to the bone sounding technique. They found that the palatal tissue is thickest in the premolar region, which is also the preferred donor site for thick free mucosal grafts such as those used in socket seal surgery (see chapter 12). The thickness of the palatal mucosa decreases distally starting at the level of the first molars where the palatal roots come to lie but successively increases toward the roof of the mouth. In this study, the mucosal thickness was greater in the tuberosity area than in the maxillary premolar region; however, in dentate patients, the surface area of the tuberosity area was not as large as that of the lateral palate and therefore yielded less graft material. In a more recent study, computer tomography measurements revealed palatal mucosa thickness to be a bit higher.[19]

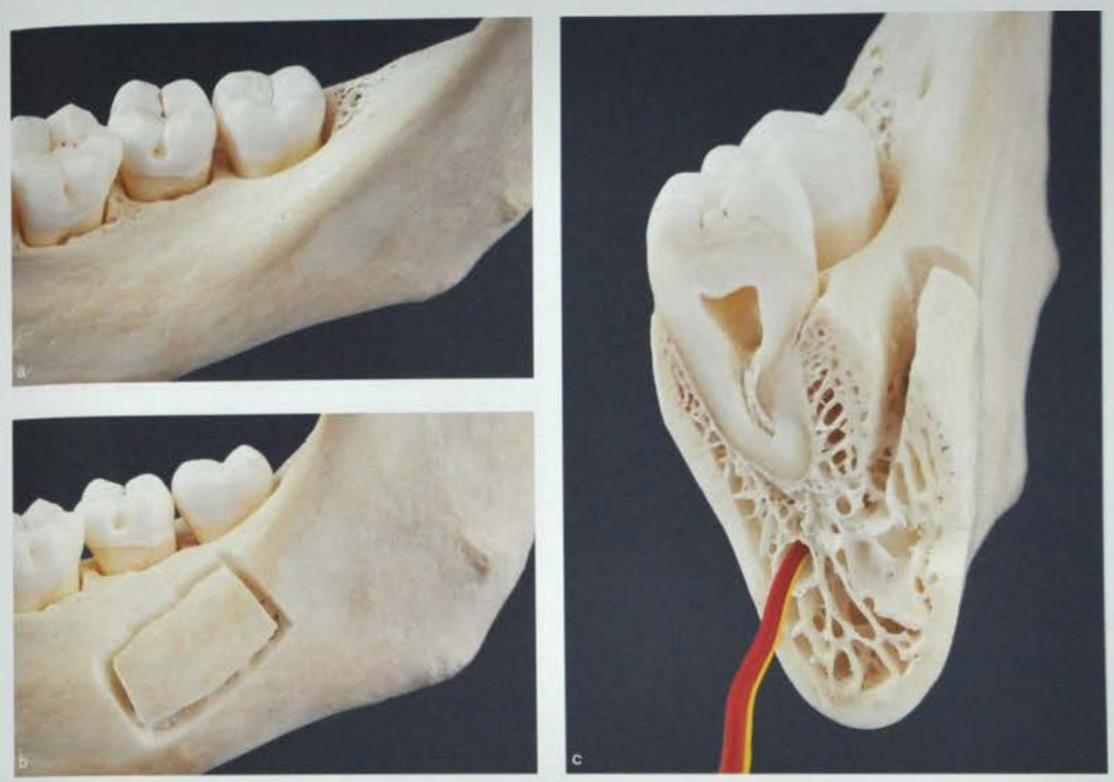


Fig 7-6 (a to c) To safely prevent damage to the inferior alveolar nerve and artery when autogenous bone graft material is harvested from the lateral mandibular angle, care should be taken to avoid performing the osteotomy too far distally and, more importantly, to avoid penetrating too far into the bone. The safest way to do this is to ensure that the osteotomy does not extend significantly beyond the compact bone and into the cancellous bone.

Subepithelial connective tissue grafts from the palate

Because the structure of the palatal mucosa is histologically similar to that of the periodontal gingiva, they are jointly referred to as the *masticatory mucosa* and differentiated from the other types of mucosa in the oral cavity (see chapter 1). The palatal mucosa consists of three layers: covering epithelium, subepithelial connective tissue, and submucosa. The structure of the keratinized palatal squamous epithelium corresponds to that of the oral gingival epithelium. The connective tissue below the palatal squamous epithelium is very coarse tissue consisting mainly of collagen fibrils; it lacks elastic fibers. The subepithelial connective tissue in the palatal raphe region is very thin and continues in a deeper layer containing varying amounts of fatty and glandular

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tissue. The palatal submucosa consists mainly of collagen fibers with a few elastic fibers that connect the subepithelial connective tissue with the periosteum.[20] Therefore, subepithelial connective tissue grafts from the palate contain both collagen fibers and varying amounts of fatty and glandular tissue.

Regarding potential complications of harvesting a subepithelial connective tissue graft from the palate, the palatine artery is an extremely important and clinically relevant anatomical structure to be protected (Fig 7-7).

In an anatomical study of the greater palatine artery (GPA) and related bony structures of the hard palate in 41 cadavers, *Klosek* and *Rungruang*[22] found that the greater palatine foramen was most frequently found in the region near the apices of the second and third molars, in the area where the vertical and horizontal segments of the palatine bone come together. The foramen was located slightly more anteriorly in men than in women. *Monnet-Corti* et al,[23] who measured the distance of the main branches of the GPA from the palatal gingival margin in 198 plaster models of periodontally healthy patients, found that the average distance from the gingival margin to the GPA ranged from approximately 12 mm in the canine area to roughly 14 mm at the second molar level. The authors concluded that it should be possible to harvest a subepithelial connective tissue graft measuring 5 mm in height in all patients and 8 mm in height in 93% of patients without a risk of damaging the GPA.

However, a cadaver study by *Fu* and coworkers[24] revealed that the predicted location of the GPA based on study casts tended to be inaccurate and that the predicted distance between the GPA and the cementoenamel junction of the first molars and premolars tended to be underestimated. Other evidence suggests that the height of the palatal vault is related to the course of the greater palatine artery: The shallower the palatal vault, the closer the palatine artery gets to the palatine gingival margin anteriorly.[25]

To reliably prevent damage to the GPA when a free connective tissue graft is harvested from the palate, the distal extent of the incision should end no further than the mesial border of the first molar. Also, care must be taken to ensure that the incision does not extend more apical than 10 mm from the cementoenamel junction of the maxillary posterior teeth. If placed roughly 2 mm from the cementoenamel junction, the initial incision can be safely extended apically to a depth of approximately 8 mm without a risk of damaging the artery. Because the cutting portion of a No. 15 scalpel blade, which this book recommends for this procedure, is approximately 8 mm in length, it can serve as a gauge for safe graft harvesting (Fig 7-8).

When a free connective tissue graft is harvested from the palate, the goal is often to obtain the largest volume of tissue possible while respecting the aforementioned anatomical limitations. However, this objective is in direct opposition to the goal of minimizing postoperative pain and reducing the risk of complications. Because of this problem, various techniques of harvesting subepithelial connective tissue from the palate have been developed.[26–28] The different methods differ mainly in the number and types of surface incisions used. *Hürzeler* and *Weng*[26] proposed a harvesting technique using a single horizontal incision as the initial incision. All of the remaining incisions were undermining incisions below the surface. Studies have shown that this single-incision technique is superior to other methods in terms of postoperative healing and morbidity.[29,30] Currently, it can be recommended as the method of choice for harvesting subepithelial connective tissue grafts from the palate.

From a surgical perspective, the main challenge is to achieve primary wound healing at the palatal donor site. If this goal is achieved, postoperative complaints will usually be less severe. Conversely, if wound dehiscence and/or flap edge necrosis should occur, resulting in secondary wound healing and/or bone exposure, palatal connective tissue grafting can result in considerable morbidity (Fig 7-9).

The key to achieving primary wound healing at the palatal donor site is to obtain a partial-thickness graft of uniform thickness and proper dimension. When the initial incision is made, the scalpel should be held strictly perpendicular to the palatal surface in the superficial tissue layers and successively parallel to the surface in the deeper tissue layers (see chapter 4). It is also advisable to place the coronal internal harvesting incision roughly 1.0 to 1.5 mm apical to the initial incision. This ensures that the access flap will rest on a well-perfused connective tissue surface instead of on bone or periosteum after surgery, which makes it much easier to achieve primary wound healing (see chapter 3) (Fig 7-10).

Depending on the clinical indication and how much tissue is available, palatal connective tissue grafts can be harvested either with or without periosteum. Grafts with periosteum are harvested by blunt dissection using a periosteal elevator. For grafts without periosteum, an

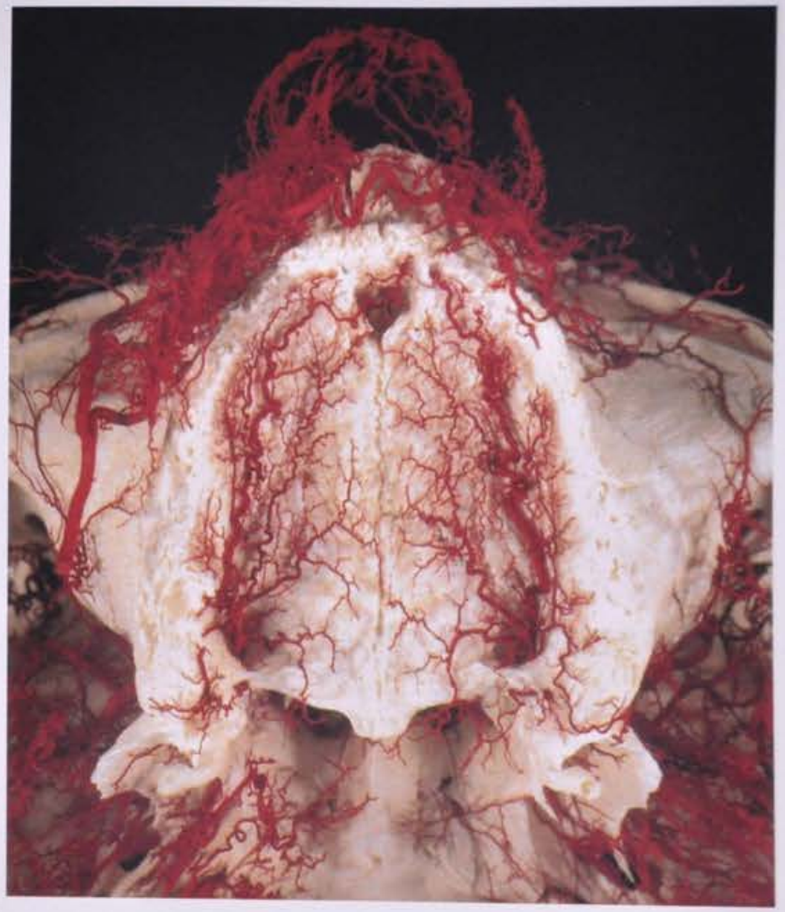


Fig 7-7 The blood vessels that supply the lateral palate region can be seen in this anatomical specimen. The greater palatine artery emerges from the greater palatine foramen and extends along the lateral palate in an anterior direction. Due to its size, damage to the greater palatine artery, particularly its distal segment, can be expected to result in massive bleeding. It is crucial to take precautions to prevent damage to the greater palatine artery when subepithelial connective tissue grafts are harvested from the palate. (From *Tillmann*.[21] Reprinted with permission.).

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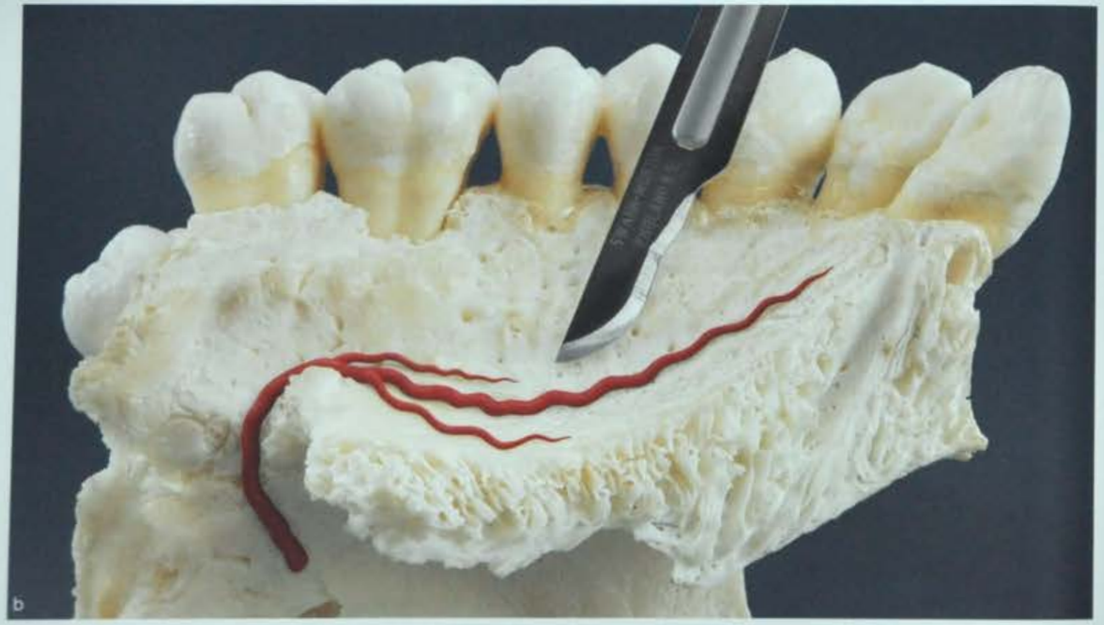


Fig 7-8 (a and b) If the initial incision is placed approximately 2 mm from the gingival margin of the maxillary posterior teeth, the current scientific evidence suggests that it would be virtually impossible to damage the greater palatine artery or its major branches if the subepithelial connective tissue graft is harvested no more than 8 mm apical to the initial incision line. Because the cutting portion of a No. 15 scalpel blade is roughly 8 mm in length, it can serve as a gauge for safe graft harvesting.





Fig 7-9 (a) If it is possible to achieve primary wound healing after a subepithelial connective tissue graft is harvested from the palate, postoperative complications will generally be minor. (b) The opposite is true if there is secondary wound healing, which is sometimes associated with bone exposure.

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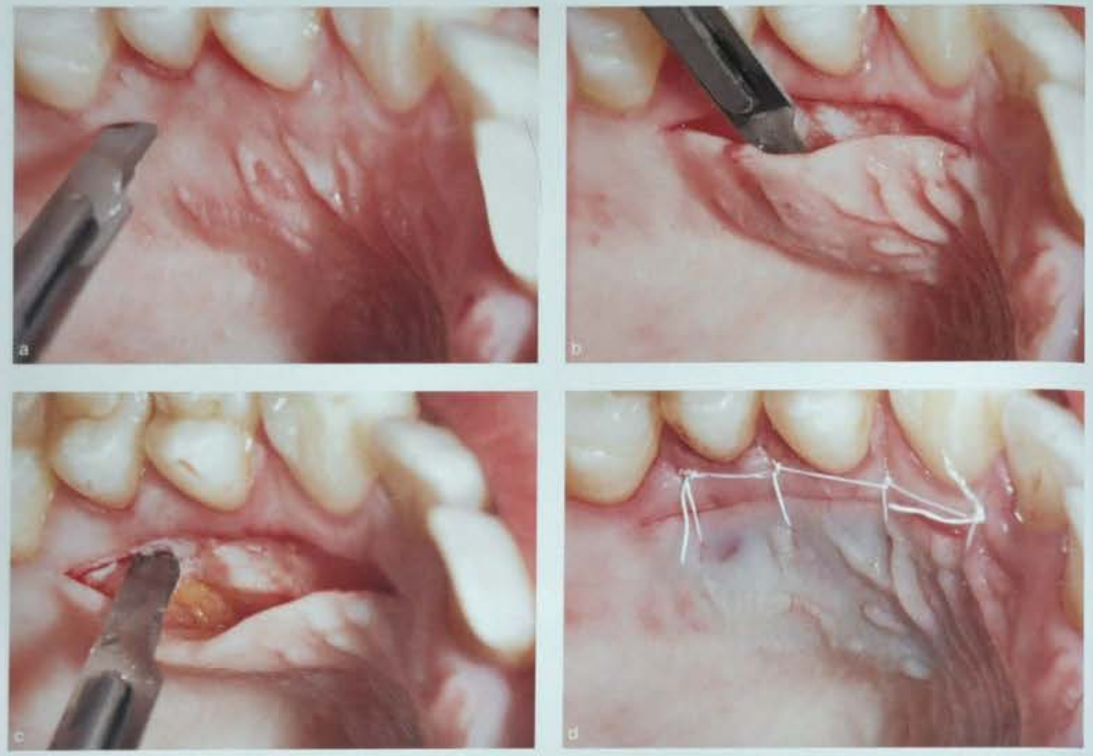


Fig 7-10 To minimize postoperative complications, it is crucial to achieve primary wound healing after subepithelial connective tissue grafts are harvested from the palate. The key is to obtain a partial-thickness graft of uniform thickness and proper dimension. (a) During the initial incision, the scalpel should be held strictly perpendicular to the palatal surface in the superficial tissue layers. (b) It should be held successively parallel to the surface when the partial-thickness incision is made in the deeper tissue layers. (c and d) Experience has shown that it is much easier to achieve primary wound healing if the initial and coronal harvesting incisions are slightly offset to create a small shelf of soft tissue on which the palatal access flap can rest postoperatively.

additional partial-thickness flap offset in the direction of the periosteum is elevated by sharp dissection using a scalpel. leaving periosteum on the bone. Although leaving periosteum on the bone certainly has advantages in terms of postoperative wound healing, clinical experience has shown that it is generally better to harvest subepithelial connective tissue grafts with periosteum, even if enough tissue is available without periosteum. Subepithelial connective tissue grafts with periosteum have superior mechanical stability, which is a tremendous advantage in terms of clinical handling, for example, when the graft is adapted to the shape of the defect or when the graft is sutured to the defect (Fig 7-11).

Palatal subepithelial connective tissue grafts harvested with periosteum often require secondary extraoral adaptation. A proven way to do this is to spread and press the graft onto a wet glass slab using surgical forceps. Two pairs of forceps and an assistant may be needed for large

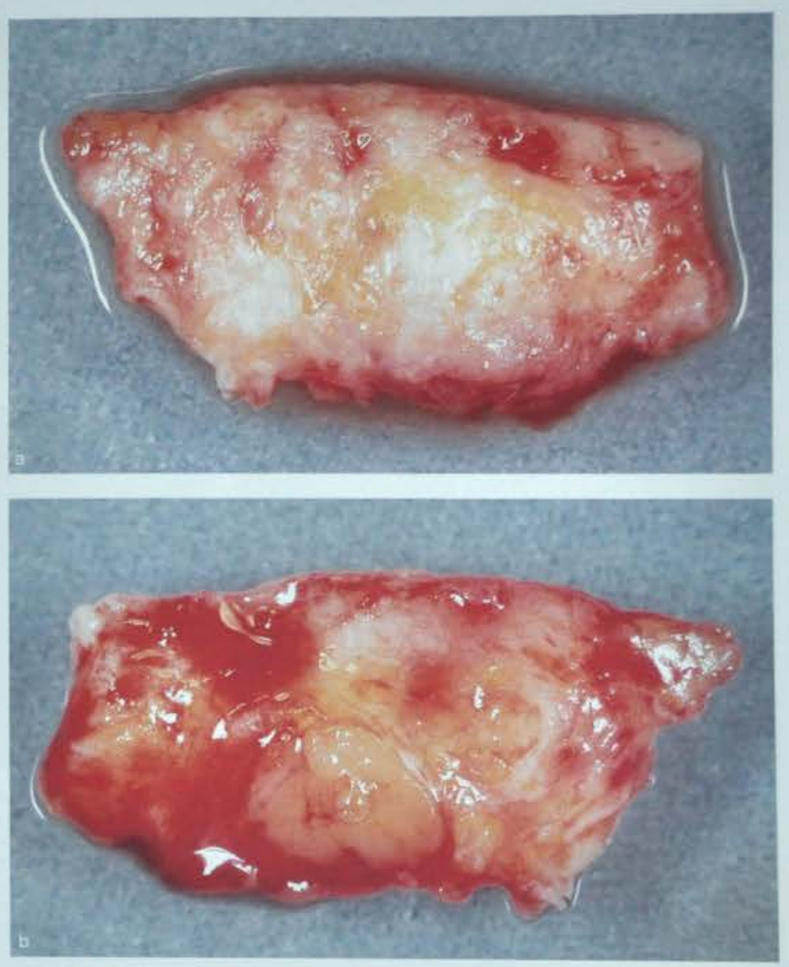


Fig 7-11 Subepithelial grafts with periosteum (a) are superior to those without periosteum (b) in terms of mechanical stability. This translates into numerous advantages in ease of intraoperative handling. Clinical experience has shown that it is generally better to harvest palatal subepithelial connective tissue grafts with periosteum.

grafts. A fresh No. 15 scalpel blade is used to cut the graft to the desired size and shape and thin the connective tissue as needed (Fig 7-12). To prevent dehydration, the graft must be stored in physiologic saline until further use.

The suture technique used to close the surgical site also has a significant impact on the course of postoperative wound healing, particularly on whether primary wound healing occurs. Parallel and crossed horizontal sling sutures are recommended for these indications. The placement of sling sutures around the maxillary posterior teeth has a wound compressing effect that is particularly beneficial in terms of promoting hemostasis and primary approximation of wound margins (Fig 7-13).

The routine use of a surgical stent after harvesting of subepithelial connective tissue grafts from the palate is recommended for many reasons. First, the stent applies pressure to the wound, which promotes postoperative hemostasis and wound healing, as already described.

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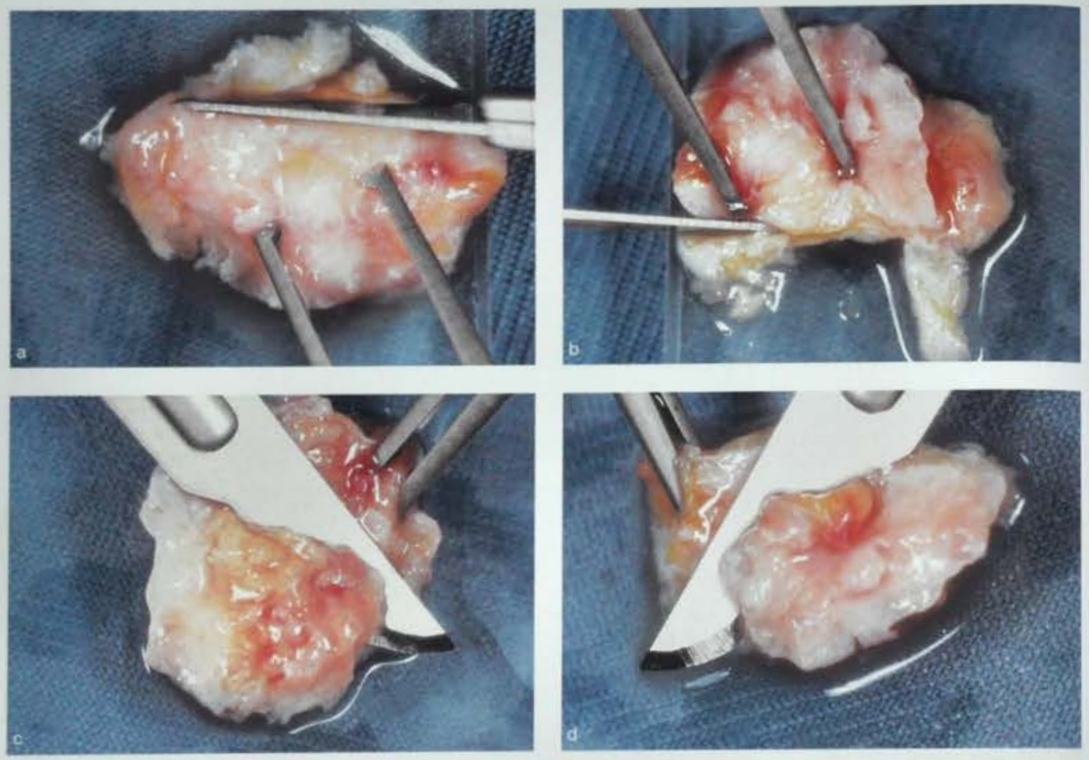


Fig 7-12 Extraoral adaptation of palatal subepithelial connective tissue grafts harvested with periosteum is often necessary. (a and b) A proven way to do this is to first spread and press the graft on a wet glass slab using surgical forceps. (c and d) A fresh No. 15 scalpel blade is used to cut the graft to the desired size and shape and to thin the connective tissue as needed.

Second, the stent enables a rapid and effective response to intraoperative or postoperative bleeding (see chapters 14 and 16). Third, the stent not only protects the palatal donor site from mechanical irritation but also enhances patient comfort considerably during the first postoperative days. This benefit should not be underestimated. The time and cost of manufacturing the stent should, of course, be minimized. From a clinical perspective, surgical stents made of thick vacuum-formed materials are cost-effective and provide reliable service for these indications (Fig 7-14).

When a surgical stent is used after soft tissue is harvested from the palate, it is generally possible to dispense with complicated suturing techniques, such as the horizontal sling sutures described earlier, and to use simpler sutures, such as continuous sling sutures.

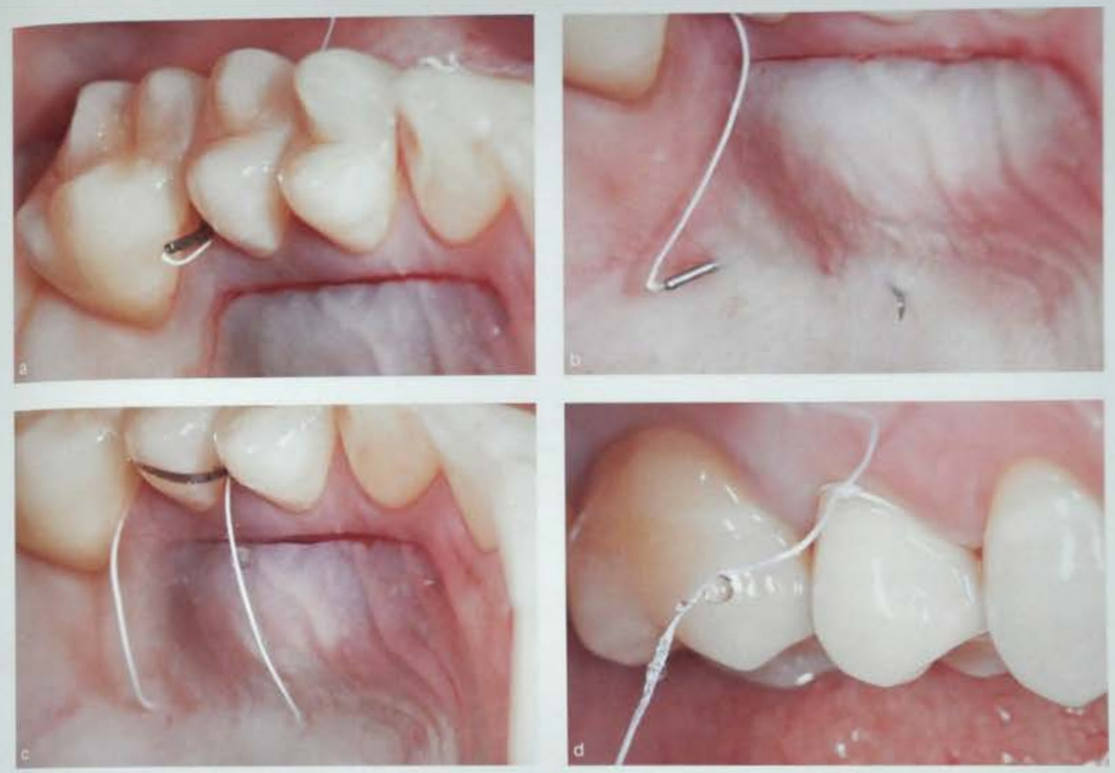


Fig 7-13 (a to d) Procedure for placement of parallel and crossed horizontal sling sutures to close the surgical wound after a subepithelial connective tissue graft is harvested from the palate. (a) First, a Gore-Tex CV-5 suture on a needle is passed, swaged end first, through the interdental space between the first molar and second premolar in a buccal to palatal direction without piercing the tissue. (b) Next, the needle is inserted in the palatal mucosa parallel to the first incision and guided from distal to mesial so that it emerges in the space between the first and second premolars. (c) The needle is then passed, swaged end first, back through the interdental space between the second and first premolars. (d) The suture knot is tied on the buccal side. To prevent trauma to the marginal periodontium of the looped tooth, care must be taken to ensure that the knot is positioned coronal to the gingival margin of the tooth. The ends of the suture are not cut at this time.

The amount of tissue needed for defect reconstruction is often greater than the amount of tissue available, even if harvested from both sides of the palate. Therefore, it is sometimes necessary to harvest subepithelial connective tissue from the palate at two different times. *Harris* et al[31] showed that this type of second surgery causes no significant problems if the second procedure is performed after a 2- to 3-month interval.

Although it is easier to obtain a thick free mucosal graft, such as those used for socket seal surgery, than it is to harvest a subepithelial connective tissue graft, the conditions for survival of the free mucosal graft in the recipient bed are disproportionately less favorable. The parts of the graft with epithelium in socket seal procedures are not covered by a flap with a blood supply but remain exposed to the oral cavity. Hence, the clinician

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Fig 7-13 (e and f) The same suture procedure is repeated in reverse. (e) First the needle is passed through the space between the first and second premolars from buccal to palatal. (f) Then the needle is inserted on the palatal side from distal to mesial (close to the initial insertion and exit sites) and passed back through the interdental space. The second knot is then tied on the buccal side, and the suture ends are cut.



Fig 7-13g Clinical situation after completion of suturing. The horizontal sling sutures placed around the maxillary premolars exert pressure on the surgical wound on the palate. This wound compressing effect promotes hemostasis and primary wound healing.











Fig 7-14 (a to e) A surgical stent is made preoperatively based on an alginate impression. The resulting cast is used to manufacture the stent with 3-mm thick thermoforming material. To obtain themost defined and most secure fit possible, several undercuts should be placed in the areas corresponding to the palatal surfaces of maxillary posterior teeth. If, during stent fabrication, it becomes clear that it will not be possible to achieve adequate retention in this manner, it sometimes helps to pull the surgical stent buccally over the tooth surfaces and anchor it like a miniplast splint.

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Fig 7-15 To ensure the survival of the thick free mucosal grafts used in socket seal surgery, it is crucial to make certain that the graft is thick enough and harvested congruent to the graft bed.

must consider the factors important for graft survival when the graft is harvested as well as the factors relating to recipient site preparation (see chapter 12). First, it is important to ensure that the "punch" is thick enough. The thicker the graft, the larger the wound surface areas accessible to diffusion and revascularization in the recipient bed following surgery. Because the palatal mucosa is thickest in the premolar region, it is advisable to harvest thick free mucosal grafts from this part of the palate. However, to avoid wound healing problems, it is crucial to ensure that periosteum is left on the bone.

It is also important to harvest the graft congruent to the soft tissue opening of the extraction socket in order to minimize the distances to be covered by diffusion and revascularization. In this respect, the harvesting of slightly overextended grafts appears to have additional advantages in terms of optimal shape adaptation. Standardized punches are not well suited for harvesting overextended grafts. Instead, the tissue should be harvested with a scalpel after the extraction socket is measured precisely (Fig 7-15). Surgical stents should be routinely used after thick free mucosal grafts are harvested from the palate.

Connective tissue grafts from the maxillary tuberosity

The maxillary tuberosity is the second important donor site for autogenous connective tissue. Connective tissue from the tuberosity area contains less fat and glandular tissue but much more collagen than that from the lateral palate. As explained before, grafts with loose tissue are better suited to achieve more ideal postoperative wound healing in the course of plasmatic circulation and revascularization than are those with dense tissue. In this respect, the very dense, coarse, and collagen-rich connective tissue from the maxillary tuberosity is certainly inferior and more susceptible to necrosis than that from the palate. Therefore, if a subepithelial connective tissue graft from the maxillary tuberosity is to be used, it is crucial that it can be completely embedded and covered by the flap during augmentation. Clinical experience suggests that subepithelial connective tissue grafts from the maxillary tuberosity are less susceptible to postoperative shrinkage than those from the palate, but currently no scientific data exist to confirm this hypothesis.

Technically, the procedure for harvesting a subepithelial connective tissue graft from the maxillary tuberosity corresponds to that for the distal wedge incision in classic periodontal surgery. Residual epithelium must be removed before the graft is placed in the recipient site. The use of a surgical stent is not required after a subepithelial connective tissue graft is harvested from the maxillary tuberosity (Fig 7-16).

7.1.4 Autograft Substitutes

As previously mentioned, the amount of autologous tissue available for bone and connective tissue autografts is limited. In most clinical situations, a second surgical site is needed to obtain a sufficient quantity of autograft material, which increases the burden on the patient and the morbidity of the surgical procedure considerably. Because of these significant disadvantages, the search for suitable autograft substitutes is currently at the center of numerous efforts by scientists in university research groups and the industry, for the good of the patient.

Three basic types of graft substitute material can be distinguished: *allogeneic* (from the same species, ie, of human origin), *xenogeneic* (from another species, eg, of porcine or bovine origin), and *alloplastic* (of artificial origin). As both allogeneic and xenogeneic materials have repeatedly become the focus of discussion due to the potential for immunologic reactions and the risk of transmission of pathogenic viruses, bacteria, and prions, development of alloplastic graft substitute materials seems to be more promising.[32,33]

The performance of graft substitute materials in the reconstruction of hard and soft tissue defects will always be measured against that of the gold standard, the autograft. In terms of their biologic properties, the graft substitute materials currently available on the market are inferior to autografts. Although most allogeneic, xenogeneic, and alloplastic graft substitute materials have tissue-conductive properties, they are cell-free graft materials unable to exert any tissue-genetic effects. Furthermore, it must be assumed that graft substitute materials do not have tissue-inductive properties unless mixed with autologous tissues. The proteins responsible for tissue induction in natural tissues are either inactivated or removed during chemical processing of allogeneic graft and xenograft materials.

In spite of these disadvantages, graft substitute materials have two distinct advantages: They are available in unlimited quantities, and they dispense with the need for a second surgical site, which considerably reduces the morbidity of the procedure. The extent to which the tissue-inductive properties of graft substitutes can be improved (eg, by adding synthetic growth proteins or bioactive substances) and the extent to which innovative medical technologies such as tissue engineering will make it possible to use graft substitute materials in more clinical indications and, thus, partly or completely dispense with the need for autografts for defect reconstruction in plastic-esthetic periodontal and implant surgery remain to be seen.

Bone substitute materials

While *allogeneic* bone substitute materials have lost importance for the reasons described earlier, *alloplastic* bone substitute materials have gained importance in recent years, as reflected by the intensified research and developmental efforts in this direction. Hydroxyapatite and tricalcium phosphate derivatives are the most commonly used alloplastic bone substitute materials. They are classified as either calcium hydroxyapatites or as α– or β–tricalcium phosphates, depending on their chemical crystalline structure and their stoichiometric composition.[34] Some alloplastic products on the market today contain 60% hydroxyapatite and 40% tricalcium phosphate, but clinical studies demonstrating the particular suitability of this combination of bone substitute materials are lacking. Bioactive glass ceramics have also been the subject of numerous experimental research projects.[35] As the results are inconsistent, the use of these materials currently cannot be recommended.

Xenografts are the most important bone substitute materials used in contemporary periodontal and implant surgery. These are calcium phosphate–based products manufactured from materials such as coral or deproteinized bovine bone.[36,37] Deproteinized bovine bone materials such as Bio-Oss are widely used today. Bio-Oss is the best studied and documented bone graft substitute currently available on the market.

Osteoconduction is a property that all allogeneic, xenogeneic, and alloplastic bone graft substitute materials have in common, though the extent of osteoconductivity varies. Pore size plays a crucial role in bone ingrowth into bone substitute materials. *Klawitter* and *Hulbert*[38]



Fig 7-16 Subepithelial connective tissue graft harvested from the maxillary tuberosity.

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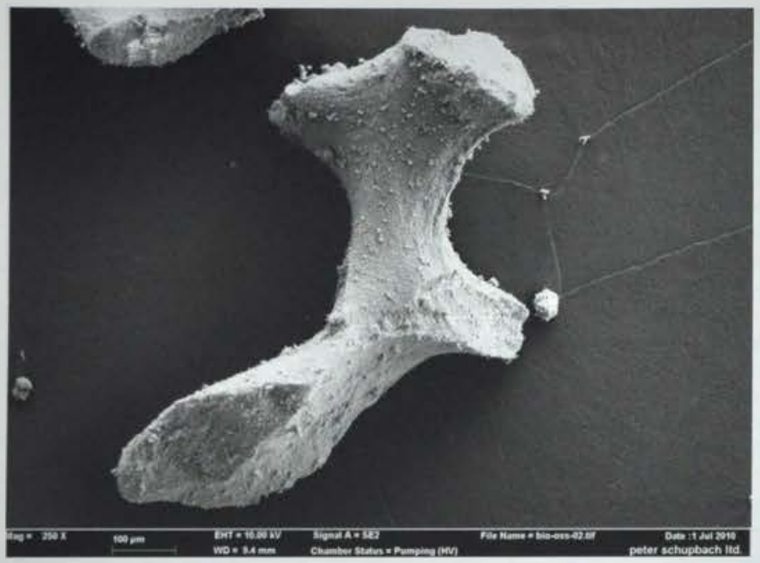


Fig 7-17 Scanning electron microscopic image of a xenogeneic bone substitute material (Bio-Oss particles). Recent evidence suggests that pore size and the presence of interconnected pores have a significant effect on the osteoconductive properties of these materials. Particle size also appears to play an important role. (Courtesy of *Peter Schüpbach*, Zurich, Switzerland.)

demonstrated that the minimum pore size needed for mineralized bone formation is approximately 100 µm, and that needed for the formation of osteon-like structures is 200 µm. The presence of interconnected pores of sufficient diameter has an additional positive effect on bone apposition of bone substitute materials.[39] Particle size also seems to have a significant effect on bone regeneration. *Shapoff* and colleagues[40] demonstrated in animals that freeze-dried bone allografts with a small particle size (100 to 300 µm) are associated with significantly more new bone formation than are those with a large particle size (1,000 to 2,000 µm). Hence, the use of small-particle bone allografts has a positive effect on osteogenesis (Fig 7-17).

Some of the bone substitute materials described are available not only in granular form but also as block grafts.[41] The use of block grafts in routine clinical practice cannot be recommended because of the scarcity of experimental and clinical studies on these grafts.

Key points:

Ideal bone substitute materials should be sterile, should not induce adverse immune reactions, should have mechanical properties similar to those of natural bone, and should have a high osteoconductive capacity. Those developed in the future should also have osteoinductive properties. None of the currently available bone substitute materials meets all of these criteria. Of all the many bone substitute materials on the market today, Bio-Oss particles made of deproteinized bovine bone material come closest to the ideal. In addition to having an ideal particle size for bone regeneration (0.25 to 1.00 mm), Bio-Oss has interconnected pores of sufficient diameter and the necessary biomechanical stability. Compared to other bone substitute materials as well as to autogenous bone, Bio-Oss has a much slower and lower resorption rate, particularly in reconstructed defects, which can be an advantage, particularly in the esthetic zone.[42–44] Regarding the potential transmission of diseases, it was shown that chemical and thermal processing of the material by the manufacturer completely inactivates and leaches out proteins in the bone. Consequently, there can be no risk of infection from the potential transmission of bacteria, viruses, or prions.[45] Currently, autogenous bone particles must be added to Bio-Oss to achieve an osteoinductive effect (Fig 7-18).

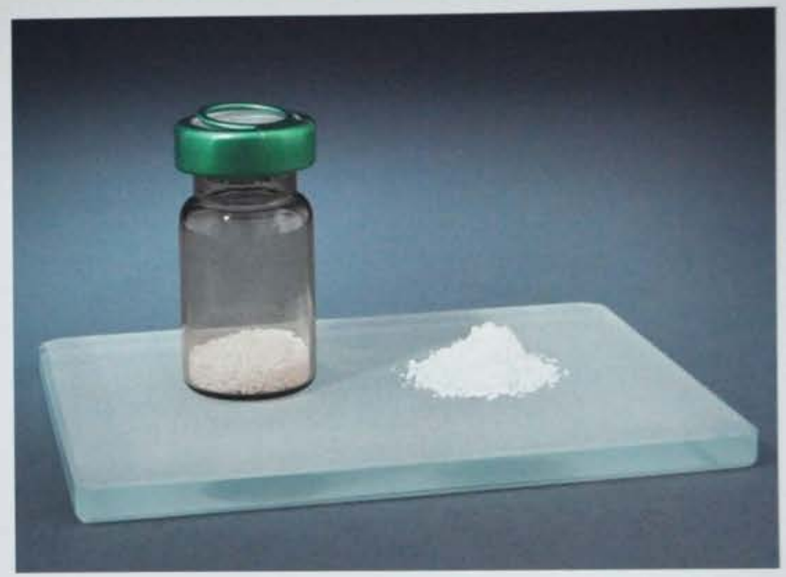


Fig 7-18 For the moment, Bio-Oss, a bovine-derived xenograft with a particle size of 0.25 to 1.00 mm, is the material that comes closest to being an ideal bone substitute material.

Connective tissue substitute materials

Unlike bone substitute materials, research and development into autogenous connective tissue substitute materials is still in its infancy. At this point in time, no *alloplastic* connective tissue substitute materials are available; of the available *allogeneic* substitutes, AlloDerm is currently the focus of scientific interest.[46] According to the manufacturer, AlloDerm is a biocompatible acellular connective tissue matrix without epithelial components. Although the histologic structure of AlloDerm grafts and connective tissue autografts are very different 6 months postoperatively, the process of graft incorporation appears to be similar.[47]

As with connective tissue autografts, evidence suggests that recession coverage with AlloDerm also results in increased marginal soft tissue thickness. Six months after treatment with a coronally positioned flap with and without an acellular dermal matrix (AlloDerm). *Woodyard* et al[48] found that marginal soft tissue thickness was greater in the group treated with a coronally positioned flap plus AlloDerm than in that treated with a flap alone. However, the results of clinical studies comparing the efficacy of AlloDerm and autogenous connective tissue grafts in the treatment of gingival recession are not uniform. Although some studies showed results comparable to those of *Woodyard's* group,[49–51] others showed that AlloDerm was inferior to autogenous connective tissue grafts.[52–54] Another study comparing the clinical results of gingival recession treatment using a subepi-

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Fig 7-19 Scientific efforts to develop substitute materials for connective tissue autografts are still in their infancy. Shown is a prototype of a porcine collagen–based xenogeneic substitute material.

thelial connective tissue graft and an acellular dermal matrix allograft suggests that keratinized tissue gain is lower with AlloDerm.[55]

Mucograft, a recently developed porcine collagen matrix, provides a *xenogeneic* alternative to autologous subepithelial connective tissue grafts. A randomized clinical trial comparing the ability of Mucograft and free mucosal grafts to increase the width of keratinized tissue in patients with fixed prosthetic restorations yielded very promising results.[56] Nevertheless, scientific evidence justifying the use of this product as a substitute for autologous subepithelial connective tissue is currently lacking (Fig 7-19).

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7.2 Procedures

7.2.1 Harvesting a Bone Block Graft from the Mandibular Angle

KEY POINTS

01. First, palpate the ascending ramus of the mandible and then make the distal crestal incision while *maintaining continuous contact with bone.*

02. To reliably prevent damage to the neurovascular bundle in the mandibular canal, do not extend the osteotomy *too far distally or into the cancellous bone.*

03. Smooth any *sharp edges of bone* in the donor site after graft removal.

04. If there is heavy bleeding, use oxidized regenerated cellulose (Tabotamp) or another suitable material for *hemostasis.*

05. Give the *patient* complete and comprehensive *postoperative instructions.*

WORKPLACE PREPARATION CHECKLIST

Autograft harvesting is never a stand-alone procedure but is always performed in conjunction with one of the surgical procedures described in the following chapters. Therefore, instead of describing the details of workplace preparation here, the reader is referred to the respective sections on procedures in conjunction with which autografts are used.

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STEP PROCEDURE



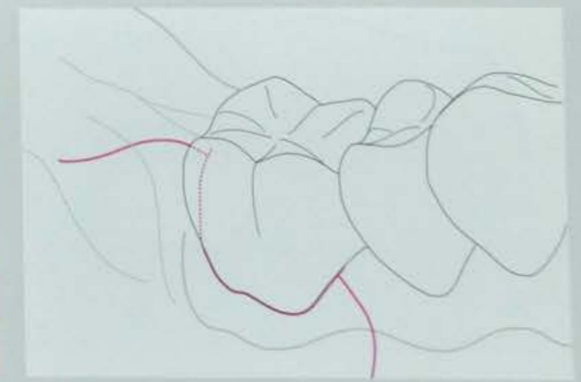




Figs 7-20 to 7-22 Clinical situation before harvesting of an autogenous bone block graft from the mandibular angle. The ascending ramus of the mandible should be palpated distal to the last molar to reliably ensure that the incision is made in continuous contact with bone. The angle between the imaginary line extending from the mandibular arch and the ascending ramus is usually about 50 degrees.







Figs 7-23 to 7-25 A No. 12d scalpel blade is used to make the crestal incision starting from the distolingual aspect of the last molar. The incision is extended distally and laterally toward the external oblique line while maintaining constant contact with bone. The length of the crestal incision is determined by the size of graft required and the anatomical limitations. Next, the intrasulcular incision is made around the distal and buccal aspect of the last molar with a No. 15 scalpel blade. Lastly, a vertical releasing incision is made on the mesial line angle of the last molar.

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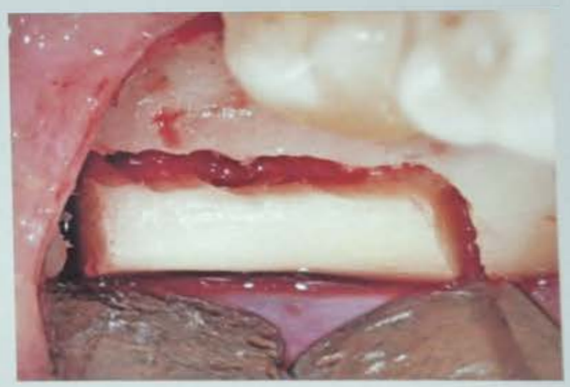
Figs 7-26 and 7-27 Starting from the vertical releasing incision, a mucoperiosteal flap is elevated with a papilla elevator and periosteal elevator, and the osseous structures around the external oblique line are exposed to a length of about 3 cm and a depth of roughly 2 cm. The situation after completion of flap elevation is shown in Fig 7-27 (bottom).





Figs 7-28 and 7-29 The initial osteotomy site preparation is made with a small, sharp Lindemann bur. The mesial vertical osteotomy is made at the level of the mesial border of the first molar. The distal vertical osteotomy should be extended distally only as far as absolutely necessary, depending on the size of the defect to be reconstructed. The vertical cuts should both end approximately 1 cm apical to the external oblique line. To prevent injury to the neurovascular bundle in the mandibular canal, the osteotomy should be extended only so far that it just reaches the cancellous bone. If bleeding from the osteotomy site is detected, the site should not be cut any deeper. Next, the first horizontal osteotomy is made coronally, parallel to the course of the mandibular posterior teeth. To avoid penetrating too deep into the cancellous bone, the osteotomy is made median to and a slight distance away from the external oblique line, which corresponds to the thickness of the compact bone in this area. The actual compact bone thickness can be reliably estimated based on the vertical osteotomies just completed.

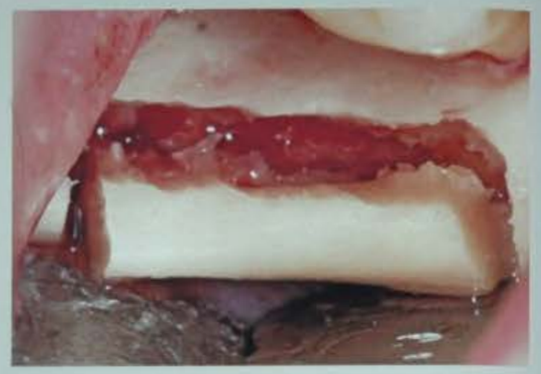




Figs 7-30 and 7-31 The second horizontal osteotomy is performed approximately 10 mm apical to the external oblique line using a high-carbon steel round bur. This notch merely marks the breaking point and should not penetrate the compact bone completely. If bone particles are to be collected during osteotomy, a bone filter must be used during drilling. To prevent contamination of the graft by oral microorganisms, the bone filter should not be attached until immediately prior to osteotomy and removed immediately thereafter. Naturally, only fresh bone particles from the osteotomy site should be collected during drilling. The situation after completion of osteotomy is shown in Fig 7-31 (right).

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Figs 7-32 to 7-34 The osteotome is rotated cautiously in the osteotomy site to break off the prepared piece of bone laterally. The resected bone fragment and bone particles must be stored in physiologic saline until further use.







Fig 7-35 to 7-37 Following osteotomy, all sharp bone edges should be smoothed with a high-carbon steel round bur to prevent wound healing complications. If there is major bleeding from the bone, a local hemostatic agent made of oxidized regenerated cellulose (eg, Tabotamp) should be placed in the defect site. Finally, the flap is returned to its original position and secured with interrupted sutures of Gore-Tex CV-5.

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Figs 7-38 Complete healing is observed 3 months after surgery.

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 1: Autograft Harvesting, Chapter 1: Harvesting a Bone Block Graft from the Mandibular Angle."

7.2.2 Harvesting a Subepithelial Connective Tissue Graft from the Palate

KEY POINTS

01. Make the initial incision:
- *2.0 mm apical* to the gingival margin.
- *Perpendicular* to the tissue surface.
- *1.0 to 1.5 mm deep.*
- Extend *from the mesial border of the first molar to the lateral incisor.*

02. Create a partial-thickness incision of uniform depth.

03. The depth of the partial-thickness incision should roughly correspond to the *length of the cutting portion of the scalpel blade.*

04. Leave a *coronal shelf of soft tissue* when cutting the graft.

05. Harvest the graft *with periosteum.*

06. Use a continuous sling suture or parallel and crossed horizontal sling sutures for *stable closure* of the surgical wound.

07. Always use a *surgical stent.*

08. Give the *patient* complete and comprehensive *postoperative instructions.*

WORKPLACE PREPARATION CHECKLIST

Autograft harvesting is never a stand-alone procedure but is always performed in conjunction with one of the surgical procedures described in the following chapters. Therefore, instead of describing the details of workplace preparation here, the reader is referred to the respective sections on procedures in conjunction with which autografts are used.

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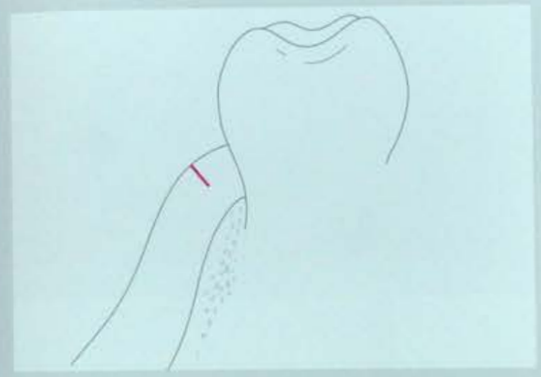
STEP-BY-STEP PROCEDURE



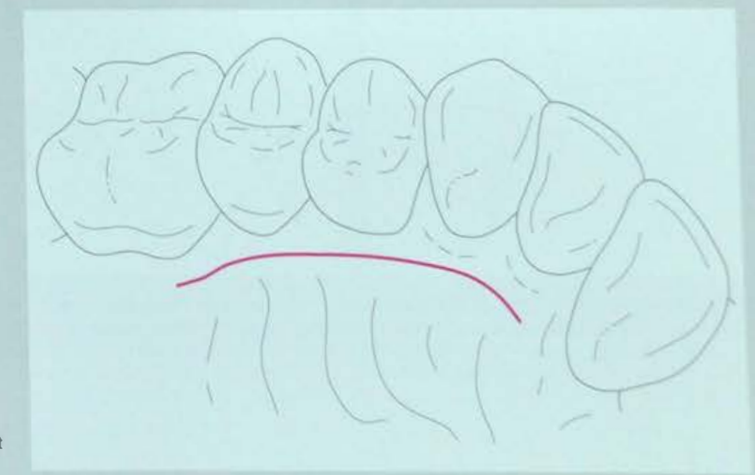
Fig 7-39 Clinical situation before harvesting of a free subepithelial connective tissue graft from the palate.











Figs 7-40 to 7-44 The initial incision is made approximately 2 mm from the gingival margin (depth of about 1.0 to 1.5 mm), cutting along the row of teeth from distal to mesial. The incision starts at the mesial border of the first molar and extends to the lateral incisor. It is crucial to ensure that the scalpel blade is kept strictly perpendicular to the tissue surface.

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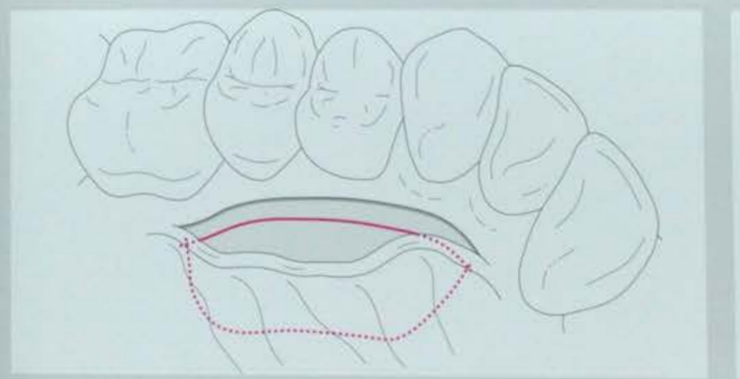
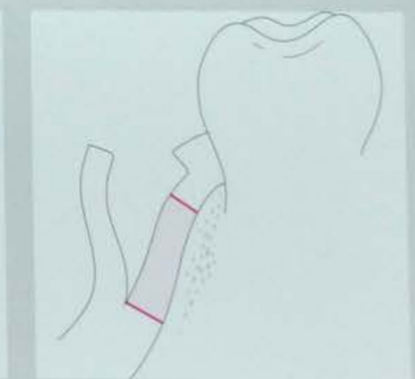





Figs 7-45 to 7-50 A No. 15 scalpel blade is used to make an undermining incision from distal to mesial, and a partial-thickness flap is elevated from the palatal mucosa. To ensure that the incision will provide a flap of sufficient dimension throughout, it is important to gradually increase the angle of the blade until it is parallel to the palatal surface by making repeated distal to medial movements, especially with the tip of the scalpel. The undermining incision is made approximately 8 mm apical to the initial incision line; the cutting portion of the scalpel blade can be used as a gauge of this distance.





Figs 7-51 to 7-56 When the contours of the graft are cut, the incisions are extended to the bone in such a way that they overlap at intersections. The coronal horizontal incision is placed approximately 1.5 mm apical to the initial incision, resulting in the creation of a small soft tissue shelf on which the flap can rest postoperatively. This makes it easier to achieve the goal of primary wound healing.

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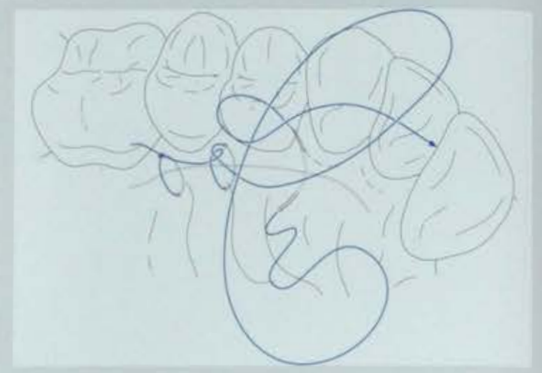

Figs 7-57 to 7-60 A periosteal elevator is used to remove the graft with periosteum by blunt dissection. To prevent dehydration, the graft must be stored in gauze soaked in physiologic saline until further use.



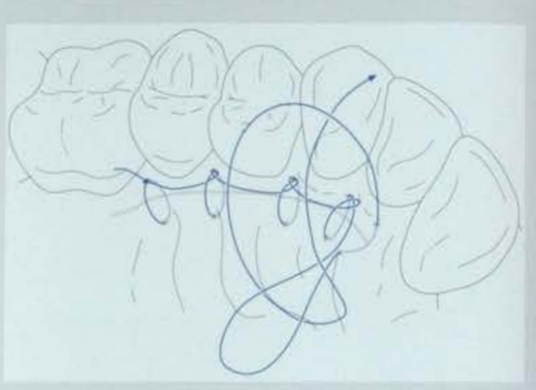

Figs 7-61 and 7-62 The site is closed with a continuous sling suture of Gore-Tex CV-5. The needle is inserted through the flap at the level of the interdental space between the first molar and second premolar, approximately 4 to 5 mm apical to the incision, and is made to emerge at the base of the papilla between the two teeth. Subsequently, the first knot is tied and the short end of the suture is cut.

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Figs 7-63 to 7-67 The needle is inserted through the flap and marginal gingiva at the level of the interdental space and is passed continuously to the lateral incisor in the same manner as before. The needle holder is always inserted through the crossed suture loop held in the left hand before the needle is grasped at the emergence site. After the last suture is made, a knot is tied and the suture is cut.



Fig 7-68 Clinical situation immediately prior to suture removal 1 week later.

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Fig 7-69 Complete healing is observed 3 months after surgery.



See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 1: Autograft Harvesting, Chapter 2: Harvesting a Subepithelial Connective Tissue Graft from the Palate."

7.2.3 Harvesting a Thick Mucosal Graft from the Palate

KEY POINTS

01. *Measure the marginal circumference* of the extraction socket to be sealed.

02. *Transfer the measurements* to the donor site, preferably the premolar area of the palate.

03. Cut the graft *slightly larger* than the measurements.

04. Keep the incision *perpendicular* to the tissue surface and 2 mm away from the gingival margin.

05. Harvest *as thick* a graft *as possible* while still leaving the periosteum on the bone.

06. Use *tissue adhesive* to dress the palatal donor site.

07. Always use a *surgical stent*.

08. Give *the patient* complete and comprehensive *postoperative instructions*.

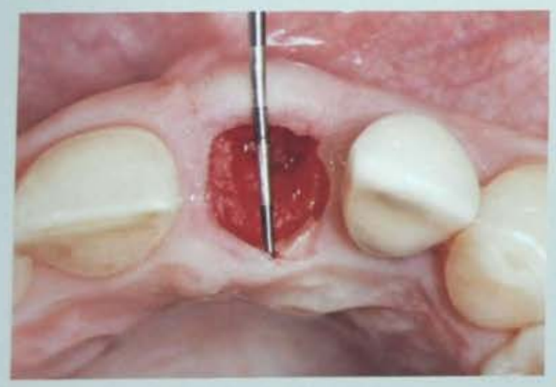
WORKPLACE PREPARATION CHECKLIST

Autograft harvesting is never a stand-alone procedure but is always performed in conjunction with one of the surgical procedures described in the following chapters. Therefore, instead of describing the details of workplace preparation here, the reader is referred to the respective sections on procedures in conjunction with which autografts are used.

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STEP-BY-STEP PROCEDURE







Figs 7-70 to 7-72 Clinical situation before harvesting of a thick free mucosal graft from the palate for socket seal surgery. First, a periodontal probe is used to precisely measure the soft tissue opening over the extraction socket to be treated.







Figs 7-73 to 7-75 The measurements are carefully transferred to the donor area on the palate (preferably in the premolar region).

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Figs 7-76 to 7-78 To allow the graft to be adequately shaped to the recipient site later, it is advisable to make the graft slightly larger than the measurements. However, the incision must be kept about 2 mm from the gingival margin.






Figs 7-79 to 7-82 The incision is made around the predetermined marks while the scalpel blade is held strictly perpendicular to the surface. Although the goal is to obtain as thick a graft as possible, the periosteum must always be left on the bone. Therefore, the incision ends directly above the periosteum, and the graft is removed from the donor site by sharp dissection.

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Figs 7-83 to 7-85 The donor site is closed with Histoacryl tissue adhesive and covered with a surgical stent. To prevent dehydration, the graft is stored in gauze soaked in physiologic saline until further use.

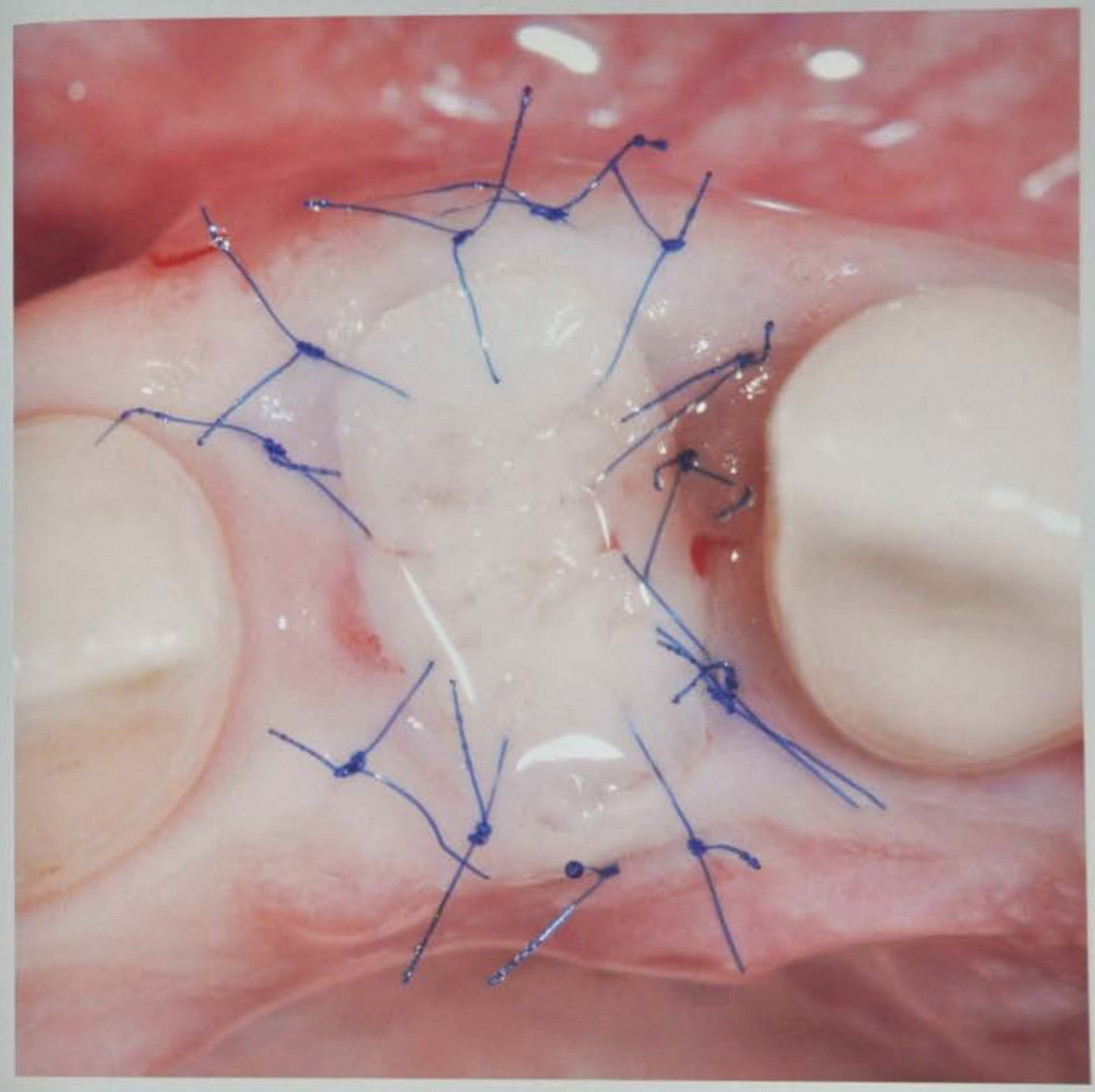


Fig 7-86 Postoperative situation immediately after suture closure.

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Fig 7-87 Clinical situation 1 week after surgery.



Fig 7-88 Complete healing is observed 3 months after surgery.

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 1: Autograft Harvesting, Chapter 3: Harvesting a Thick Mucosal Graft from the Palate."

7.2.4 Harvesting a Subepithelial Connective Tissue Graft from the Maxillary Tuberosity

KEY POINTS

01. Make a *triangular wedge incision* distal to the last molar:
- As far distal as possible while remaining within the masticatory mucosa.
- Perpendicular to the tissue surface.
- 1.0 to 1.5 mm deep.

02. Make an *undermining partial-thickness incision* buccal and palatal up to the mesial surface of the last molar.

03. Dissect the wedge-shaped graft *supraperiosteally*.

04. *Close the donor site* with interrupted sutures and a crossed periosteal suture.

05. Give the *patient* complete and comprehensive *postoperative instructions*.

WORKPLACE PREPARATION CHECKLIST

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STEP-BY-STEP PROCEDURE

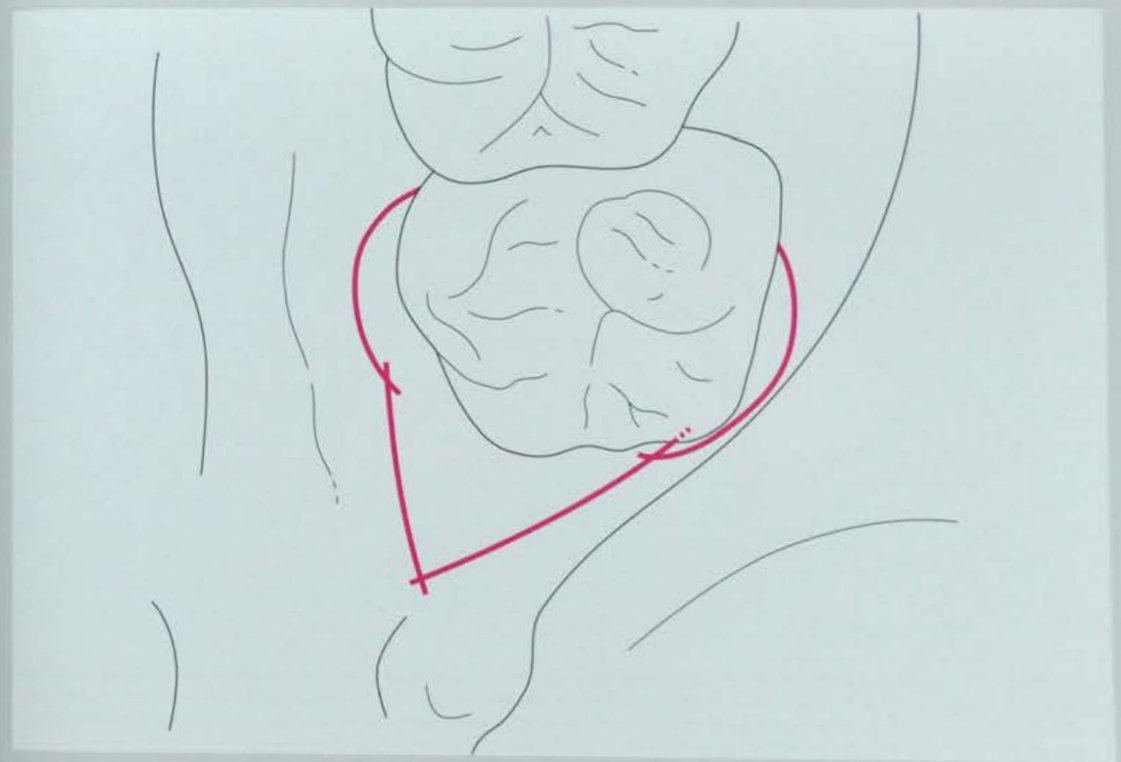




Figs 7-89 and 7-90 Clinical situation before harvesting of a subepithelial connective tissue graft distal to the maxillary second molar. The bone level indicated by the periodontal probe confirms that there is a good supply of tissue in this area.





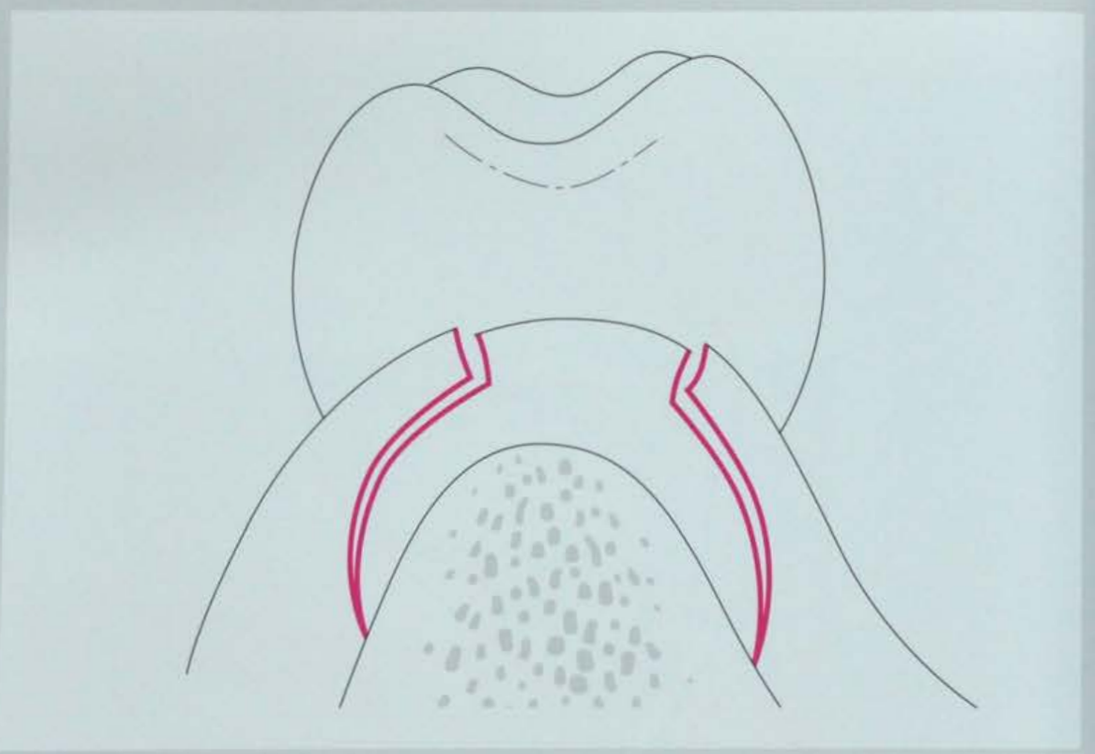


Figs 7-91 to 7-93 Two converging incisions are made with a No. 15 scalpel blade. They should start at the distal surface of the last molar and extend as far distally as possible while remaining in the masticatory mucosa. The incisions should be made perpendicular to the surface to a depth of approximately 1.0 to 1.5 mm. To harvest as large a volume of tissue as possible, the incisions should include all of the soft tissue around the distal tooth surface.

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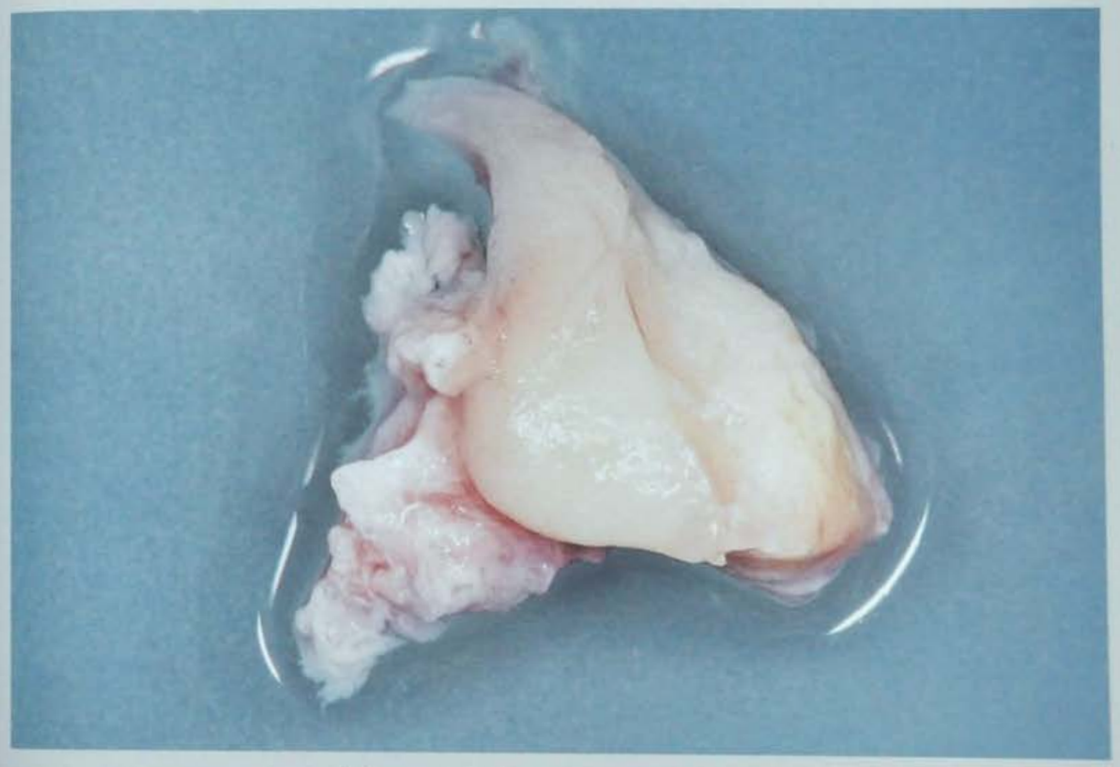




Figs 7-94 to 7-96 After the intrasulcular incision around the last molar is completed, an undermining partial-thickness incision is made with a No. 15 scalpel blade. This incision starts at the distal incisions and is extended buccally and palatally up to the mesial surface of the same tooth. The scalpel is guided successively parallel to the buccal or palatal soft tissue surfaces to yield a partial-thickness flap of uniform thickness throughout. The situation after completion of flap elevation is shown in Fig 7-96 (bottom).



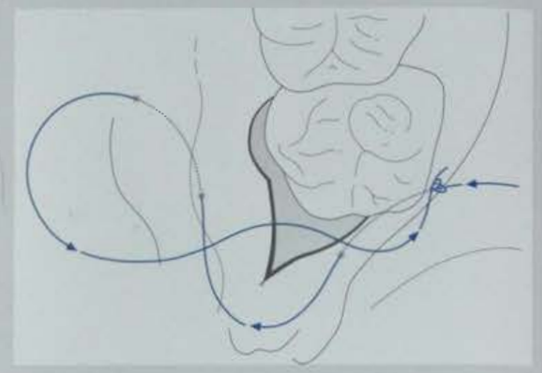




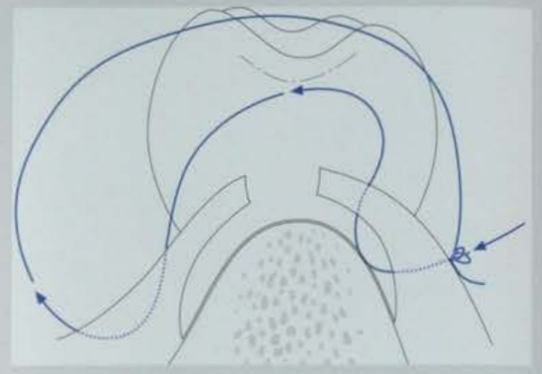
Figs 7-97 to 7-99 After a supraperiosteal incision is made, the graft is removed from the donor site by sharp dissection. Figure 7-99 (bottom) shows the wedge-shaped connective tissue graft immediately after harvesting. To prevent dehydration, the graft must be stored in gauze soaked in physiologic saline until further use.

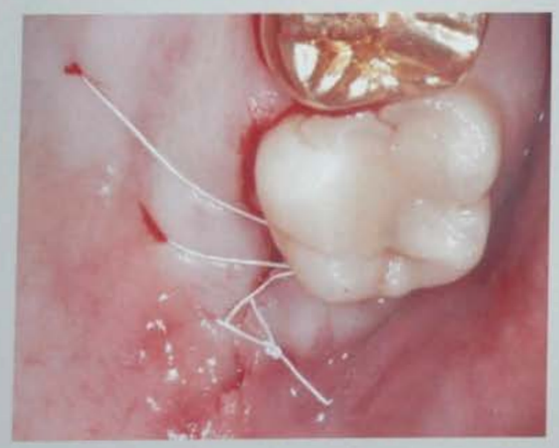
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Figs 7-100 to 7-104 The donor site is closed with a crossed periosteal suture of Gore-Tex CV-5. The first suture is placed externally, slightly coronal to the mucogingival junction, through the buccal flap. First, the needle enters slightly mesial to the distal surface of the last molar, passes obliquely through the flap in an apicocoronal direction, and emerges in the coronal portion of the buccal flap, slightly distal to the last molar. Next, the needle enters the palatal flap distal to the donor site, passes through it horizontally, from distal to mesial, and emerges on the buccal side, where the suture knot is tied. Anchorage of the suture in this manner (by the periosteum buccally and by the masticatory mucosa palatally) serves two purposes: apical flap repositioning and wound compression. Interrupted sutures can be used to close the remaining wound areas in the distal region, but it is acceptable to leave these small areas open to heal by secondary intention because the periosteum has been left on the bone.



Fig 7-105 Clinical situation immediately prior to suture removal, 1 week later.

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Fig 7-106 Complete healing is observed 3 months after surgery.

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 1: Autograft Harvesting, Chapter 4: Harvesting a Subepithelial Connective Tissue Graft from the Maxillary Tuberosity."

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CHAPTER 8

GINGIVAL AUGMENTATION

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8.1 Theory

8.1.1 Indications

There are a number of different indications for gingival augmentation. Gingival grafts are most commonly used to augment gingival tissue in order to cover exposed roots, stabilize the soft tissue, and prevent further gingival recession, but they are also used to mask discolored roots of endodontically treated teeth that show through the thin gingival tissues.

Gingival augmentation to prevent gingival recession following prosthetic treatment

Visibility of the tooth-restoration interface can be a cosmetic problem when supragingival restoration margins are placed in the esthetic zone. Therefore, many dentists use subgingival restoration margins in the anterior region (Fig 8-1).

However, this cosmetic solution is a biologic compromise because the preparation of intrasulcular restoration margins generally results in mechanical trauma to the affected soft tissue.[1] Intrasulcular restoration margins result in increased plaque accumulation and inflammatory changes in the surrounding soft tissue, which can ultimately lead to a loss of periodontal attachment and gingival recession.[2] Restoration margins that were originally intrasulcular can ultimately drift to a supragingival position over time. In a clinical long-term study of approximately 300 crowns placed with originally subgingival restoration margins, *Valderhaug*[3] demonstrated that roughly 40% and 70% of the crown margins had shifted to a supragingival position after 1 and 10 years, respectively.

Current evidence suggests that a narrow band of keratinized gingiva does not increase the risk of gingival recession, even at sites with subgingival restoration margins, but a low marginal soft tissue thickness does (see chapter 1). Therefore, gingival recession can be expected to develop over the long term if subgingival restoration margins are used at sites with thin marginal soft tissues.

To avoid this problem and the associated loss of periodontal attachment, intrasulcular restoration margins preferably should not be used in the first place. Manufacturers are working to develop new materials and systems where the tooth-restoration interface is made as inconspicuous as possible, which is particularly important in the facial region. The use of all-ceramic materials and adhesive bonding techniques with tooth-colored composite materials play an important role in these new restorative concepts.

If there is a significant color difference between the tooth and the restoration, it may be impossible to conceal the tooth-restoration interface, especially if the tooth becomes discolored after endodontic treatment. Internal bleaching can successfully eliminate this problem in many cases. Although the risk of recurrence cannot be excluded, the risk of complications is usually minimal when bleaching is performed correctly.[4,5] In teeth with post-and-core restorations, however, internal bleaching is contraindicated if post removal would endanger the tooth; subgingival margin placement is then the only way to obtain a good cosmetic result. The goal of treatment in these patients must be to keep the restoration margins within the sulcus over the long term and to ensure that they do not shift to a supragingival position. Prophylactic gingival augmentation can have a positive effect on the long-term outcome of treatment in these cases because it is likely to stabilize the soft tissues and prevent further gingival recession (see chapter 1).

Hirsch et al[6] came to the same conclusion after performing flap debridement surgery with a subepithelial connective tissue graft in the mandibular anterior region for surgical treatment of periodontitis in a series of 14 patients. In their study, open flap debridement was performed (ie, the roots of the involved teeth were scaled and cleaned) after placement of an intrasulcular incision and elevation of an access flap. Before flap closure, a subepithelial connective tissue graft harvested from the palate was sutured to the defects to augment the buccal soft tissue. Although surgical debridement with flap repositioning normally results in significant gingival recession, the mean recession depths in these patients had decreased by nearly 2 mm 6 months postoperatively and decreased even further at 19 to 58 months of follow-up. The authors concluded that flap debridement combined with a subepithelial connective tissue graft is an effective way to prevent gingival recession after surgical treatment of periodontitis.

Key point:

Gingival augmentation can help to stabilize the soft tissue and prevent further gingival recession after placement of restorations with intrasulcular restoration margins, especially in patients with thin gingival biotypes (Fig 8-2).





Fig 8-1 (a and b) The tooth-restoration interface of anterior restorations is often placed in the sulcus to avoid esthetic problems, but this cosmetic solution is a biologic compromise.

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Fig 8-2a Clinical situation before prosthetic treatment. Because of the great color difference between the natural tooth roots and the desired shade of the new crowns, the restoration margins had to be placed within the sulcus to achieve a good cosmetic result. Preprosthetic gingival augmentation was performed to prevent further gingival recession due to the patient's thin gingival biotype.





Fig 8-2 (b and c) After insertion of the long-term provisional restorations, a connective tissue graft harvested from the palate was placed for gingival augmentation. Complete healing is observed 5 months after surgery.

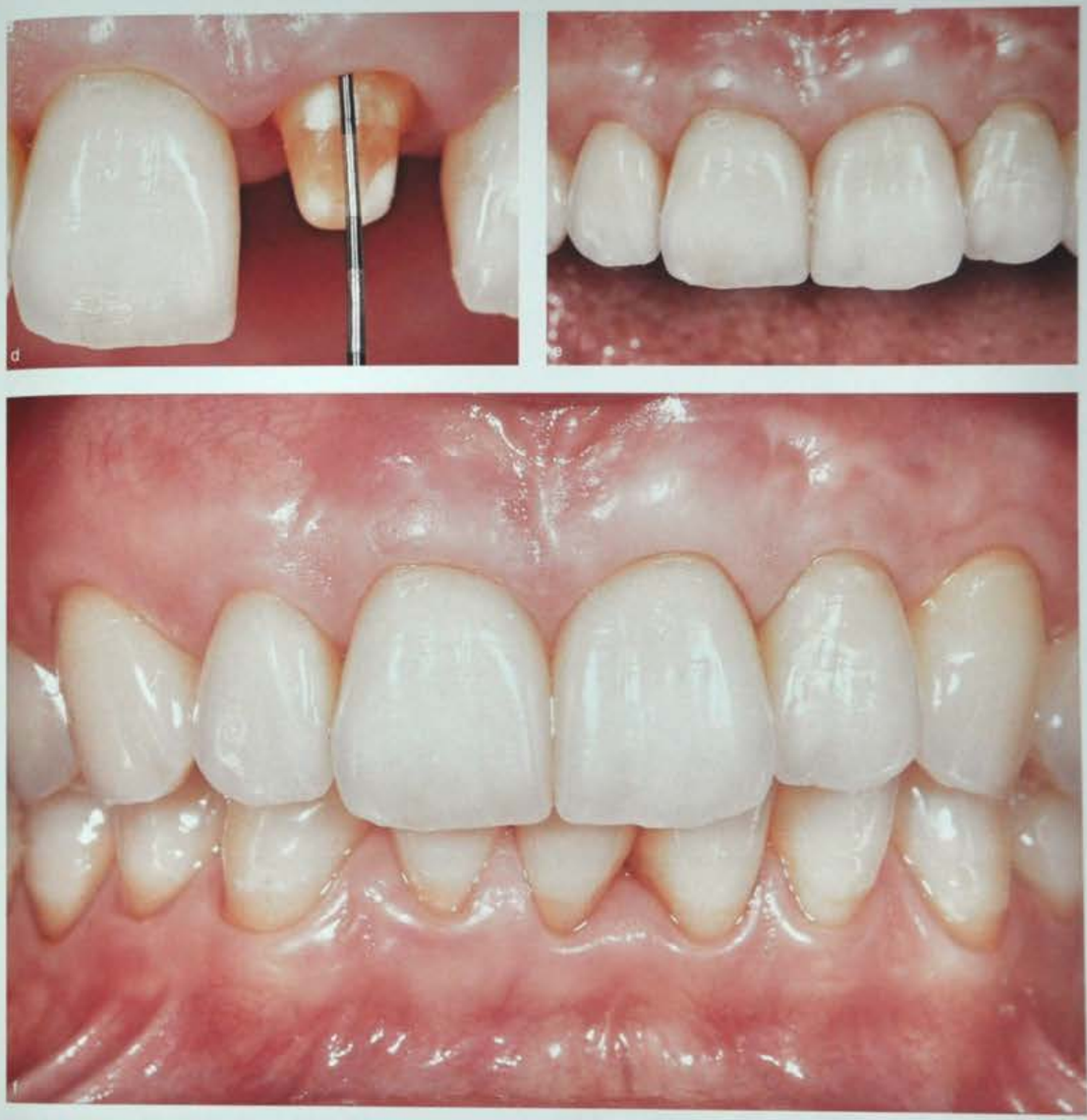


Fig 8-2 (d to f) Clinical situation during and after placement of the final restoration in the significantly thickened gingiva.

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Fig 8-2g The patient after completion of treatment. (Dental technician *Uli Schoberer*, Seehausen, Germany.)

Gingival augmentation to reduce gingival translucency

Jung et al[7] investigated in vitro color changes in soft tissues caused by restorative materials placed below the surface of experimental sites with different mucosal thicknesses. Four different test specimens made of titanium and zirconia with and without zirconia ceramic veneers were placed under the mucosa in the test region. The color changes in the test groups were measured by spectrophotometry and compared to changes in control specimens without materials placed under the mucosa. Relative to the control group, color changes occurred in all test groups but decreased with increasing mucosal thickness. Unlike titanium, zirconia did not induce any visible color changes once mucosal thickness reached 2 mm, regardless of whether the material was placed with or without veneers. At a mucosal thickness of 3 mm, no change in color could be distinguished by the human eye in any of the specimens, including those made of titanium (Fig 8-3 and Table 8-1).

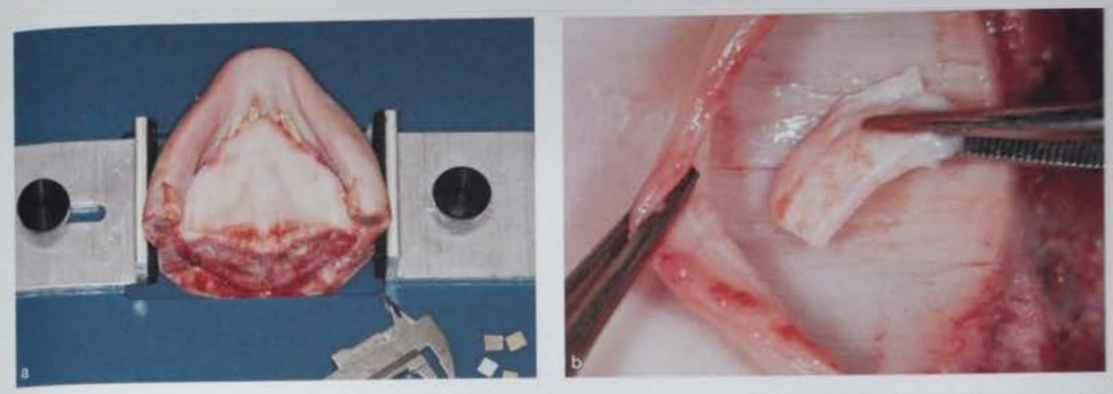


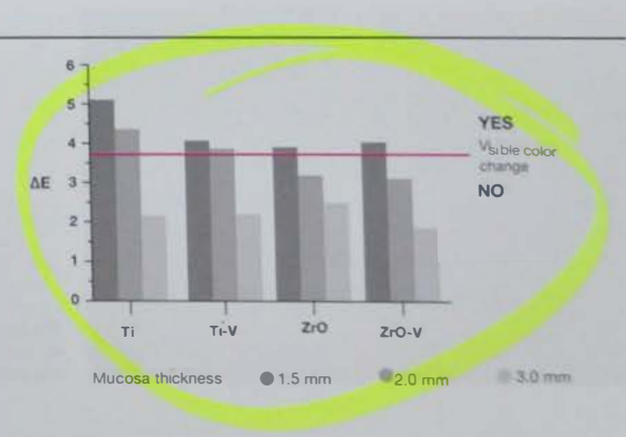
Fig 8-3 (a and b) Color changes induced by the test specimens in the central palatal areas of pig maxillae. To simulate different mucosal thicknesses, connective tissue grafts of different thicknesses were harvested from additional pig jaws and placed under the palatal flaps to yield defined mucosal thicknesses of 1.5 mm, 2.0 mm, and 3.0 mm.[7]



Fig 8-3 (c and d) The test was performed using four different test specimens made of titanium and zirconia with and without zirconia ceramic veneers. The test specimens were placed under the mucosa, and the color of the tissue was evaluated by spectrophotometry at the different soft tissue thicknesses.[7]

Table 8-1

All of the investigated materials resulted in a relative color change (ΔE), the intensity of which decreased with increasing mucosal thickness. Unlike titanium, zirconia did not induce any visible color changes from a mucosal thickness of 2.0 mm, regardless of whether it was placed with or without veneers. At a mucosal thickness of 3.0 mm, no change in color could be distinguished by the human eye in any of the specimens, including those made of titanium.[7] Ti: titanium; Ti-V: veneered titanium; ZrO: zirconia; ZrO-V: veneered zirconia.



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Table 8-2

Mean gingival thickness measured roughly 2 mm apical to the gingival margin, as determined by ultrasound by *Eger* et al[9]

	Central incisor	Lateral incisor	Canine	First premolar	Second premolar
Gingival thickness, maxillary	1.28 mm (± 0.40)	1.14 mm (± 0.39)	0.89 mm (± 0.34)	1.05 mm (± 0.35)	1.06 mm (± 0.42)
Gingival thickness, mandibular	0.87 mm (± 0.33)	0.91 mm (± 0.35)	0.83 mm (± 0.29)	0.75 mm (± 0.21)	0.94 mm (± 0.27)

Assuming these in vitro results can be applied to patients in clinical practice and given the fact that the mean gingival thickness in the maxillary and mandibular anterior regions is approximately 1 mm[8,9] (Table 8-2), it is clear that even if roots of teeth in these areas are only slightly discolored, they may show through the gingiva, resulting in grayness of the gingiva. This can compromise the cosmetic outcome of prosthetic treatment (Fig 8-4).

If the affected tooth is not a candidate for internal bleaching for the reasons specified earlier, gingival augmentation can be performed to make the soft tissue thicker and less transparent. However, the goal is not to establish a gingival thickness of 3 mm. Even if it were possible to surgically obtain a horizontal soft tissue dimension of 3 mm, gingiva this thick would appear hypertrophic and unesthetic. Endodontically treated teeth rarely become as dark as the titanium specimens used in the experiments described above. Therefore, it should be possible to achieve good cosmetic results at sites with gingival thicknesses of less than 3 mm in many patients.

Key points:

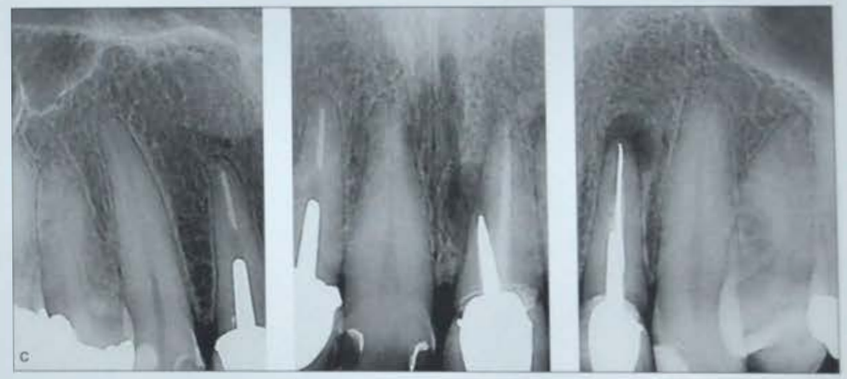
The lighter the color of the affected tooth root, the higher the probability of complete masking of discoloration after gingival augmentation; the darker the root, the greater the probability of color deviation after gingival augmentation (Fig 8-5). If a heavily discolored root can be treated by internal bleaching, a combination of bleaching and augmentation is likely to produce the best results. Regarding the color of the affected root, it does not appear to make a significant difference whether metal posts or tooth-colored post materials are used for post-and-core buildup.[10]



Fig 8-4 Even if the roots of endodontically treated teeth are only slightly dark and discolored, they may show through the gingiva, resulting in grayness of the gingiva.



Fig 8-5 (a and b) Clinical example of soft tissue augmentation performed to reduce gingival translucency without additional internal bleaching. Pretreatment photographs clearly reveal the grayness of the gingiva around the endodontically treated maxillary right lateral incisor (tooth 12), left central incisor (tooth 21), and left lateral incisor (tooth 22), on which crowns are to be placed.



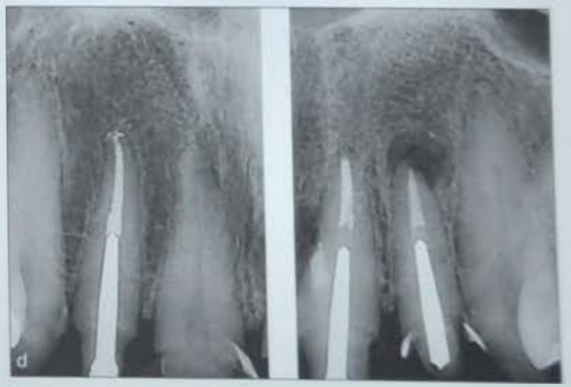


Fig 8-5 (c and d) For teeth 12 and 22, the metal post-and-core restorations were removed, the root canal fillings were revised, and internal bleaching was performed. In the case of tooth 21, the post-and-core restoration was removed, the root canal filling was revised, and a perforation was sealed. Because internal bleaching of tooth 21 was contraindicated due to the risk of complications, gingival augmentation was performed to reduce the visibility of the dark root, which was showing through the gingiva.

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Fig 8-5e Clinical situation immediately before placement of the final restoration 5 months after placement of the provisional restoration, internal bleaching of teeth 12 and 22, and gingival augmentation at tooth 21.





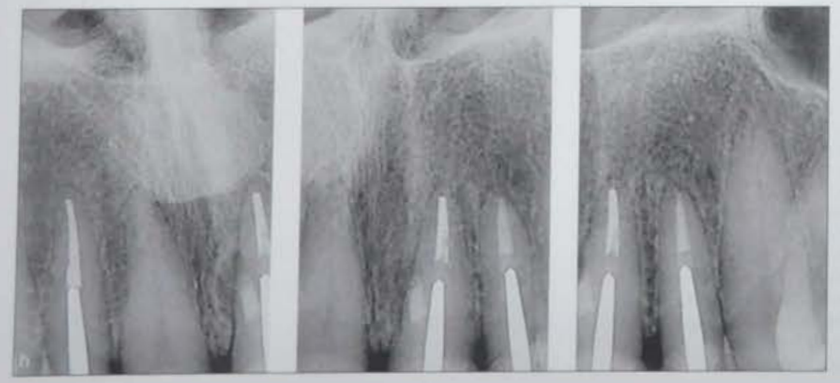


Fig 8-5 (f to h) Clinical and radiographic situation after placement of the final restoration. Compared to baseline, the cosmetic improvement is significant even though a slight gray shadow can still be seen on the gingiva around tooth 21.



Fig 8-5i The patient is shown at completion of treatment. (Endodontic treatment: *Wolf Richter*, Munich; dental technician: *Uli Schoberer*, Seehausen, Germany.)

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Fig 8-6 Gingival recession has developed in the mandibular anterior region after orthodontic treatment.

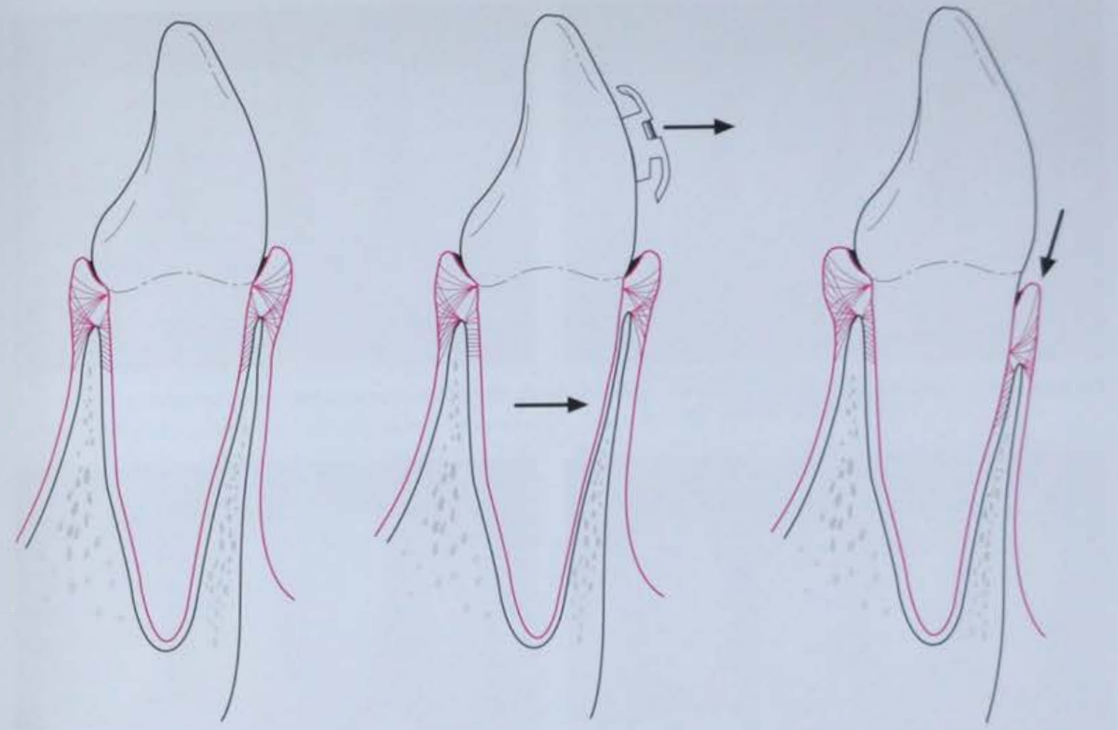


Fig 8-7 Labial gingival recession secondary to orthodontic treatment can always occur at sites with dehiscence of bone or when orthodontic treatment causes buccal displacement of a tooth from its socket (arrows). The risk of gingival recession is exacerbated in patients with thin gingival biotypes.

Gingival augmentation to prevent gingival recession following orthodontic treatment

Gingival recession can always occur secondary to orthodontic treatment at sites with dehiscence of bone or when orthodontic treatment causes buccal displacement of a tooth from its socket (Figs 8-6 and 8-7). For details, see chapter 9.

Studies have shown that labial orthodontic tooth movement is always associated with slight recession of the buccal gingiva, regardless of the quality of bony support.[11,12] Investigators have found that, in patients with adequate plaque control, gingival recession is very mild and not associated with a loss of periodontal attachment.[11] Stretching of the buccal gingiva caused by labial tooth movement has been implicated as the cause of the slight apical displacement of the gingival margin.[13] Conversely, loss of attachment and more extensive gingival recession occur at sites with inadequate plaque control.[11,13] No correlation between the extent of gingival recession and the width of keratinized gingiva around the affected tooth has been observed.[11,14] Stretching and thinning of the gingiva are the suspected cause of the reduced plaque resistance and inflammatory gingival recession.[11,13,15] A thin gingiva seems to be the point of least resistance to external stresses such as microbial plaque and toothbrush trauma and therefore increases the risk of gingival recession secondary to orthodontic treatment.

Key points:

The risk of gingival recession is dependent on the extent of tooth movement, the strength of applied orthodontic forces, the presence of plaque or gingival inflammation, and the dimensions of the soft tissue surrounding the tooth.[16] A careful assessment of the periodontal structures surrounding the teeth must be made before orthodontic treatments involving labial tooth movement are performed. As long as tooth movement is restricted to the confines of the alveolar socket, the risk of gingival recession is low, regardless of the dimensions of the surrounding soft tissue. However, if the orthodontic movement is likely to result in buccal dehiscence, the risk of gingival recession is determined by the volume of soft tissue surrounding the tooth. Thin gingiva is associated with a high risk of gingival recession, especially because the orthodontic treatment is likely to result in a further decrease in soft tissue thickness.

To prevent gingival recession secondary to buccal orthodontic tooth movement, augmentation of the marginal gingiva before orthodontic treatment should be considered for patients with thin gingival biotypes. In principle, recession defects can be corrected by periodontal surgery.

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Fig 8-8 (a and b) Gingival augmentation is performed before orthodontic treatment to prevent further gingival recession.



Fig 8-8 (c and d) A significant increase in soft tissue thickness can be seen in these clinical photographs taken 1 week (c) and 5 months (d) after gingival augmentation.

even after completion of orthodontic treatment. However, because periodontal attachment loss can only be regained to a certain extent, every effort should be made to minimize the risk of gingival recession before orthodontic treatment (Fig 8-8). For further details, see chapter 9.

In summary, the goal of gingival augmentation is to increase the volume of soft tissue in the horizontal plane. This serves to reduce the translucency of the gingiva and thus to make the dark roots of discolored endodontically treated teeth less visible.[7] In addition, gingival augmentation can stabilize the gingiva, providing long-term protection against the risk of gingival recession.[17–19] Therefore, gingival augmentation may be indicated as a preventive measure before orthodontic or restorative treatment.

8.1.2 Technical Aspects of Gingival Augmentation

After flap elevation, only minimal coronal repositioning is needed to achieve complete coverage of the connective tissue transplant. For esthetic reasons, the thickness of the subepithelial connective tissue graft should not exceed 1.0 to 1.5 mm. Symmetric augmentation is also important for the esthetic outcome. Therefore, it is recommended that the procedure include augmentation of both central incisors, all four incisors, or all six anterior teeth. Vertical releasing incisions should not be used because of the risk of scarring and disruption of the natural gingival coloration and surface texture in the esthetic zone. The lack of vertical incisions is also better for the blood supply to the flap and graft. Tunnel flap techniques have therefore become established procedures for the treatment of multiple adjacent gingival recessions.

To begin the clinical procedure, a rounded microblade is used to make an intrasulcular incision to start the partial-thickness flap and undermining procedure. To create adequate space for the connective tissue graft, the incision must extend coronally to the base of the papilla and apically beyond the mucogingival junction. The incision must extend at least one tooth wider than the planned augmentation site. Specially designed tunneling blades should be used to prevent flap perforation (see chapter 2). The graft is drawn into the tunnel, positioned, and then secured in place with vertical double-crossed sutures. Interproximal contact points preoperatively splinted with small drops of flowable composite resin serve as suture anchors.

8.1.3 Predictability and Long-Term Stability

Gingival augmentation generally has an excellent prognosis. Scientific data on the long-term stability of augmented gingiva are currently not available.

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8.2 Procedures

8.2.1 Gingival Augmentation with Subepithelial Connective Tissue Graft

KEY POINTS

01. Clean the tooth surfaces *before making the first incision.*

02. *Splint* the contact points with flowable composite resin as needed.

03. Create a partial-thickness flap/tunnel:
- Extending *coronally* to the base of the papilla.
- Extending *apically* beyond the mucogingival junction.
- Extending *laterally* at least one tooth beyond the planned augmentation site.

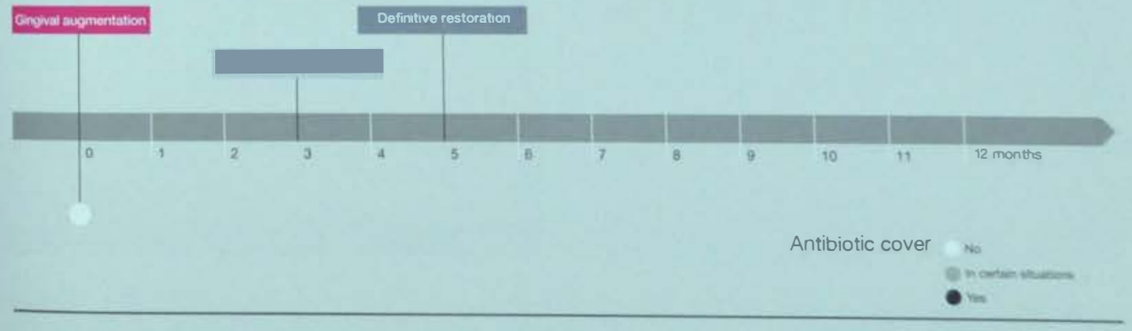
04. Prepare a subepithelial connective tissue graft:
- *Maximum thickness:* 1.0 to 1.5 mm.
- Adequate size.

05. Use vertical double-crossed sutures to *secure the connective tissue graft.*

06. Apply *gentle pressure* to the wound for several minutes.

07. Give the *patient* complete and comprehensive *postoperative instructions.*

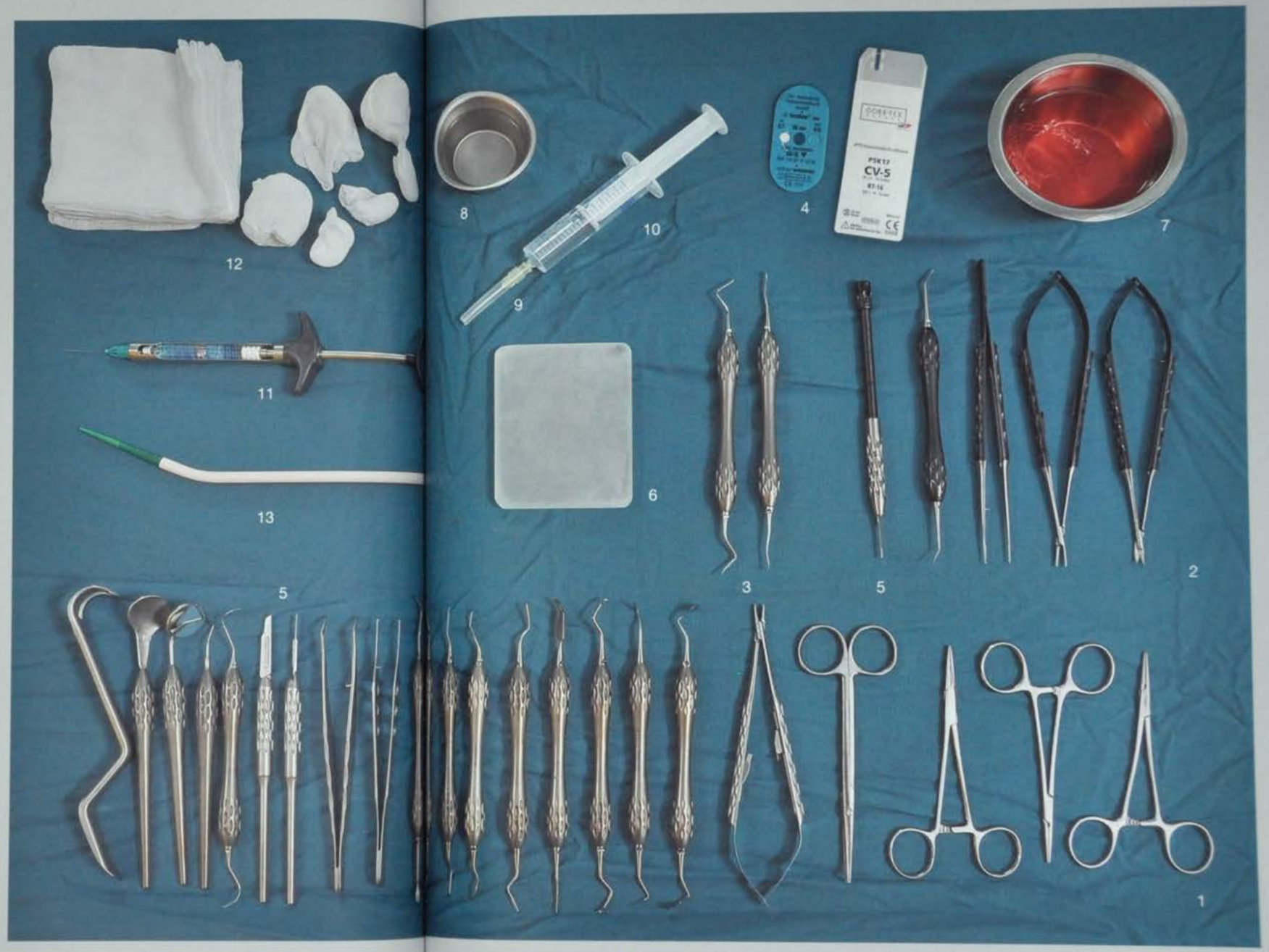
TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Tunneling blades I and II
4. Suture materials: Gore-Tex CV-5 and 6-0 Seralene DS-15
5. No. 15 macroblade and Keydent microblade
6. Glass slab
7. 0.1% chlorhexidine solution in a metal dish
8. Sterile water in a metal dish
9. Blunt cannula
10. 10-mL syringe
11. Local anesthetic
12. Large and small pledgets
13. Periodontal stent



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STEP-BY-STEP PROCEDURE









Figs 8-9 to 8-12 Pretreatment clinical and radiographic features of the maxillary right central incisor (tooth 11), which was restored with a porcelain veneer and became dark and discolored after endodontic treatment. The dark roots can be seen through the soft tissue, resulting in local grayness of the gingiva.





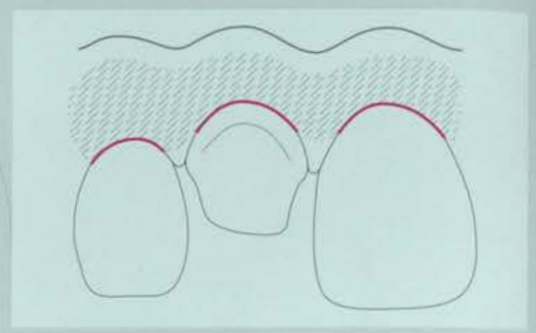
Figs 8-13 and 8-14 At the first appointment, the partial crown is removed and the tooth is prepared for a new crown. The buccal preparation margin is located slightly within the sulcus. A long-term provisional restoration is placed.



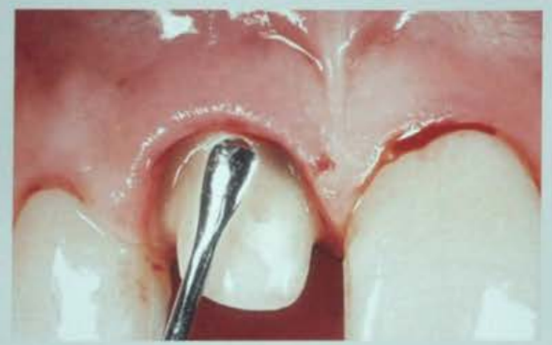
Fig 8-15 The visibility of the periodontal probe through the marginal gingiva demonstrates the lack of thickness and translucency of the gingiva at the affected site.

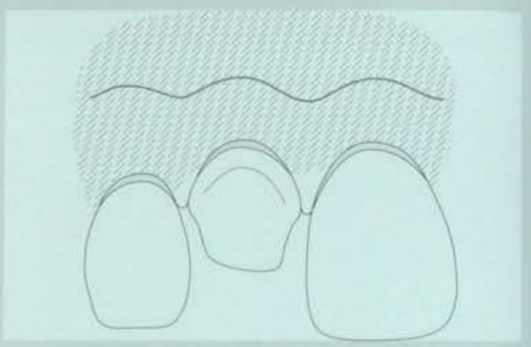
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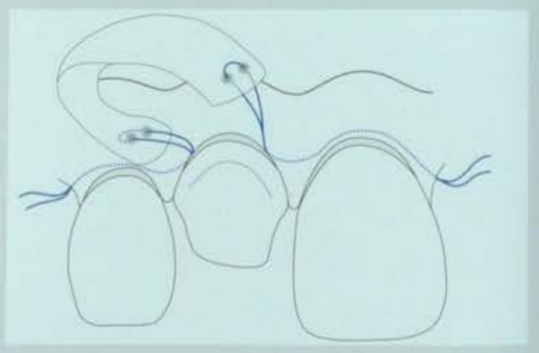
Figs 8-16 and 8-17 Preparation of the recipient site starts with the use of a microblade to create an intrasulcular incision and a partial-thickness flap/tunnel. Sharp undermining of the papilla is limited to the base region. No mobilization of interdental soft tissue is required.





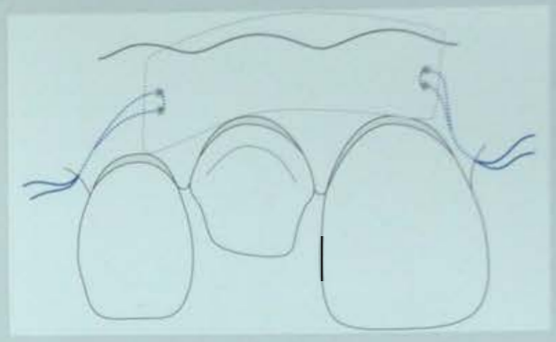
Figs 8-18 and 8-19 The undermining procedure is performed with tunneling blades to minimize the risk of perforation. To ensure adequate space to accommodate the connective tissue graft, the partial-thickness tunnel must extend apically beyond the mucogingival junction. Before the graft is placed, it is important to ensure that the incision is in a single plane, that is, that the tunnel is unobstructed and open.



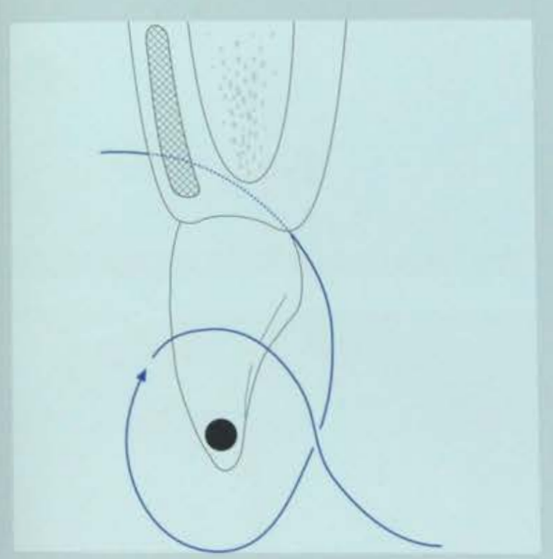


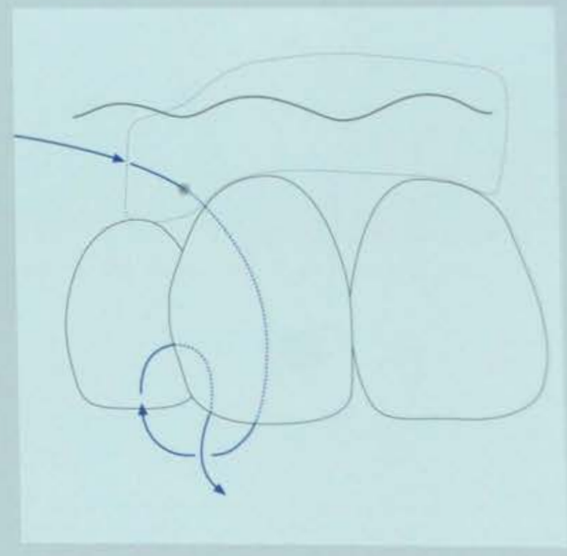
Figs 8-20 and 8-21 The connective tissue graft is drawn into the tunnel with the positioning sutures (Gore-Tex CV-5) as follows: The needle is bluntly inserted in the tunnel (swaged end firs) one tooth lateral to the augmentation site and exits marginal to the tooth where the connective tissue graft is to be placed. The needle then engages the edge of the connective tissue graft—first, from the interior to the exterior, and then, at a slightly more apical position, from the exterior to the interior—before it passes back through the tunnel and returns to the starting position.





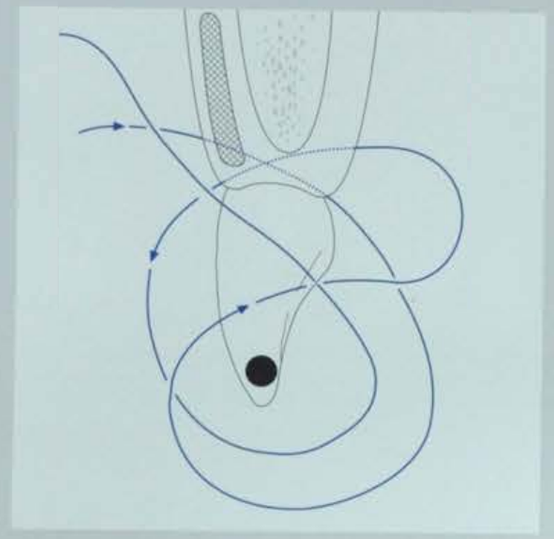
Figs 8-22 and 8-23 Controlled insertion and positioning of the connective tissue graft in the tunnel is achieved by gentle tugging on the positioning sutures. The provisional restoration is placed with a small amount of provisional cement to prevent cement overflow. The interproximal contact points mesial and distal to the provisional restoration are splinted with flowable composite resin without enamel etching.

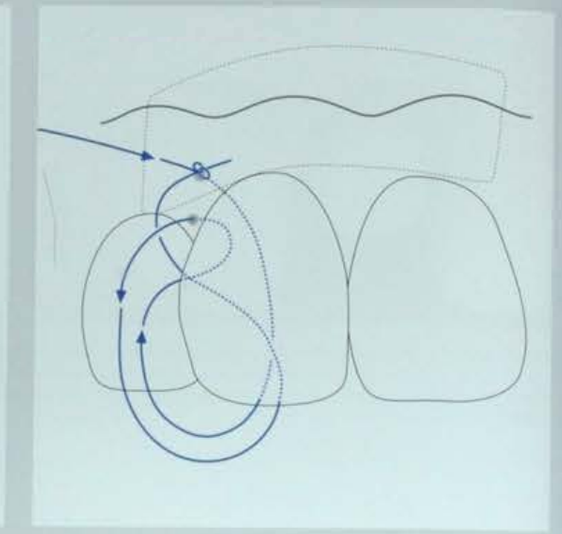


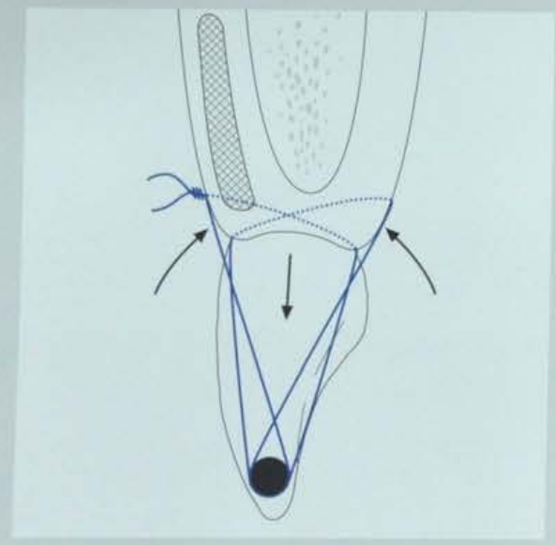


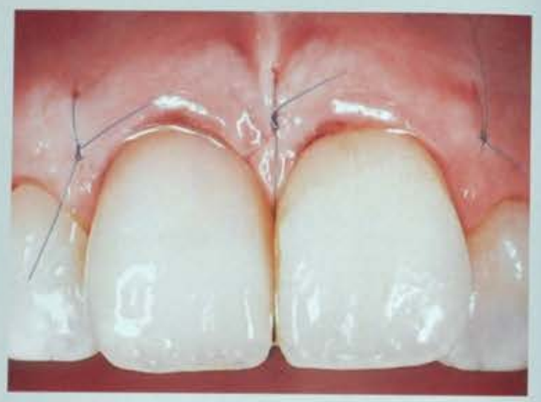
Figs 8-24 and 8-25 The site is closed with three vertical double-crossed sutures (6-0 Seralene DS-15). First suture: Starting on the buccal side, the needle enters slightly coronal to the mucogingival junction, engages the connective tissue graft, passes beneath the splinted contact point, and exits on the palatal side, slightly apical to the tip of the papilla. The needle then returns across the teeth to the buccal side, passes back-first beneath the splinted contact point without engaging the tissue, and exits again on the palatal side.

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Figs 8-26 to 8-30 Second suture: Starting from the palatal side, the needle enters at the base of the papilla and exits slightly apical to the tip of the papilla on the buccal side (without engaging the graft). Next, the needle is guided back to the palatal side and is again passed beneath the splinted contact point, back-first so as not to engage the tissue, and is returned to the buccal side, where the suture is tied. The positioning sutures are then removed, and gentle pressure is applied to the wound for a few minutes.





Figs 8-31 and 8-32 Result 1 week after surgery. The sutures and the composite resin material in the interproximal areas can now be removed. The site has healed without complications.





Figs 8-33 and 8-34 Three months after surgery, internal bleaching is performed with 30% sodium perborate, which is left in the root canal for 1 week.

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Figs 8-35 and 8-36 Five months after gingival augmentation and 2 months after internal bleaching, the gingival translucency has decreased and the grayness of the gingiva has been eliminated.





Figs 8-37 to 8-40 Clinical and radiographic appearance of the site after placement of the definitive restoration, an all-ceramic crown.







Fig 8-41 The patient is shown at completion of treatment. (Endodontic treatment: *Wolf Richter*, Munich; dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery. Volume 2: Gingiva Augmentation with Subepithelial Connective Tissue Graft."

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CHAPTER 9

TREATMENT OF GINGIVAL RECESSION

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Fig 9-1a Periodontitis-related gingival recession usually affects the entire tooth circumference.



Fig 9-1b Toothbrush trauma and malpositioned teeth are the most frequent etiologic factors associated with buccal gingival recession.

9.1 Theory

9.1.1 Epidemiology and Etiology of Gingival Recession

Epidemiologic studies have shown that gingival recession can occur in persons with either good or poor oral hygiene.[1–3] Those with poor oral hygiene tend to be older individuals whose recession defects affect all tooth surfaces and are associated with periodontal disease,[4] whereas those with good oral hygiene are typically younger individuals whose buccal tooth surfaces are primarily affected.[5] Toothbrush trauma and malpositioned teeth are the most frequent etiologic factors associated with buccal recession defects[6–9] (Fig 9-1).

Etiopathogenesis

Gingival recession is a process primarily involving two anatomical structures: the *marginal gingiva* and the underlying *buccal alveolar bone*. Bone dehiscence must be present for gingival recession to occur.[10–12] Bone dehiscence may be a consequence of bone anatomy or may be associated with tooth position, orthodontic tooth movement, inflammatory processes, or occlusal overload.[11,13–17] The main etiologic factors responsible for the development of gingival recession secondary to dehiscence are poor oral hygiene and excessive toothbrushing.[18] Other factors include tension resulting from a high frenum or muscle attachment[19] as well as iatrogenic and self-induced trauma.[7,20–23] Subgingival restoration margins may also result in soft tissue recession[24] (Fig 9-2).

Individuals with a thin gingival biotype have a greater risk of gingival recession than those with a thick biotype (see chapter 1). An association between physiologic aging of the periodontal fiber apparatus and gingival recession has also been discussed.[25–28] However, there does not appear to be a correlation between the width of keratinized gingiva and the development of gingival recession (see chapter 1). Etiologic factors in gingival recession are summarized in Table 9-1.

Stillman's cleft

Gingival recession defects must be distinguished from *Stillman's* clefts, which are soft tissue defects of traumatic etiology.[29] "For decades, occlusal overload was thought to be an etiologic factor for *Stillman's* cleft, but there is no scientific proof to date. *Stillman's* clefts should be treated conservatively by removing plaque and, more importantly, by eliminating the underlying cause of the soft tissue trauma (eg, excessive toothbrushing). If properly treated, *Stillman's* clefts usually disappear spontaneously; otherwise, they may progress to gingival recession (Fig 9-3).

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Fig 9-2 (a and b) Buccal dehiscence defects may result in the development of gingival recession for a number of reasons.

Table 9-1

Etiologic factors in gingival recession

Buccal dehiscence defects	Gingival recession
Anatomical abnormalities	Toothbrush trauma
Malpositioned teeth	Plaque
Orthodontic treatment	Ligament strain or muscle pull
Periodontitis	Iatrogenic causes
Biologic width violation	Oral habits
Occlusal traurna	Subgingival restorations
	Age

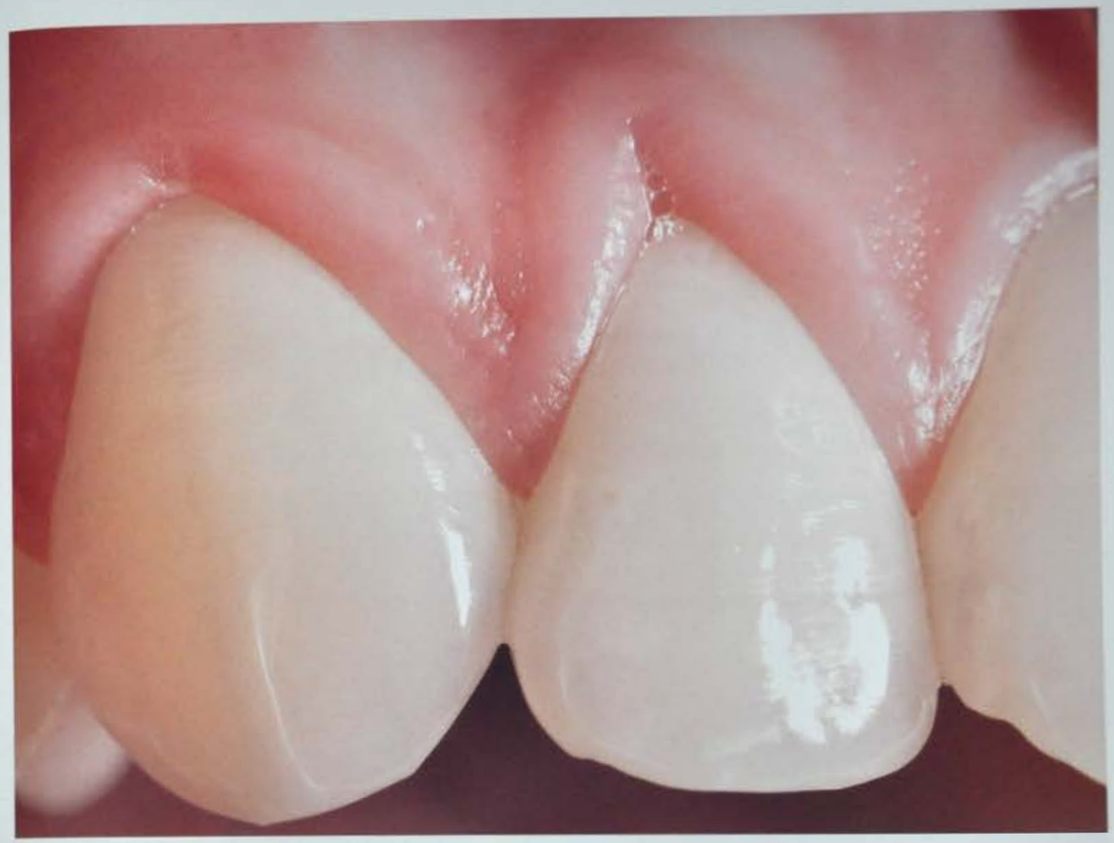


Fig 9-3 *Stillman's* cleft.

9.1.2 Indications for Treatment of Gingival Recession

Because gingival recession is not a risk factor for periodontal disease per se,[30,31] the decision to treat gingival recession is most frequently based on cosmetic reasons. However, in cases where gingival recession has become progressive and the recession sites are susceptible to injury and difficult to clean, there is a medical indication for treatment. Today, the significance of root coverage for treatment of cervical sensitivity or for prevention of root caries has faded into the background because of the availability of other less invasive treatment options[32] (Fig 9-4).

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Fig 9-4 (a) The decision to treat gingival recession is most frequently based on cosmetic reasons. (b) There is a medical indication for treatment in cases where the gingival recession has become progressive and the recession sites are susceptible to injury and difficult to clean.



Fig 9-5 (a to c) After root coverage, healing occurs mainly by the development of long junctional epithelium, resulting in the restoration of periodontal health.

9.1.3 Goals of Gingival Recession Treatment

Periodontal health

The results of animal studies[33–35] and human histologic studies[36,37] illustrate which periodontal healing outcomes can be expected after coverage of gingival recession defects. Repair, consisting of new connective tissue attachment in the most apical region and long junctional epithelium in the coronal part of the covered root surface, results in the restoration of periodontal health (Fig 9-5). Little or no regeneration of alveolar bone can be expected following conventional surgical techniques such as coronally advanced flap (CAF) procedures with or without free connective tissue grafts (CTGs).[38]

Several attempts to achieve periodontal regeneration after treatment of multiple gingival recession defects have been described. The goals of these procedures are to increase the amount of new connective tissue attachment and to achieve the regeneration of both soft tissue and alveolar bone. Some investigators have used tetracycline, citric acid, ethylenediaminetetraacetic acid (EDTA), or fibronectin to condition exposed root surfaces, but

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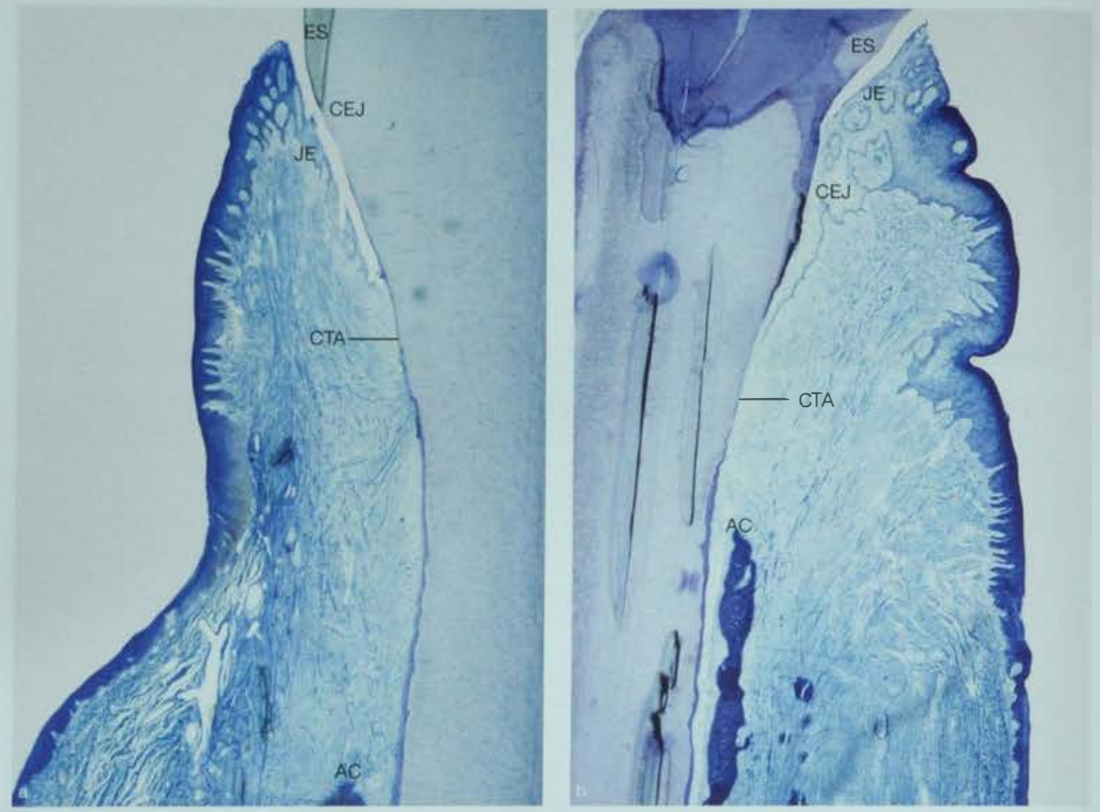


Fig 9-6 Histologic results after root coverage by subepithelial connective tissue graft (a) and guided tissue regeneration (b) in a dog: Healing was predominantly the result of the formation of long junctional epithelium. Both techniques achieved new connective tissue attachment in the apical region, but GTR additionally resulted in the formation of new bone.[35] ES: enamel space; CEJ: cemento-enamel junction; JE: junctional epithelium; CTA: connective tissue attachment; AC: alveolar crest.

none of these agents has demonstrated relevant effects in humans or animals.[39] Other researchers investigated the potential of regenerative procedures and agents to correct gingival recession defects. Guided tissue regeneration (GTR) has produced good results in some studies in terms of achieving new connective tissue attachment and alveolar bone regeneration[40,41] (Fig 9-6).

CAF with enamel matrix derivative (EMD) was found to achieve better results than CAF alone in terms of new bone formation.[38,40,41] EMD, which is currently marketed under the trade name Emdogain, is derived from the developing tooth germ of fetal pigs. As EMD is hydrophobic, propylene glycol alginate is used as the carrier. Prior to the application of EMD, the affected root surface is cleaned, carefully dried, and preconditioned with EDTA (Fig 9-7). Currently, there is some doubt as to whether prior root conditioning with EDTA actually has a clinically relevant benefit.[42]



Fig 9-7 Prior to the application of EMD, the affected root surface is cleaned, carefully dried, and preconditioned with EDTA.

As GTR has lost its former significance for treatment of gingival recession because of its high rate of complications,[43] great hopes have been placed on EMD. Acellular extrinsic fiber cementum (AEFC) is located directly on the dentin of the root and contains inserting periodontal fibers called *Sharpey's fibers* (see chapter 1). Consequently, AEFC is the main tissue responsible for tooth anchorage to the alveolar bone. Although the precise mechanism is not completely understood, studies suggest that proteins (enamel matrix proteins) released by *Hertwig's* epithelial root sheath during tooth development are responsible for the formation of AEFC.[44] The enamel matrix, a product of ameloblast secretion, is instead mainly composed of enamel matrix proteins, the most prevalent of which is amelogenin (> 90%).[45,46] The correlation between amelogenin and the formation of AEFC was confirmed in human histologic studies demonstrating the presence of a very thin layer of highly

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mineralized enamel between the dentin and the cementum.[45] This finding suggests that the presence of amelogenin on the dentin surface during tooth development could be necessary for the formation of AEFC.

To test this theory, *Hammarström*[45] extracted the lateral incisors from two monkeys and prepared standardized cavities in the mesial and distal root surfaces immediately after extraction. The test cavities were treated with EMD before reimplantation, and the control cavities were not. While histologic studies performed 8 weeks later showed the new development of AEFC at sites treated with EMD, the control sites exhibited only repair cementum (cellular intrinsic fiber cementum lacking Sharpey's fibers).

A number of clinical studies have shown the advantages of the adjunctive use of EMD in periodontal surgery.[47–50] Regenerative procedures combined with EMD achieved results equal to those of GTR with a lower rate of complications.[51–53]

Encouraged by these findings, a number of studies have been conducted to determine whether the use of EMD could also enhance the healing outcome of root coverage. In a buccal dehiscence model in monkeys, *Hammarström* and coworkers[54] raised mucoperiosteal flaps from the canine to the first molar on each side of the maxilla and then removed the buccal bone plate, the exposed periodontal ligament, and the cementum. Root surfaces in the test group were treated with EMD before the flaps were repositioned and sutured, whereas those in the control groups were not. Histologic studies performed 8 weeks postoperatively showed new AEFC formation with inserting periodontal fibers extending over to newly formed alveolar bone at the test group sites. In the control group, healing was characterized by the formation of a long junctional epithelium with very little new cementum and hardly any new bone. Human histologic studies produced similar results.[38,55]

Based on these promising results, controlled clinical studies were performed to compare the results of CAF with and without EMD. Unfortunately, the findings of the different studies were not uniform. While some investigators concluded that CAF + EMD has advantages in terms of the percentage of covered root surface,[56–58] others found no statistically significant difference.[59,60] *Spahr* and coworkers[61] observed that CAF + EMD resulted in a higher stability of the marginal gingiva 2 years after surgery, whereas *Del Pizzo* et al[62] found no significant difference at 2 years. In a systematic review of the literature on CAF with and without EMD, *Cairo* and colleagues[63] concluded that the additional use of EMD results in better outcomes in terms of achieving complete root coverage.

Notwithstanding, two clinical aspects seem to be of fundamental importance for restoration of periodontal health after root coverage:

1. Thorough removal of biofilm from the exposed root surface before root coverage is crucial.[64] If the root surfaces are cleaned during surgery (ie, after flap elevation), it is hard to tell which root surfaces were exposed and which were covered before flap elevation. This poses the risk that intact attachment fibers could be removed in the process of mechanical root debridement. Therefore, exposed root surfaces should always be cleaned prior to surgery. It is sufficient to clean the exposed root surfaces with a rubber cup and polishing paste, instrumentation of the root surface is not necessary[65] (Fig 9-8).
2. Postoperative wound stability is the only way to ensure that a stable blood clot will form on the newly covered root surface, and this is crucial for complication-free healing.[66] Because it is not possible to immobilize the wound completely, the use of optimal flap designs and suturing techniques is extremely important (see chapters 3 and 4).

Keratinized gingiva

Although the presence of a very narrow band of keratinized gingiva can sometimes cause clinical problems or complicate restorative dental treatments, it poses no problem for the long-term prognosis of the affected teeth from a scientific perspective (see chapter 1). However, the presence of a sufficiently wide band of keratinized gingiva is absolutely essential for a good cosmetic outcome (see chapter 5). Consequently, the decision regarding the type of procedure and surgical approach used to achieve root coverage is influenced by the goal of predictably establishing keratinized tissue on the exposed root surfaces.

Keratinization of the oral mucosa has been intensively investigated in various studies. Mechanical stimulation can achieve an increase in keratinization of the epidermis by means of extraoral functional adaptive processes. The presence of keratinized epithelium on the masticatory mucosa was long regarded as adaptation to mechanical stress during chewing. However, animal studies have shown that keratinization of the gingiva is not a consequence of functional adaptation but is genetically determined. In heterotopic transplantation studies in monkeys, *Karring* et al[67] coronally transplanted the alveolar mucosa in the original location of the marginal gingiva and apically transplanted the keratinized gingiva in the original location of the alveolar mucosa. Four months later, the apically transplanted keratinized gingiva was still in the pouch and unchanged, whereas the coronally transplanted alveolar mucosa exhibited a narrow band of keratinized gingiva.



Fig 9-8 Thorough root cleaning prior to the surgical root coverage is crucial for restoration of periodontal health.

Their histologic studies suggested that connective tissue originating from the periodontal ligament had migrated coronally, thus displacing the alveolar mucosa coronally transplanted to the marginal gingiva in the immediate postoperative period, and that, subsequently, epithelial cells originating from the surrounding alveolar mucosa had migrated coronally and covered the newly formed connective tissue. The connective tissue was apparently able to induce the differentiation of epithelial cells from nonkeratinized to keratinized epithelium and thus to

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Fig 9-9 *Karring* et al[67] observed the formation of keratinized gingiva after coronal transplantation of the alveolar mucosa. The connective tissue, which had originated from the periodontal ligament and migrated coronally after transplantation, was apparently able to induce the differentiation of epithelial cells from nonkeratinized to keratinized epithelium and thus to establish a narrow band of keratinized gingiva. The authors concluded that the specificity of these tissues is genetically determined and, therefore, is not subject to functional adaptive changes.



Fig 9-10 In an animal study by *Karring* and coworkers,[69] keratinization of the overlying epithelium did not occur when the gingival CTGs were completely covered with alveolar mucosa. Keratinization did not occur until after the overlying epithelium was removed and healing by secondary intention occurred. The authors concluded that uncovered gingival connective tissue is capable of inducing nonkeratinizing epithelial cells from the alveolar mucosa to differentiate into keratinizing epithelial cells.

induce the formation of a narrow band of keratinized gingiva. The authors concluded that the specificity of these tissues is genetically determined and therefore not subject to functional adaptive changes (Fig 9-9). Human histologic studies and clinical case reports support these findings.[36,68]

In another study investigating the role of gingival connective tissue in determining epithelial differentiation in monkeys, *Karring* et al[69] harvested free subepithelial connective tissue grafts (SCTGs) from the keratinized gingiva and alveolar mucosa and transplanted them in pouches created in the connective tissue as close as possible to the overlying epithelium. After 3 to 4 weeks, no change in the alveolar mucosa covering the transplants was observed. The transplants were then exposed by removing the overlying epithelium to allow epithelialization from the surrounding nonkeratinized alveolar mucosa.

During the next 12 months, clinical and histologic studies of the transplants were performed at various intervals. These studies showed that the gingival CTGs had become covered with keratinized epithelium, whereas the alveolar mucosa grafts were covered with nonkeratinized epithelium. Because the epithelium covering both types of grafts must have originated from the overlying epithelium, the authors concluded that gingival connective tissue is capable of inducing nonkeratinizing epithelial cells from the alveolar mucosa to differentiate into keratinizing epithelial cells. However, if the connective tissue removed from the area of keratinized gingiva is covered with alveolar mucosa, the epithelium does not seem to be influenced by the underlying connective tissue. The assumption that the transplanted tissue has no direct contact with the epithelium of the overlying flap could be causally relevant[69] (Fig 9-10).

These findings are consistent with those of clinical studies dealing with changes in mucogingival dimensions following root coverage.[70–74] In a retrospective clinical study, *Cordioli* et al[74] compared changes in mucogingival dimensions following SCTG in combination with envelope flap or CAF. All parts of the SCTG were covered following CAF, whereas some parts of the graft were intentionally left uncovered at sites treated by the envelope technique. Follow-up examination 12 to 18 months after the procedures showed a significantly greater increase in keratinized gingiva width in the envelope flap group. This increase was found to correlate with the percentage of postoperative exposure of the CTG. In the CAF group, the increase in keratinized tissue width was very small. In fact, the keratinized tissue width at follow-up was about the same as the preoperative width. In these patients, keratinization occurred only in those parts of the graft that had been covered with gingiva, and the parts located in the mucosal region remained nonkeratinized.

The low increase in keratinized tissue found in the CAF group[74] was also observed in other studies.[70,72,75–78] This is likely due to coronal migration of connective tissue from the periodontal ligament, as was described earlier. Inadvertent partial exposure of the CTG as a result of minor postoperative wound dehiscence is another possible cause. This could explain why *Bouchard* and coworkers[70] found a greater increase in keratinized tissue after CAF when the SCTG was not fully covered. *Borghetti* and *Louise*[71] therefore recommended that the operator intentionally leave small portions of the SCTG uncovered in patients with small amounts of keratinized gingiva. Interestingly, the adjunctive use of EMD resulted in an additional keratinized tissue gain.[56,57,59]

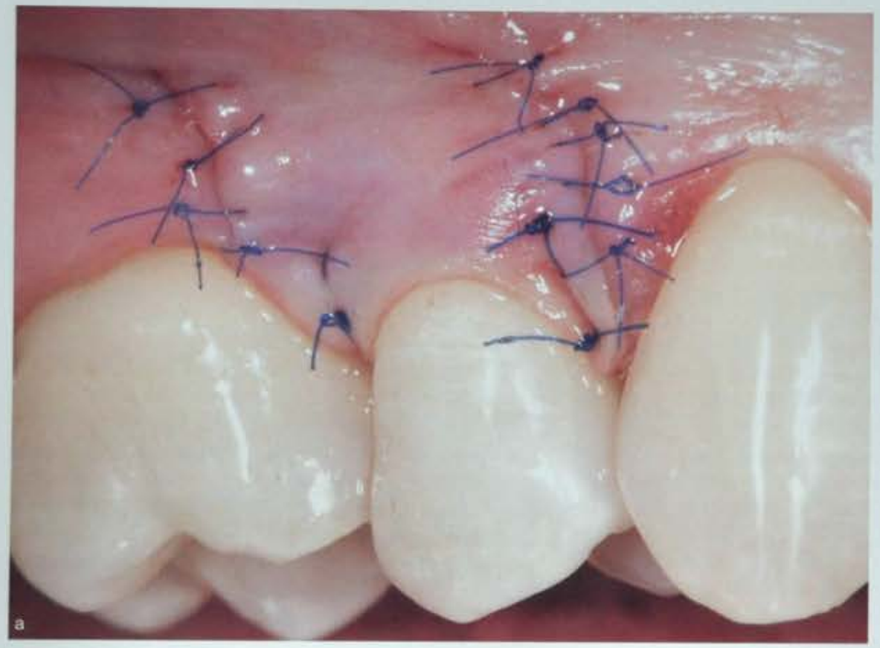
Other longer-term clinical studies demonstrated greater keratinized tissue gain at sites treated by CAF.[79–81] *De Sanctis* and *Zucchelli*[81] observed a continuous increase in keratinized gingiva width by a mean of 1.78 mm over a period of 3 years following root coverage. The amount of keratinized tissue gain increased in proportion to the pretreatment recession depth and keratinized tissue width. Therefore, the authors considered it unlikely that the previously described wound healing processes alone could be responsible for the gradual increase in keratinized gingiva width observed over the years. Instead, they presumed that the width increase after CAF was caused by apical migration of the mucogingival junction to its genetically determined position.

Ainamo et al[82] made the following observation based on much older long-term studies following the course of the mucogingival junction after resective periodontal surgery: 18 years after apically positioned flap surgery, the mucogingival line tends to return to its original coronal position. The results of this study are comparable to those of *the* retrospective clinical long-term study by *Agudio* and coworkers,[83] who treated recession sites with free mucosal grafts. If the same phenomenon should also occur after coronal displacement, the apical return of the mucogingival line would initiate a maturation process resulting in keratinized gingiva gain over the course of time.[84,85]

If the time required for the reestablishment of the mucogingival line is disregarded, the CAF could be considered a universal technique for virtually all clinical cases. As long as there is no definitive evidence confirming the supposedly genetically determined position of the mucogingival junction and it remains unclear how much time this maturation process requires (assuming it takes place predictably), it would appear prudent to select the most appropriate root coverage procedure for a given case from the pool of available alternatives in order to safely achieve sufficient keratinization. In view of the aforementioned healing processes, there are two ways to ensure a sufficiently wide band of keratinized gingiva after surgical root coverage:

1. Cover the CTG or the exposed root surfaces by means of CAF at sites with a sufficiently broad band of keratinized tissue.
2. Intentionally leave the most coronal portions of the CTG uncovered (Fig 9-11).

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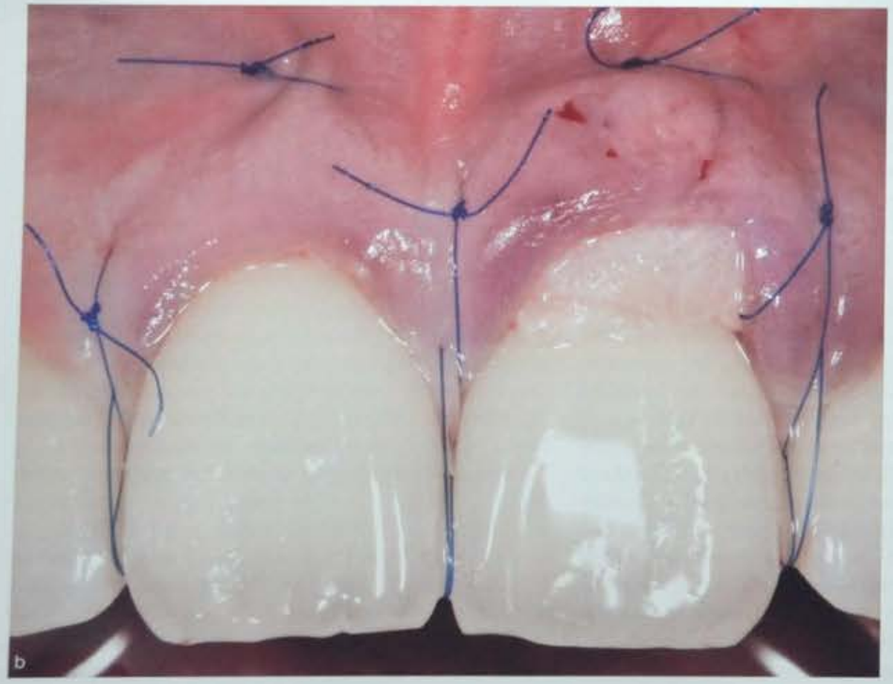


Fig 9-11 There are two ways to ensure a sufficiently wide band of keratinized gingiva after surgical root coverage: (a) The CTG or the exposed root surfaces can be covered by means of CAF at sites with a sufficiently broad band of keratinized tissue, or (b) the most coronal portions of the CTG can be left intentionally uncovered.

Thick gingiva

Studies have shown that individuals with thin gingiva have a higher risk of gingival recession than those with thick gingiva (see chapter 1). It is therefore presumed that the majority of patients with gingival recession have thin gingival biotypes. Likewise, it is assumed that combining root coverage surgery with gingival augmentation helps to improve the long-term prognosis. The process of transforming thin gingiva into thicker gingiva should help to stabilize the marginal soft tissue and reduce the risk that recession will recur following root coverage procedures.

Free CTGs harvested from the palate or tuberosity area are ideally suited for cases requiring a combination of soft tissue augmentation and root coverage[86–90] (Fig 9-12). They are used in a number of different flap procedures. To avoid esthetic problems, it is important to ensure that the thickness of the CTG is not excessive. Ideally, the graft thickness should not exceed 1.0 to 1.5 mm (Fig 9-13). Although clinical experience suggests that adherence to this recommendation enhances stability, at present there is no clear scientific evidence demonstrating whether and to what extent gingival thickness remains stable over the long term after augmentation (see chapter 8).

In this context, *Zucchelli* and coworkers[91] evaluated the results of root coverage using the coronally positioned flap procedure and autogenous CTGs harvested from palatal donor sites 1 year after surgery. They found that the degree of graft shrinkage was significantly lower at sites where free mucosal grafts had been de-epithelialized outside the mouth and used instead of SCTGs. Moreover, a higher percentage of collagen-rich connective tissue without submucosa was found at the sites treated with the mucosal grafts.

CTG harvesting creates an additional surgical site, placing added stress on the patient.[92] Furthermore, the amount of autogenous connective tissue that can be harvested from the palate or tuberosity area is limited. Multiple harvest sites may be needed to cover multiple recession defects. Furthermore, the potential complications associated with the harvesting and transplantation of connective tissue autografts must be considered.[88,93] Because of these drawbacks, various materials are currently being discussed as potential substitutes for connective tissue autografts. Alloplastic, xenogeneic, and allogeneic materials have been the focus of scientific attention. AlloDerm, an allogeneic acellular dermal matrix derived from donated human skin tissues, was used



Fig 9-12 Free CTGs are ideally suited for combined soft tissue augmentation and root coverage.





Fig 9-13 (a and b) Ideally, CTGs used for root coverage should be no thicker than 1.0 to 1.5 mm. It may be necessary to thin the graft after harvesting.

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in most of the investigations performed so far. As the results of these studies are so inconsistent, no conclusions can be made at present (see chapter 7).

Therefore, autogenous connective tissue is still the *gold standard* for soft tissue augmentation. If it were possible to achieve comparable root coverage results using graft substitutes, this would be a significant step forward in terms of patient comfort. The extent to which other approaches to avoiding the use of connective tissue autografts will play a role in the future is currently unclear. It remains to be seen whether augmentation procedures using graft substitutes can achieve stability comparable to that achieved using specific advancement flap designs.[81,94] The question of whether the adjunctive use of EMD can enhance the results of gingival augmentation is also unclear. Furthermore, it would be helpful if the question of whether it is possible to completely dispense with additional augmentation measures in patients with thick gingival phenotypes could be answered based on scientific evidence.

Complete coverage

The outcome of root coverage procedures is generally assessed based on clinical parameters, the most important of which include probing depth, clinical attachment level, keratinized tissue width, and esthetic indices as well as the mean percentage of root coverage and the percentage of complete root coverage. Strictly speaking, complete root coverage is not possible unless the gingival margin will be located 1 to 2 mm coronal to the cementoenamel junction (CEJ) after completion of treatment.[95] However, because the gingival margin is often slightly lower (ie, at the level of the CEJ), many clinicians interpret merely reaching the CEJ as 100% treatment success. Strictly speaking, this results in the overrating of treatment outcomes.

Only those procedures that predictably permit complete root coverage should be used. The problem is that the information available from reviews and meta-analyses of the literature does not allow clinicians to determine whether certain procedures are superior to others in terms of the predictability of achieving complete root coverage.[63,96–99] The reported figures for the mean percentage of root coverage and the percentage of complete coverage vary considerably from one study to another. Based on the data in the literature, it would appear that the average rates achieved are about 80% for root coverage and 50% for complete root coverage.

The considerable variation within individual studies and between studies suggests that the available procedures for root coverage are highly technique sensitive. However, it does not appear that the use of any one given procedure is the most important factor, but rather that operator experience with a procedure, appropriate case selection, and a realistic estimation of the prognosis are the main keys to success.

Esthetic integration

The majority of root coverage procedures are performed for cosmetic reasons. Apart from achieving complete coverage of the root surface with a healthy, thick, and sufficiently broad keratinized gingiva, it is also important that the newly formed tissue blend in with the natural environment in terms of color, surface texture, and harmony (Fig 9-14). Recent studies have given these aspects more consideration. Gingival esthetic indices are used to assess the potential of different procedures in terms of their esthetic outcomes. The absence of scarring, naturalness, and harmonious transitions between tissues are the main criteria for successful root coverage.[100,101]

9.1.4 Technical Aspects

In addition to classic advancement flap procedures such as the *CAF*,[88] the *unilateral advancement flap*,[102] and the *bilateral advancement flap*,[87] "incision-free" (ie, vertical releasing incision–free) flapless root coverage procedures have also gained significance in recent years. *Raetzke*[90] described the *envelope technique* as the first incision-free flapless procedure for coverage of singular, localized recession defects. The envelope technique has since been adapted by many authors, particularly for treatment of multiple recession defects.[103–106]

For many years, limited mobility of the flap in the coronal direction was a major problem. Consequently, large proportions of the CTG were not covered by the flap and thus exposed, resulting in a risk of necrosis. To improve the chances of graft integration and, thus, the overall predictability of the envelope technique, *Azzi* et al[107] developed a *tunnel technique* for treatment of multiple adjacent defects. The use of a mucoperiosteal-mucosal flap allowed for sufficient mobility and coronal advancement of the flap without vertical releasing incisions.

The incision-free procedure was a significant improvement over traditional advancement flap procedures in terms of the blood supply to the flap and the graft. Moreover, it seemed plausible that the cosmetic outcome could be enhanced by eliminating the use of vertical releasing incisions. A *modified tunnel technique* was developed by *Zuhr* et al[108] for this reason. To ensure optimal nutrition to the CTG, a mucosal partial-thickness "tunnel" spanning multiple teeth is used to introduce the CTG. Patented Tunneling Knives are used to reliably prevent flap perforation (see chapter 2). A full-thickness mucoperiosteal flap is elevated only in the papillary region. Blunt dissection of the papilla is performed using papilla elevators. Complete elevation of the buccal papilla is necessary for maximal advancement of the flap in the coronal direction. In this inaccessible region, mucoperiosteal flaps are safer and less risky than mucosal flaps.



Fig 9-14 Status of maxillary anterior region after root coverage. Although virtually complete root coverage was achieved, the cosmetic outcome is not satisfactory.

If there is insufficient keratinized gingiva apical to the recession, small portions of the inserted CTG located in the marginal region can remain uncovered, as in the envelope technique. This makes it possible to increase the width of keratinized tissue in combination with root coverage. Consequently, the modified tunnel technique can be performed regardless of the amount of keratinized tissue available apical to the recession defect. However, because the exposed portions of the CTG are supplied only by diffusion from the apical direction, there is a risk that part of the graft may become necrotic (see chapter 7). Therefore, it is essential to ensure that no more than about 1 mm of the CTG remains uncovered in the vertical direction and that the ratio of the covered to uncovered graft area is as favorable as possible (Fig 9-15).

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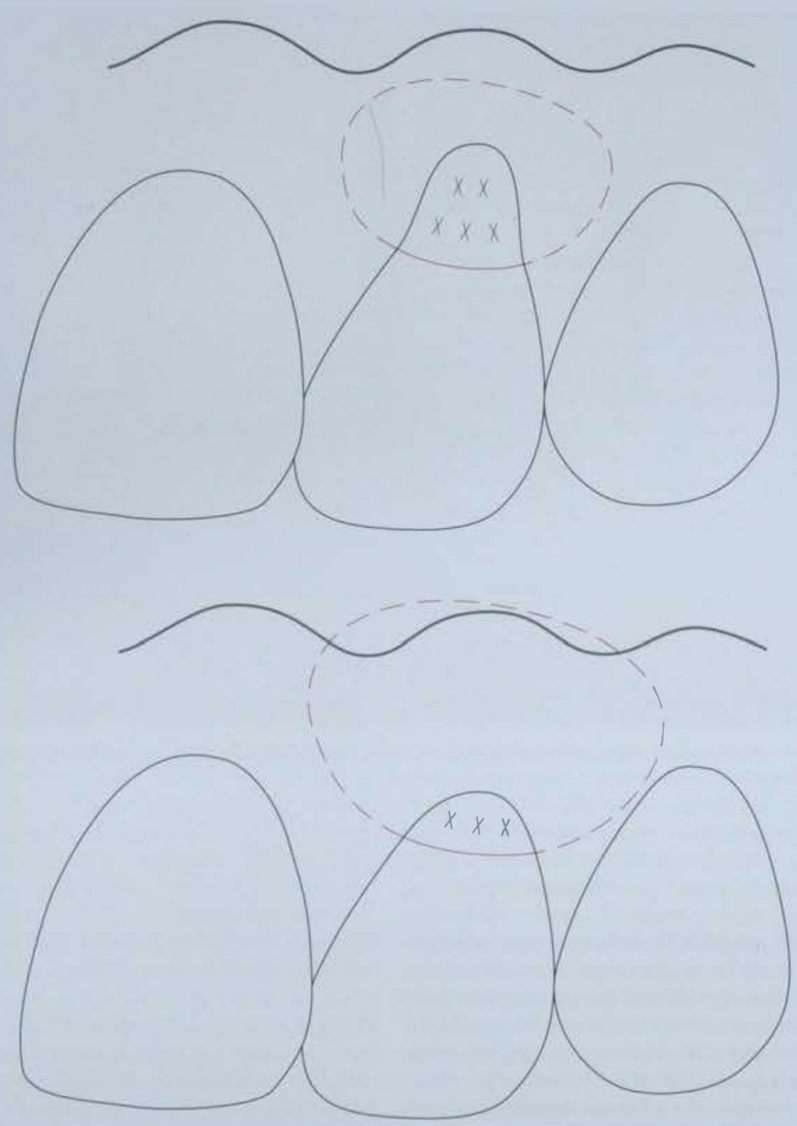


Fig 9-15 (a and b) If the modified tunnel technique is to be used to increase the width of keratinized tissue in combination with root coverage, the coronal portions of the CTG must be left uncovered. To prevent necrosis, it is essential to ensure that no more than about 1 mm of the CTG remains uncovered in the vertical direction and that the ratio of the covered to uncovered graft area is as favorable as possible.

Positioning sutures are used to draw the graft into the tunnel. Briefly, the needle enters at the end of the tunnel distal to the recession defect, engages the graft laterally, and exits the tunnel by the same route. The graft can be safely drawn into the tunnel and positioned by gentle tugging on the positioning sutures. Vertical double-crossed sutures are used to secure the graft. This suturing technique has several advantages: The sutures immobilize the flap and the graft in the desired coronal position, and they compress the soft tissues against the root surface, resulting in a shortening of the diffusion distances, which has an additional positive effect on the supply of nutrients to the CTG (see chapter 4).

Even if appropriate surgical procedures are available for all possible clinical situations, the number of procedures used should be limited, and the procedures used should be as uncomplicated as possible. The following approaches may be used depending on the goals of treatment.

Single gingival recessions

Clinical experience has shown that it is sufficient to have a repertoire of three approaches for root coverage of localized gingival recession. The recession depth and the amount of keratinized tissue apical to the recession determine which approach is indicated. Classical advancement flap procedures can be employed to treat localized gingival recessions less than 3 mm in depth. If there is at least 2 mm of keratinized tissue apical to the recession, CAF in combination with either EMD or connective tissue autograft should be relatively easy to perform and is thus the method of choice. If there is less than 2 mm of keratinized tissue apical to the recession, the double lateral bridging flap with connective tissue autograft is recommended. The modified tunnel technique can be used as an alternative to traditional advancement flap techniques in these cases. If there is less than 2 mm of keratinized tissue apical to the recession, small portions of the CTG should be left uncovered (Table 9-2). If the size of the defect is 3 mm or larger, the traditional advancement flap techniques described for treatment of localized gingival recessions less than 3 mm in depth must be used. The modified tunnel technique cannot be used in these cases because of limited flap mobility in the coronal direction (see Table 9-2).

Multiple gingival recessions

The modified tunnel technique can generally be used for coverage of multiple adjacent recession defects (Fig 9-16). The question of whether parts of the CTG

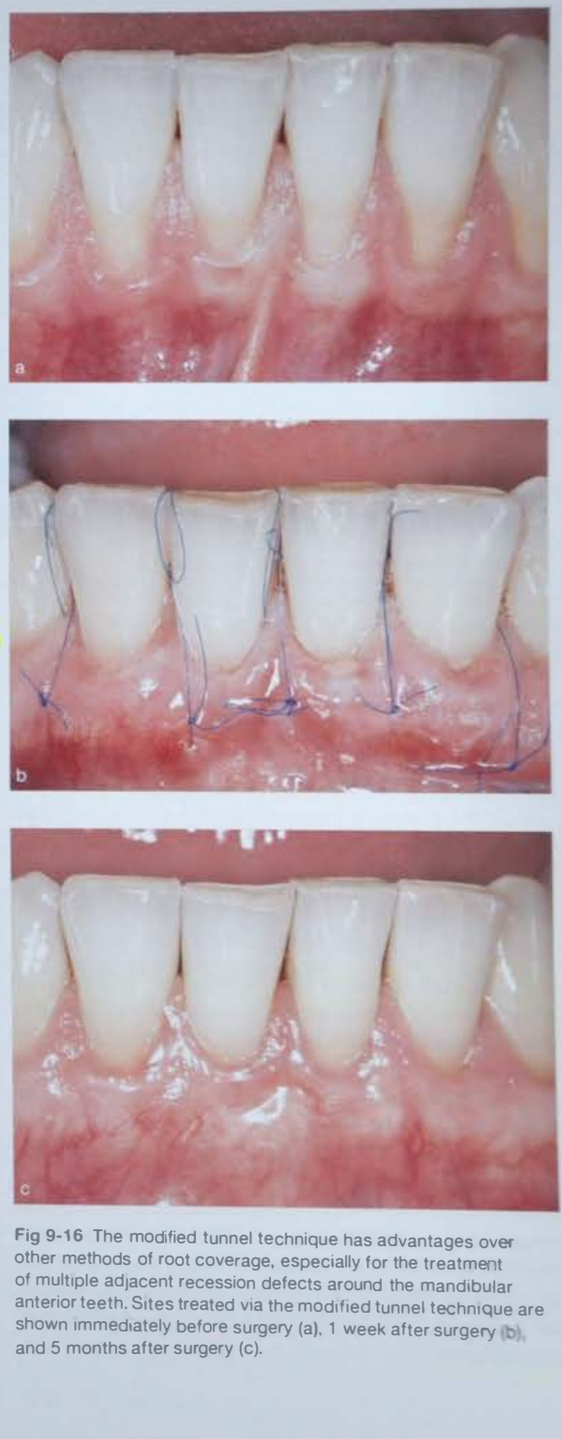


Fig 9-16 The modified tunnel technique has advantages over other methods of root coverage, especially for the treatment of multiple adjacent recession defects around the mandibular anterior teeth. Sites treated via the modified tunnel technique are shown immediately before surgery (a), 1 week after surgery (b), and 5 months after surgery (c).

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Table 9-2

Criteria used for selection of the appropriate root coverage techniques in different clinical situations*

Width of keratinized tissue apical to the recession	Procedures
Singular gingival recessions (recession depth < 3 mm)	
≥ 2 mm	CAF with free CTG or EMD Tunnel technique with free CTG
< 2 mm	Double lateral bridging flap with free CTG Tunnel technique† with free CTG
Singular gingival recessions (recession depth ≥ 3 mm)	
≥ 2 mm	CAF with free CTG or EMD
< 2 mm	Double lateral bridging flap with free CTG
Multiple gingival recessions	
≥ 2 mm	CAF with free CTG or EMD Tunnel technique with free CTG
< 2 mm	Tunnel technique† with free CTG

CTG: connective tissue graft; EMD: enamel matrix derivative.
*Single and multiple recession defects are treated by different approaches. In localized gingival recession, the recession depth determines which technique will be used. †A small portion of the free CTG is left uncovered.

should be left uncovered or not depends on how much keratinized tissue is available apical to the recession. In cases where there is at least 2 mm of keratinized tissue apical to the recession, CAF with either connective tissue autograft or EMD can be used instead of the modified tunnel technique.

The presence of a shallow vestibule in the mandibular anterior region makes it more difficult to achieve wound stability during the early postoperative days—the critical period for the realization of uncomplicated wound healing. Particularly in these cases, clinical experience has shown that the modified tunnel technique can achieve better results than the alternative methods (see Fig 9-16 and Table 9-2).

9.1.5 Predictability

Root coverage procedures are usually elective procedures. Therefore, the prognosis for a successful outcome is one of the main criteria for deciding whether or not to perform root coverage surgery. The prognosis is determined by *patient-specific*, *defect-specific*, and *technique-specific* factors.[109]

Patient-specific factors

The general factors that affect wound healing after plastic periodontal or implant surgery also apply to the treatment of gingival recession (see chapter 3).

Defect-specific factors

To assess the prognosis of root coverage based on defect-specific factors, several aspects must be analyzed and considered.

Vertical height of the papillae adjacent to the recession defects is of crucial prognostic significance. The Miller classification takes this factor into consideration. *Miller* described four classes of recession defects.[110] In Class I and Class II recession, the papillae mesial and distal to the recession defects are completely intact. Class I is characterized by marginal tissue recession that does not extend to the mucogingival junction, whereas Class II is characterized by marginal tissue recession that extends to or beyond the mucogingival junction. Class III marginal tissue recession is characterized by a moderate loss of papillary height mesial and/or distal to the recession defects, whereas Class IV is characterized by a complete loss of papillary height mesial and/or distal to the recession defects. The predictability of complete root coverage is very good at sites with Class I or Class II gingival recession. In Class III recession, however, only partial root coverage can be expected. At Class IV sites, even partial root coverage cannot be predictably achieved (Fig 9-17).

The enormous growth of knowledge on the diagnosis and treatment of gingival recession has prompted a rethinking of the current classification system and will result in more modifications of the *Miller* classification in the years to come.[111] The systematic classification of gingival recessions recently put forward by *Cairo* and co-workers[112] is important in this context.

In addition to the Miller classification, evidence suggests that the absolute dimensions of the recession defect are of prognostic significance. Recession defects ≥ 3 mm in width and ≥ 5 mm in depth are associated with a lower probability of success.[84,113–115]

Keratinized tissue width apical to the recession does not appear to be a prognostic indicator.[85,116] Likewise, the *height and width of adjacent papillae* do not appear to play a prognostic role outside of the *Miller* classification.[117]

The *absence of inflammation* of the periodontal tissues at the time of surgery is also crucial.[118] Good personal oral hygiene and professional periodontal pretreatment may be needed to achieve this condition (see chapter 3).

Technique-specific factors

Flap thickness has a major impact on the outcome of root coverage, whereas the *type of flap* used (mucoperiosteal or mucosal) does not.[119] *Baldi* et al[120] determined that 0.8 mm is the critical flap thickness for the success of CAF procedures. In a systematic review of the literature, *Hwang* and *Wang*[121] concluded that there is a high correlation between flap thickness and mean and complete root coverage in free CTG and GTR procedures but not with CAF therapy alone.

Graft thickness also appears to affect the outcome of root coverage. *Borghetti* and *Gardella*[122] recommended that the graft thickness should not exceed 2 mm. This has no clinical consequences for root coverage because it is already recommended that grafts used for root coverage should be no thicker than 1.0 to 1.5 mm to ensure a good cosmetic outcome.

Graft orientation does not appear to affect the prognosis. In a clinical study, *Al-Zahrani* et al[123] concluded that it made no difference to the outcome of root coverage whether the periosteal surface of the graft was facing the root surface or soft tissue (Fig 9-18).

Closure of flap without tension plays an important role in root coverage procedures. It is crucial that the flaps lie in the desired position on the root surface without tension. Different studies have shown that *tension-free flap* closure is crucial to the success of treatment.[124,125]

In order to achieve complete root coverage, postoperative shrinkage must be taken into account. This is accomplished by slight *overcorrection* (overcompensation). The marginal gingiva should lie 1.0 to 1.5 mm coronal to actual target level immediately after surgery.[126]

Microsurgical technique also seems to have a positive effect on the outcome of root coverage[127] (see chapter 3).

9.1.6 Long-Term Stability of Root Coverage

Many experts believe that achieving a thick gingiva after root coverage is the most important guarantor of long-term treatment success. However, the currently available scientific studies do not clearly support this view. Some studies on the long-term stability of root coverage have shown that advancement flap techniques in combination with connective tissue autografts can achieve very good results over periods of 2 to 5 years.[77,84,128–130] In a 5-year clinical study, *Paolantonio* and colleagues[77] treated 35 patients with *Miller* Class I and Class II gingival recessions with free gingival grafts and 35 with subpedicle CTGs harvested from the palate. In the latter group, the mean percentage of

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Class I
The papillae mesial and distal to the recession defects are completely intact. Marginal tissue recession does not extend to the mucogingival junction.



Class II
The papillae mesial and distal to the recession defects are completely intact. Marginal tissue recession extends to or beyond the mucogingival junction.



Class III
Moderate loss of papillary height mesial and/or distal to the recession defects.



Class IV
Complete loss of papillary height mesial and/or distal to the recession defects.

Fig 9-17 *Miller* classification of marginal tissue recession. Complete root coverage is possible and predictable in the treatment of Class I and Class II recession. While partial root coverage can be expected in the treatment of Class III recession, no predictable results can be achieved in Class IV recessions.[110]

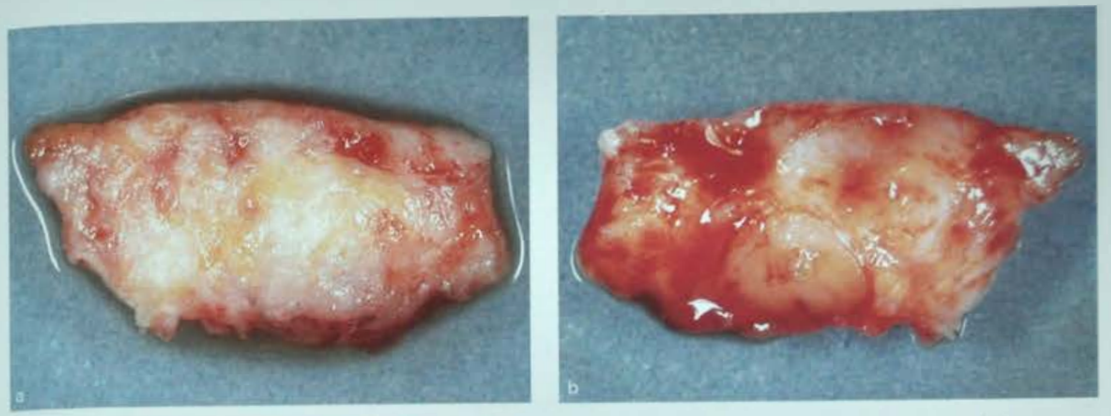


Fig 9-18 Evidence suggests that graft orientation does not play a role in the outcome of root coverage. In terms of prognosis, it does not matter whether the periosteal surface (a) or the connective tissue surface (b) of the graft is facing the root surface.

root coverage at 5 years was 85.23%, and complete root coverage was achieved in 17 of 35 patients.

Pini Prato and coworkers[130] compared the clinical outcomes of CAF alone to those of CAF + SCTG for treatment of multiple gingival recessions in a split-mouth study. The 5-year follow-up showed a clear tendency to the recurrence of recession at the sites treated with CAF alone, while the sites treated with CAF + CTG showed coronal migration of the gingival margin.

The results of other clinical studies confirm that the long-term prognosis is impaired when root coverage is performed without autogenous CTGs.[61,62,131,132] In another clinical study on the coverage of single recession defects with CAF, *Pini Prato* and coworkers[133] also observed recession of the gingival margin at 39% of the treated sites 14 years after surgery.

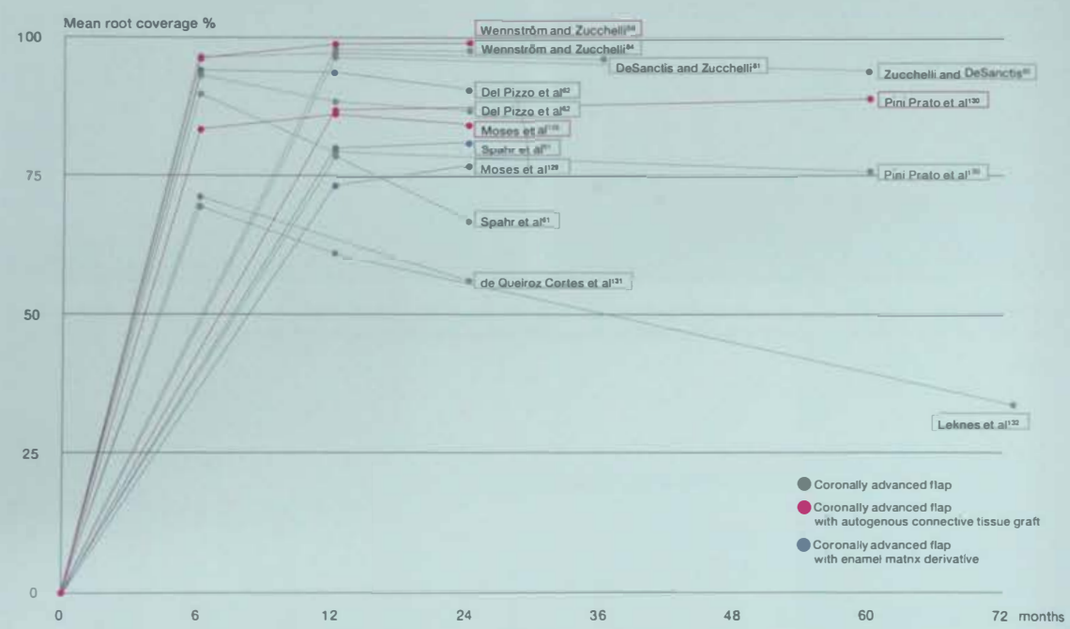
Other investigators achieved long-term stability without autogenous CTGs. *Wennström* and *Zucchelli*[84] observed no statistically significant difference between the outcomes of CAF with and without additional CTGs in terms of stability—as far as could be determined after 2 years. Further clinical studies on the treatment of gingival recession with CAF procedures without CTGs also demonstrated good long-term stability at 3 and 5 years.[80,81] The reason for this could be that the investigators used special flap designs that made it possible to achieve thickening of the marginal gingiva without CTGs. In this context, the lack of scientific evidence from prospective and controlled long-term studies that extend for more than 2 years and specifically evaluate gingival thickness must be considered.

Newly formed alveolar bone and new connective tissue attachment presumably have a positive effect on the long-term stability of root coverage, too. Because of the high risk of complications, GTR no longer plays a major role in this context, whereas EMD is increasingly being discussed as an alternative to free CTGs. Data from the currently available studies on this subject are contradictory. Moreover, studies with observation periods longer than 2 years are scarce. In a clinical long-term com-

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Table 9-3

Long-term results achieved using various root coverage procedures



parison of CAF with either EMD or connective tissue autograft, CAF + CTG produced superior results 2 years postoperatively.[129] The question of whether combining CTG with EMD provides any additional benefit cannot be answered based on the current evidence.[134]

Heavy smoking appears to have a negative impact on the long-term stability of root coverage[135] (Table 9-3).

Key points:

The current evidence suggests that CAF with connective tissue autograft is still the most predictable way to achieve long-term stability of root coverage (Fig 9-19). The challenges of the future will be to improve the quality of attachment and the regeneration of buccal alveolar bone to optimize the long-term prognosis. To ensure the long-term stability of root coverage, dental follow-up care must be provided at close intervals, and the patient's oral hygiene regimen must be modified to include a gentle toothbrushing method.[81,82] Good results have been achieved when patients use a soft toothbrush in conjunction with the modified Bass technique of toothbrushing (see chapter 6).

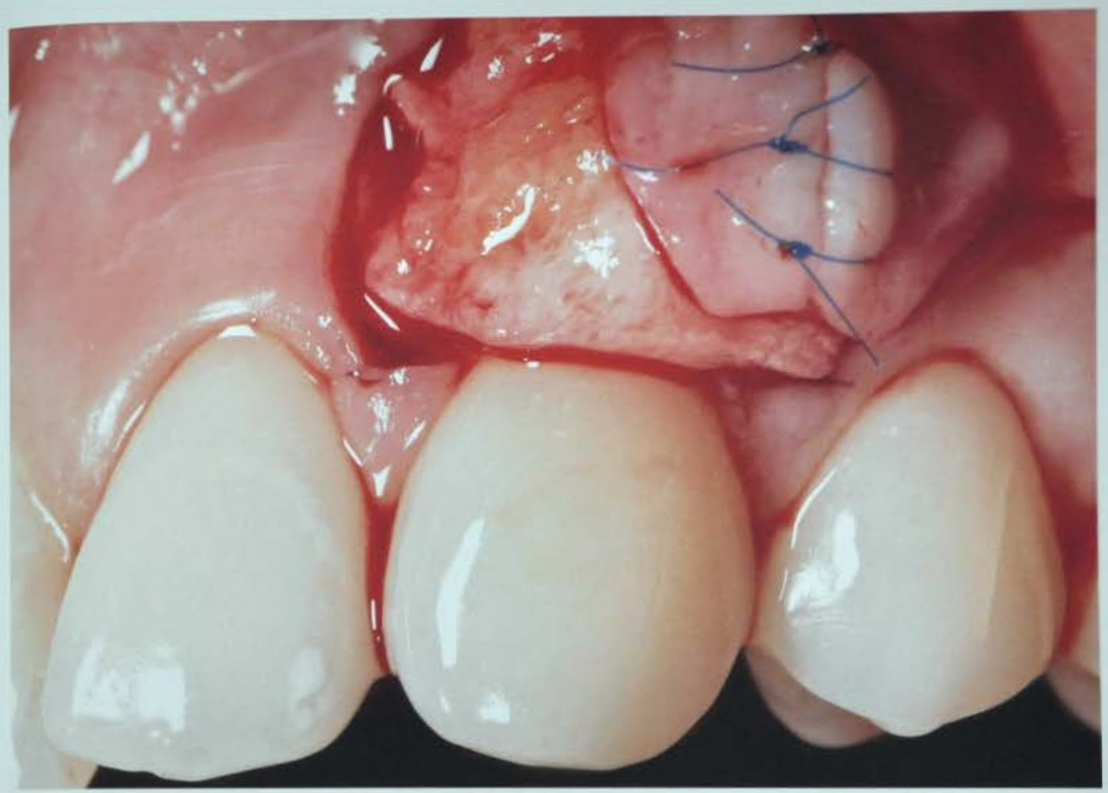


Fig 9-19 Current evidence suggests that CAF with connective tissue autograft is still the most predictable way to achieve long-term stability of root coverage.

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Fig 9-20 Gingival recession often occurs in combination with wedge-shaped defects.

9.1.7 Special Cases

Wedge-shaped defects

Gingival recession often occurs in combination with wedge-shaped defects around the affected teeth.[136] When root coverage procedures are performed, it may be necessary to place restorations to cover such defects in the cervical area of the teeth (Fig 9-20).

From a biologic perspective, the CTG and/or advancement flap should ideally be positioned on a natural root surface. Consequently, root areas apical to the CEJ should not be covered with restorative materials unless absolutely necessary.[137] Restorations should be limited to wedge-shaped defects in areas where the visible clinical crown will be located. Small concavities located apical to the CEJ normally do not impair the cosmetic outcome and can be compensated for, to a certain degree, by using a thicker CTG.

However, if the depth of a wedge-shaped defect apical to the CEJ exceeds a certain limit, the gingiva will lack the necessary support from the underlying root after root coverage. Consequently, the gingiva will dip into the wedge-shaped defect, resulting in a straight and unesthetic gingival margin contour. Clinical experience has shown that wedge-shaped defects apical to the CEJ should be filled if the defect depth in the bucco-oral direction is approximately 2 mm or deeper (Fig 9-21).

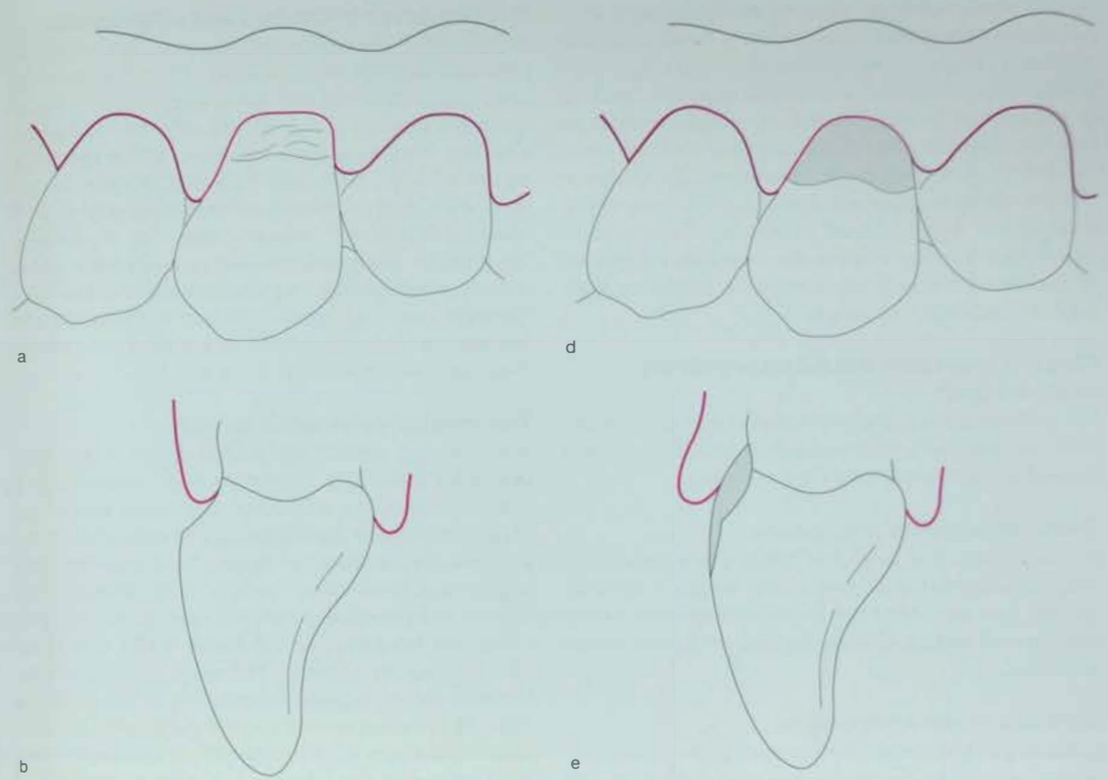




Fig 9-21 (a to c) After root coverage, the cervical defect on the maxillary left canine affects the esthetic appearance, and the marginal gingiva lacks mechanical support from the underlying tooth root. The soft tissue dips into the defect, resulting in a straight and unnatural gingival contour.



Fig 9-21 (d to f) The wedge-shaped defect has been repaired with composite resin. The marginal gingiva now has mechanical support, resulting in a convex and esthetic gingival contour.

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Glass-ionomer cements used to be recommended as restorations for wedge-shaped defects because of their positive biologic characteristics,[138–141] but they have proved to be too porous and difficult to polish, resulting in esthetic compromise. Therefore, composite resins are now the materials most commonly used to repair cervical defects. With composite restorations, the quality of the restoration is important, particularly in terms of polishability.[142] Wedge-shaped defects should be repaired before root coverage because the supragingival location of the defect makes it much easier to produce a high-quality composite restoration.

Gingival recession around prosthetically restored teeth

It is difficult to treat gingival recession around prosthetically restored teeth with restoration margins extending beyond the former CEJ into the root region.

Teeth with tangential preparations

In many cases, it is helpful to define a new preparation margin coronal to the old preparation margin. Root coverage can then be carried out in the conventional manner after the root surface apical to the new restoration margin is cleaned.

Teeth with chamfer preparations

In these cases, coronal displacement of the restoration margin is contraindicated for biologic, functional, and esthetic reasons. If performed, root coverage would result in a deep subgingival restoration margin, which would have critical consequences from a biologic perspective. Therefore, it is strongly recommended that root coverage surgery not be performed in these cases. Orthodontic extrusion, which can help to harmonize the gingival contours of the affected teeth, can be considered as an alternative solution (Fig 9-22).

Root coverage in children and adolescents

Broadening of the keratinized gingiva occurs during jaw growth in children and adolescents. However, the width of keratinized tissue is still affected by changes in buccooral tooth position during development (see chapter 1). This can result in gingival recession, which appears to be reversible in most cases. In a clinical study in children with gingival recession, *Andlin-Sobocki* et al[143] observed that 25 of 35 recession sites, with depths ranging from 0.5 to 3.0 mm, resolved spontaneously within 3 years in patients with appropriate oral hygiene. Consequently, root coverage in children and growing adolescents should be considered very critically. A cautious "wait and see" approach is recommended.

Peri-implant dehiscence defects

Root coverage around implants is subject to the same principles that apply to root coverage around natural teeth. However, the anatomical conditions around implants are different from those around natural teeth. For example, peri-implant soft tissues have a poorer blood supply than those around natural teeth because of the absence of a periodontal ligament (see chapter 1). In addition, the interproximal soft tissue height around implants is usually reduced. Therefore, peri-implant dehiscence defects generally correspond to at least *Miller* Class III recession around natural teeth, with the associated consequences. Therefore, the prognosis for treatment of peri-implant dehiscence must be assumed to be worse than that for treatment of gingival recession around natural teeth (Fig 9-23).

In a clinical cohort study in 10 patients with peri-implant dehiscence and a contralateral unrestored clinical crown without recession, *Burkhardt* et al[144] surgically covered the dehiscence defects by CAF in combination with free CTG. The investigators found that, although the procedure generally resulted in significant clinical improvement, complete coverage could not be achieved at any of the sites treated. This should be taken into account whenever treatment of peri-implant dehiscence defects is considered or planned.

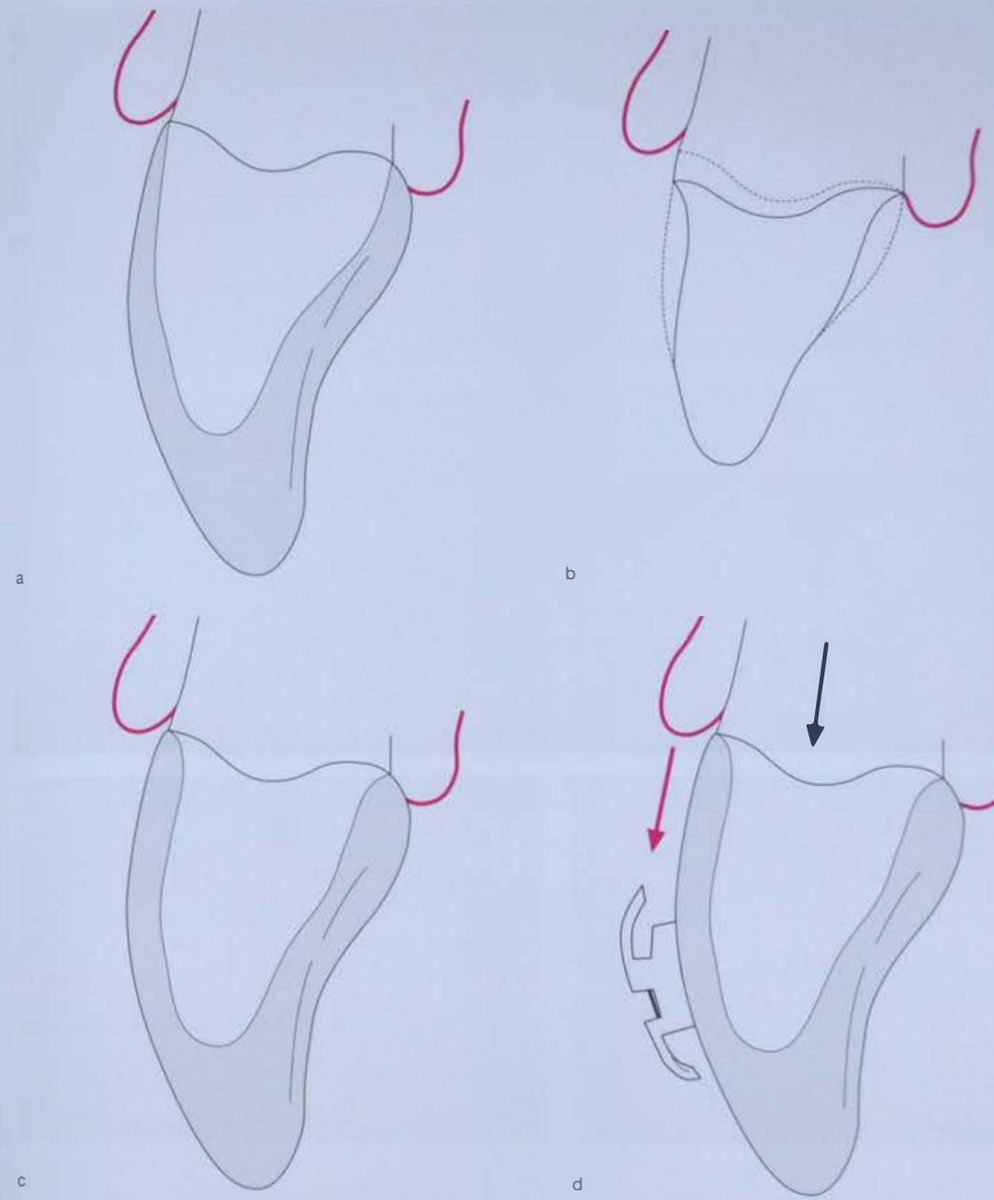


Fig 9-22 In teeth with root surfaces prepared for prosthetic restorations, root coverage will likely cause problems that are critical from a biologic perspective. (a and b) For teeth with tangential preparations, it is often helpful to define a new preparation margin coronal to the old preparation margin. Root coverage can then be carried out in the conventional manner. (c and d) For teeth with chamfer preparations, orthodontic extrusion of the affected teeth could help to harmonize the gingival contours and can be considered an alternative solution.

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Fig 9-23 (a to h) Failed attempt to cover a peri-implant dehiscence defect at the site of the maxillary left central incisor. The failure of treatment is obvious on the photographs taken 6 weeks (g) and 12 weeks (h) after treatment by the modified tunnel technique.

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9.2 Procedures

9.2.1 Coronally Advanced Flap with Subepithelial Connective Tissue Graft for Treatment of Localized Gingival Recession

KEY POINTS

01. Select the procedure based on the *recession depth* and the *amount of keratinized tissue* apical to the recession defect.

02. Clean the root surface *before the procedure* is started.

03. Elevate a partial-thickness flap:
- Elevate a *flap of uniform thickness without beveled edges.*
- Ensure that the flap lies in the desired position *without tension.*
- *Completely de-epithelialize* the papillae.

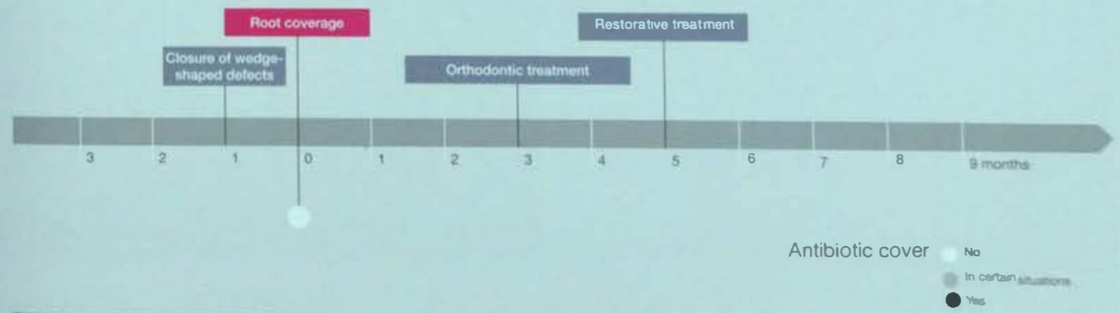
04. Harvest a subepithelial connective tissue graft:
- *Maximum thickness:* 1.0 to 1.5 mm.

05. Place sutures:
- Ensure *stable fixation* of the flap and the graft to the root surface.
- Provide 1.0 to 1.5 mm of *overcorrection* in the vertical direction.
- Ensure *perfect approximation of the flap edges* in the papillary region and in the coronal part of the vertical releasing incisions.

06. Apply *gentle pressure* to the wound for several minutes.

07. Give the *patient* complete and comprehensive *postoperative instructions.*

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, 7-0 Seralene DS-12, 7-0 Serafit DS-12, and 7-0 Seralene HS-8, if needed
4. No. 15 and 12D macroblades and Keydent microblade
5. Glass slab
6. 0.1% chlorhexidine solution in a metal dish
7. Sterile water in a metal dish
8. Blunt cannula
9. 10-mL syringe
10. Local anesthetic
11. Large and small pledgets
12. Periodontal stent

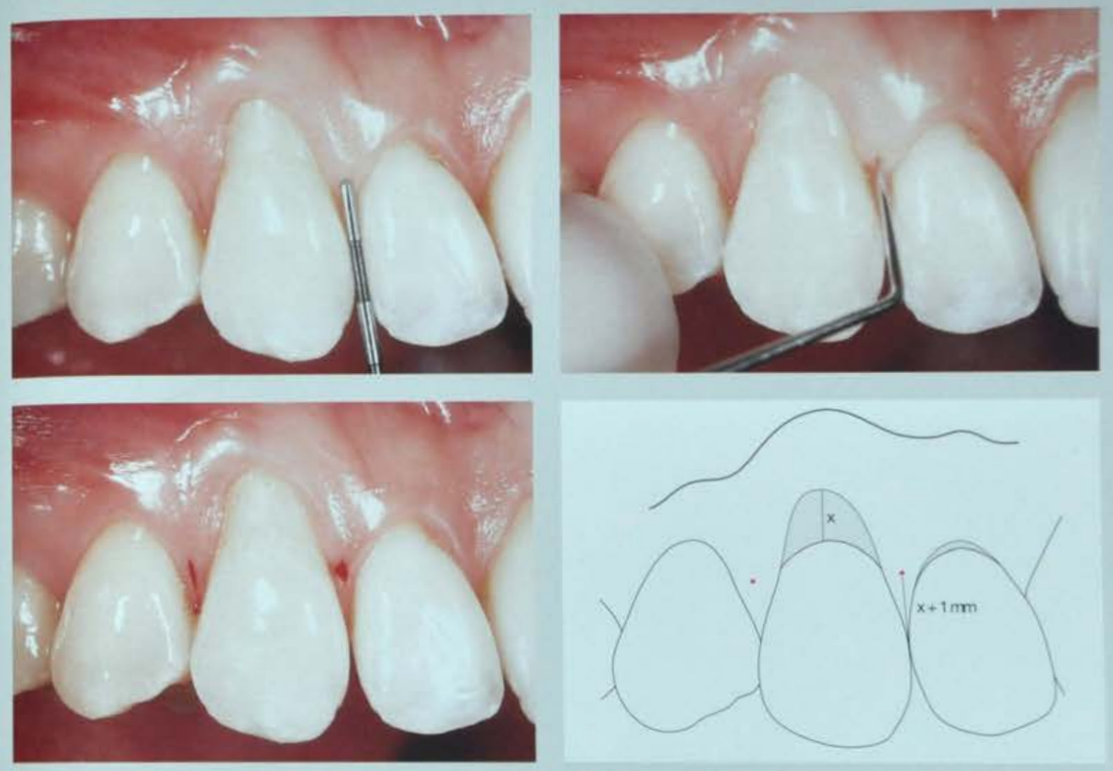


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STEP-BY-STEP PROCEDURE



Figs 9-24 to 9-26 The maxillary right canine has a *Miller* Class I recession defect with a depth of about 4 mm. The width of keratinized tissue apical to the recession is about 3 mm.



Figs 9-27 to 9-30 After mechanical cleaning of the exposed root surface, a periodontal probe is used to transfer the recession depth (x) to the papilla for primary incision planning. The surgical markings are placed at a distance of x + 1 mm apical to the tip of the papilla to achieve the desired amount of overcorrection.

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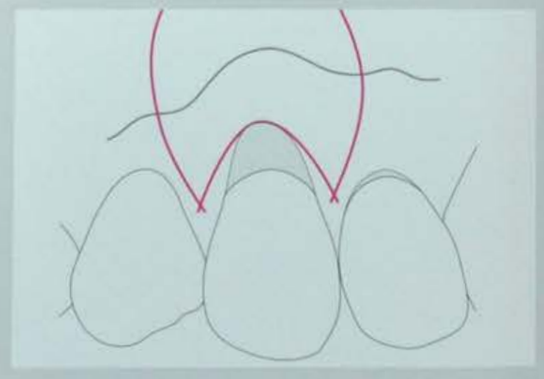


Fig 9-31 The outline of the flap, which has been made with a surgical marker, illustrates the essential features of a CAF. The initial incision extends from the markings in the papillary area toward the lowest point of recession. Next, two C-shaped vertical incisions are extended toward the vestibule. For proper partial-thickness flap elevation, the blade must be held perpendicular to the tissue surface, and the intersecting lines of the incision must be clear cut with overlap.









Figs 9-32 to 9-35 The No. 15 macroblade is excellent for making the vertical incisions, but the microblade should be used in the marginal area. For optimal wound healing, a bleeding wound bed should be created at the gingival zenith without unnecessary tissue sacrifice.





Figs 9-36 and 9-37 A No. 15 macroblade is used to extend a partial-thickness incision along the markings in the papillary area. To avoid perforation, the operator's eyes should always be directly focused on the blade working beneath the flap (left). The incision is continued apically until the flap has adequate mobility, enabling placement in the desired coronal position without tension (right). It is crucial to leave enough connective tissue on the periosteum in the apical region to allow the CTG to be stably secured later.

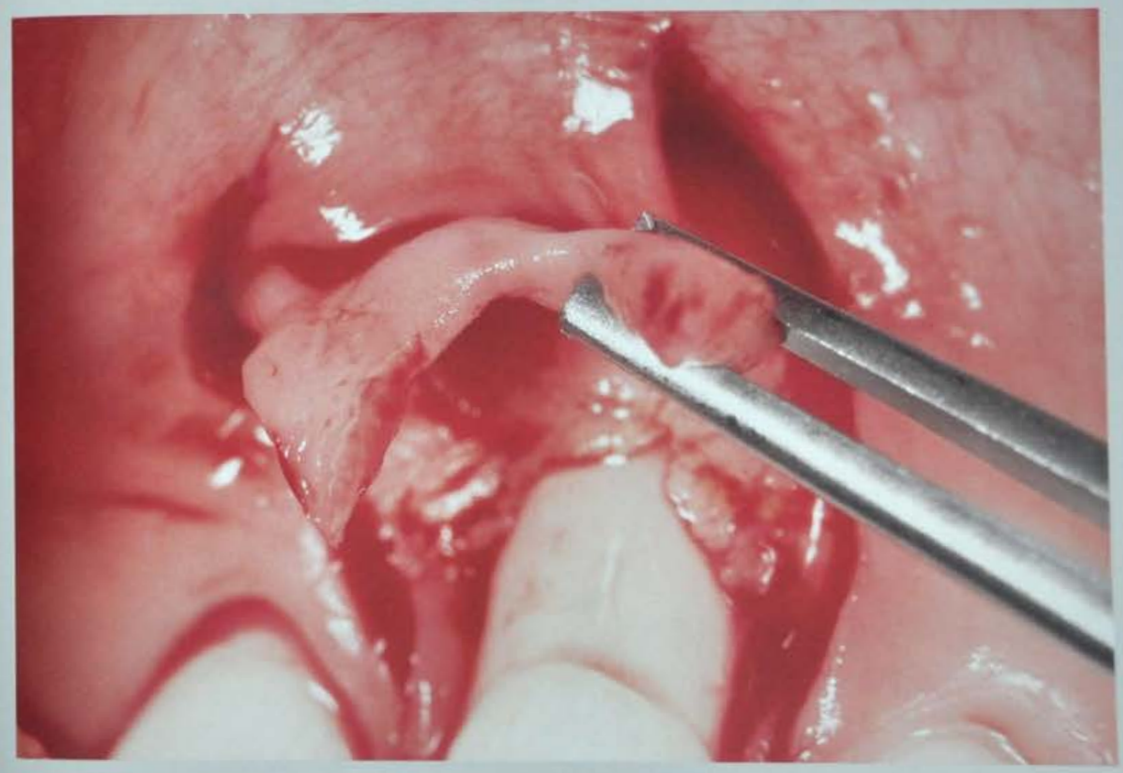


Fig 9-38 Sufficient flap thickness throughout, even along the margins, is one of the most important criteria for success of the split-thickness flap procedure.

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Figs 9-39 to 9-41 As a wound surface must be created in the area where the flap and the graft will be placed, the epithelium must be removed. First, two vertical incisions are placed along the adjacent teeth. The adjacent papillae are then carefully and completely de-epithelialized up to the tips of the papillae with a No. 12D macroblade.







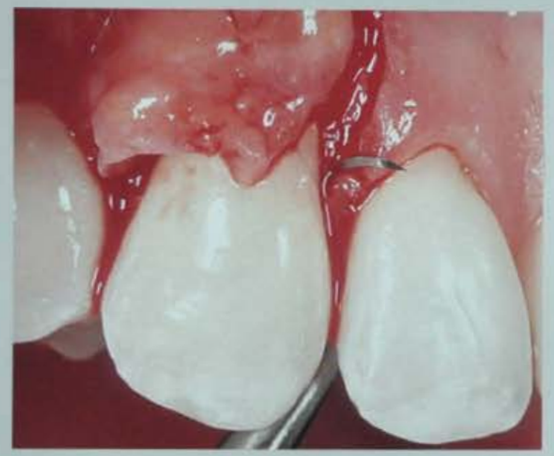






Figs 9-42 to 9-47 The SCTG is harvested from the palate. Once the donor graft has been harvested, it is thinned and trimmed so that it precisely fits over the recipient site.

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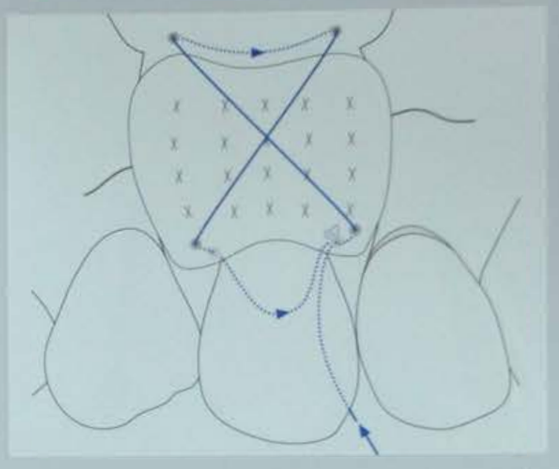
Figs 9-48 and 9-49 The graft is placed on the recipient site and immobilized with crossed horizontal sling sutures of absorbable suture material (6-0 Serafit DS-12). The needle should enter the mesial papillary base on the palatal side, emerge buccally (adjacent to the de-epithelialized papilla), and engage the CTG. It is important to ensure that the graft is correctly positioned and that there is adequate overcorrection.





Figs 9-50 and 9-51 From distal to mesial, the horizontal sling suture passes through the periosteum apical to the graft. From the distal side, it passes through the graft and the base of the papilla and back to the palatal side.





Figs 9-52 and 9-53 Once the suture has been tied on the palatal side, the crossed suture lying across the graft serves not only to stabilize the wound area but also to compress the graft against the root surface.





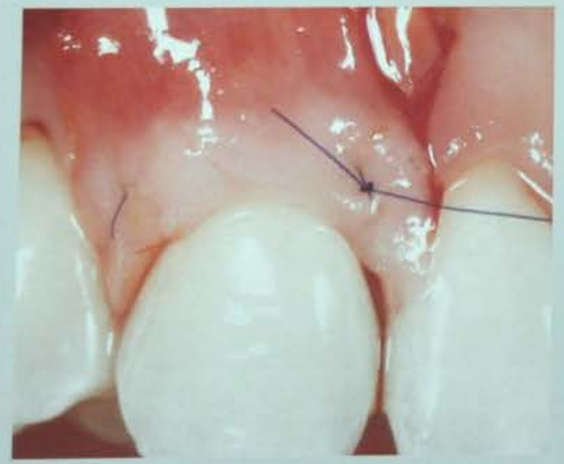
Figs 9-54 and 9-55 A second parallel horizontal sling suture is used to immobilize the flap over the graft on the root surface. A 6-0 Seralene DS-15 suture is used for this purpose. From the mesial side slightly coronal to the mucogingival junction, the needle is passed through the flap, graft, and base of the papilla to the palatal side to adapt the flap and graft to the root surface in the desired position. On the distal side, the needle coming from the palatal aspect is passed buccally through the tip of the papilla and the flap without engaging the graft. The exit site on the buccal side should be positioned so that the needle engages the flap about 1 to 2 mm apical to the flap margin.

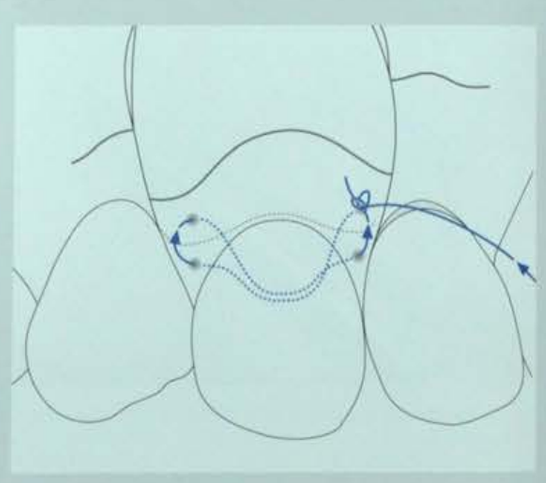
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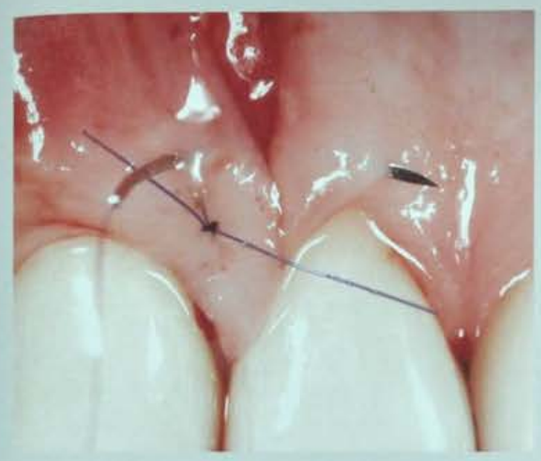


Figs 9-56 and 9-57 From the distal side, the suture is now passed palatally through the flap, graft, and distal papilla before exiting on the patatal side. From there, the needle is then passed through the mesial papilla and exits through the flap about 1 to 2 mm apical to flap margin.





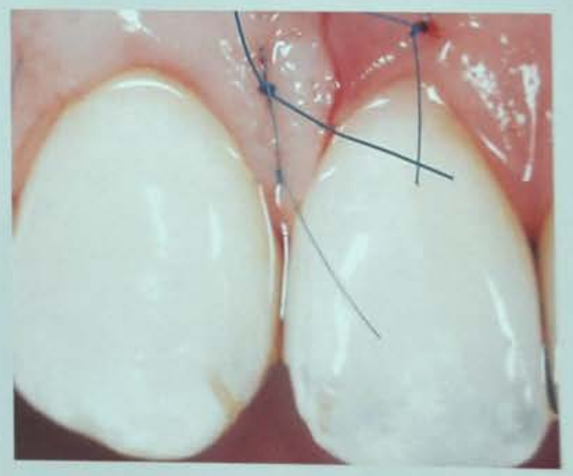
Figs 9-58 and 9-59 Once the second sling suture has been tied, it immobilizes the flap and the graft in the desired coronal position and compresses the soft tissues against the root surface. This ensures wound stability during the early healing phase.





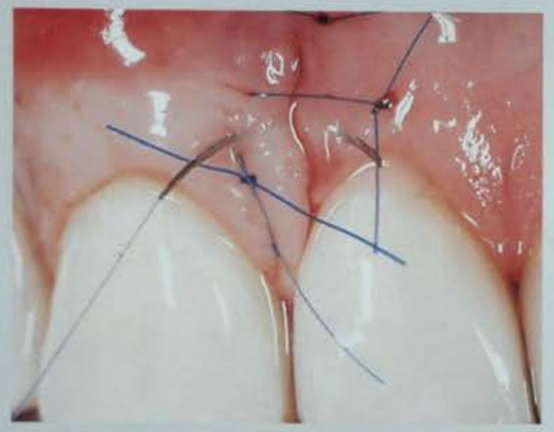
Figs 9-60 and 9-61 To prevent visible scarring, the vertical incisions in the keratinized gingiva must be sutured with special care. The goal must be to achieve virtually perfect approximation of the wound margins to ensure maximum predictability of primary wound healing. Interrupted sutures (7-0 Seralene DS-12) are used to close the site. When mobile and immobile components of a flap are connected, suturing should always be performed from mobile to immobile tissue. To facilitate suturing, a papilla elevator is used to gently raise the immobile wound margin (about 0.5 to 1.0 mm from the edge) as a full-thickness flap. To improve the coronal orientation of the flap, the needle can be made to exit through the immobile wound margin at a slightly more coronal position. The suture is tied, and the knots are placed lateral to the incision line. Experience has shown that it is better to begin suture placement with the second suture from the top.

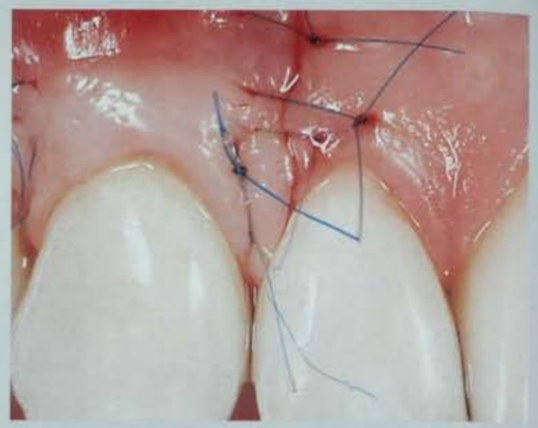




Figs 9-62 and 9-63 A vertical mattress suture is used for approximation of each papilla. The first suture is started on the buccal side. It is important to insert the needle very close to the tip of the papilla to achieve close approximation. From a slightly more apical position on the palatal side, the needle is passed back to the buccal side, and the suture is loosely tied over the first insertion site.

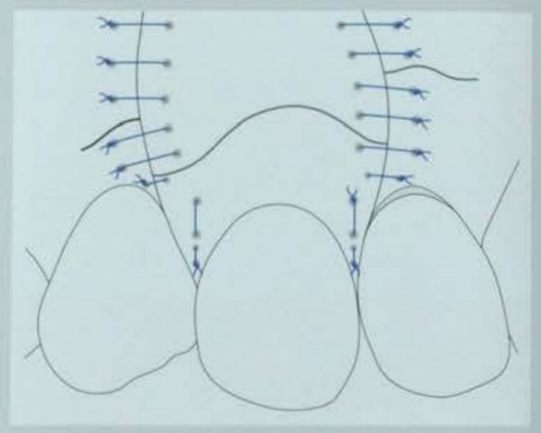
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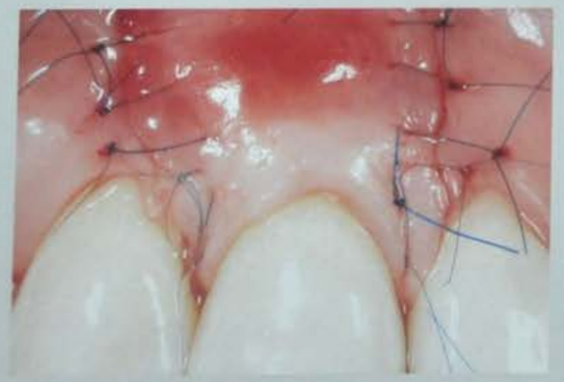




Figs 9-64 and 9-65 The most coronal knot is tied to close the vertical incisions. It is often very difficult to do this using conventional 3/8 needles. The use of a 7-0 Seralene HS8 suture may facilitate knot tying in some cases.







Figs 9-66 to 9-68 Stable primary wound closure has been achieved, and the recession is covered with about 1 mm of over-correction. After closure, gentle pressure is applied to the site for several minutes.

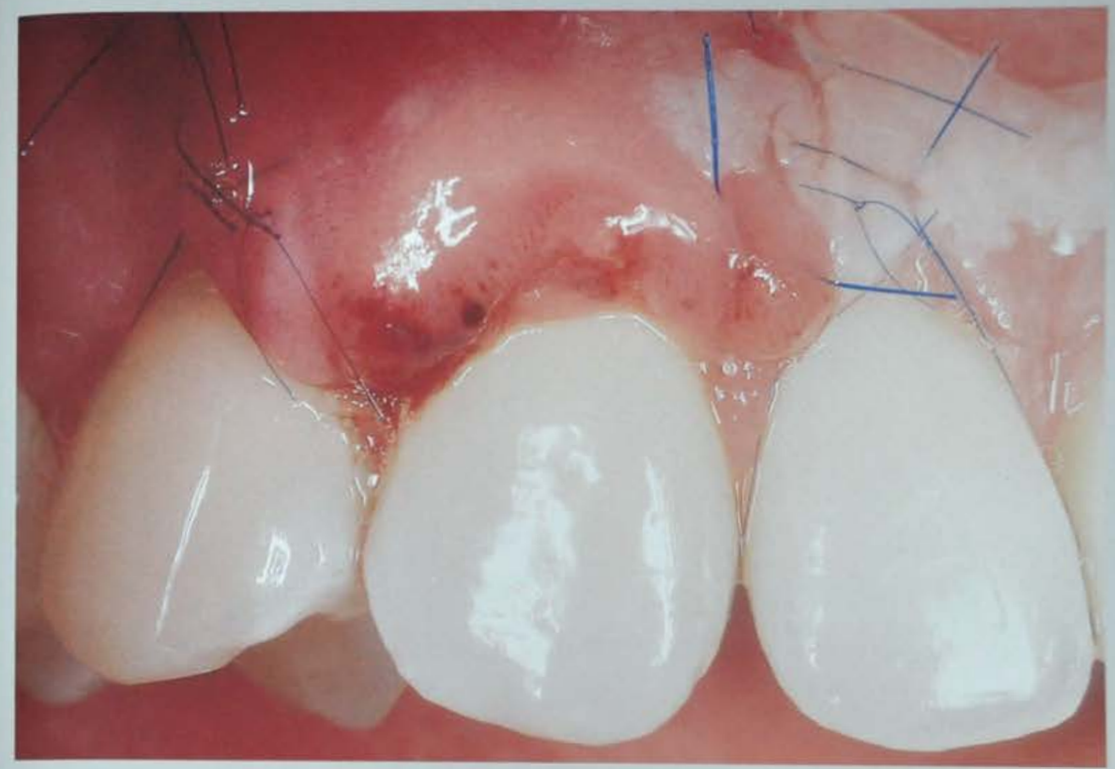
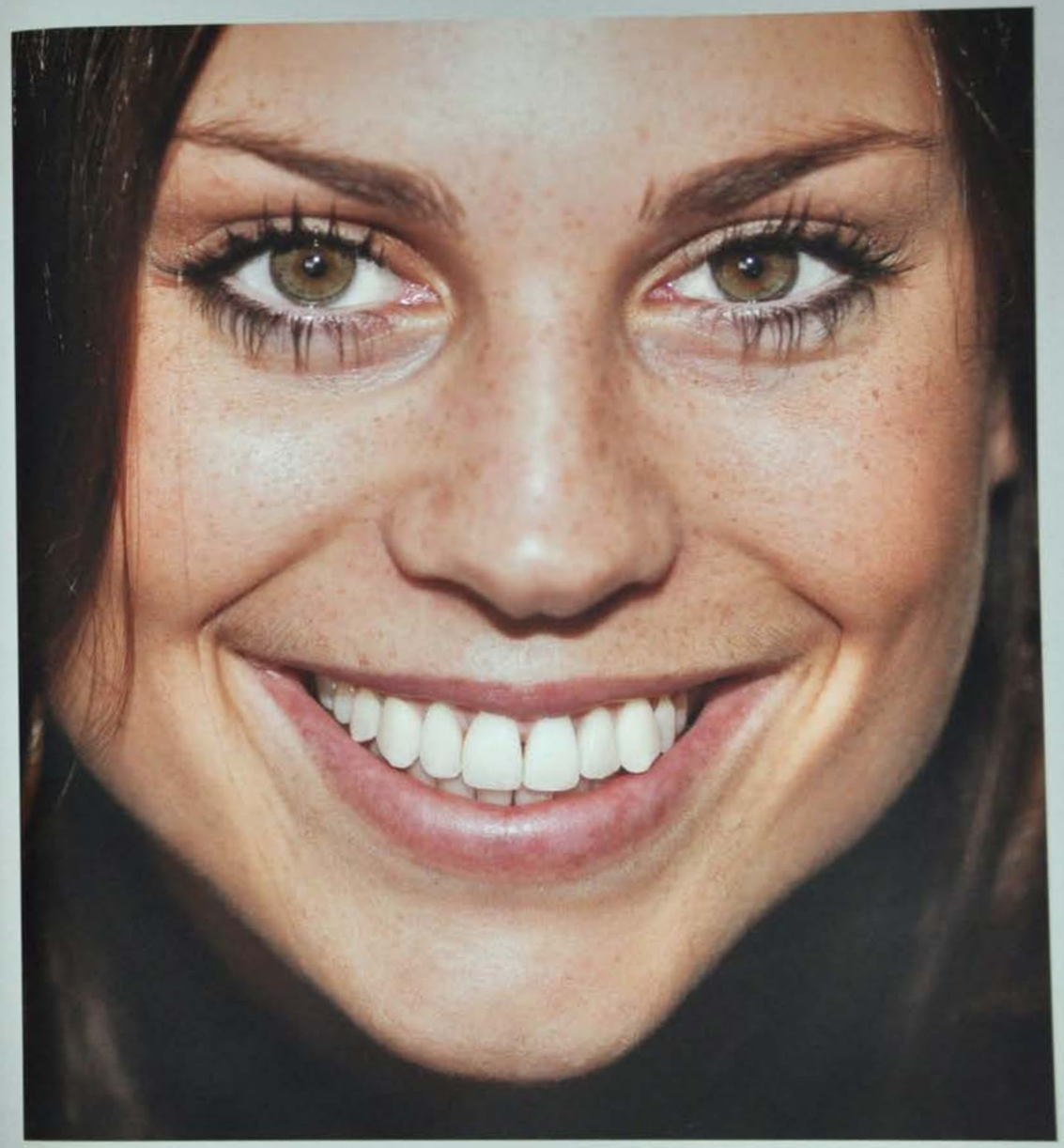


Fig 9-69 Result 1 week after surgery, just before suture removal.

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Figs 9-70 to 9-72 Final result 5 months after surgery.

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 3, Chapter 1: Coronally Advanced Flap with Subepithelial Connective Tissue Graft for Treatment of Localized Gingival Recession."

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9.2.2 Double Lateral Bridging Flap with Connective Tissue Autograft for Treatment of Localized Gingival Recession

KEY POINTS

01. Select the procedure based on the *recession depth* and the *amount of keratinized tissue* apical to the recession defect.

02. Clean the root surface *before the procedure* is started.

03. Elevate a partial-thickness flap:
- Elevate a flap of *uniform thickness without beveled edges*.
- Suture the two smaller flaps together before *completely releasing* the second flap.
- Ensure that the flaps lie flat and firm in the desired position *without tension*.

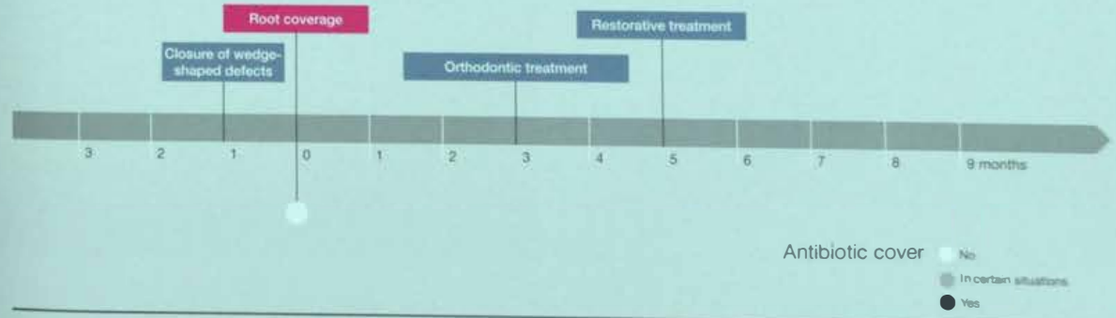
04. Harvest a subepithelial connective tissue graft:
- *Maximum thickness*: 1.0 to 1.5 mm

05. Place sutures:
- Ensure *stable fixation* of the flap and the graft to the root surface.
- Provide 1.0 to 1.5 mm of *overcorrection*.

06. Apply *gentle pressure* to the wound for several minutes.

07. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, 7-0 Seralene DS-12, and 7-0 Serafit DS-12
4. No. 15 macroblade and Keydent microblade
5. Glass slab
6. 0.1% chlorhexidine solution in a metal dish
7. Sterile water in a metal dish
8. Blunt cannula
9. 10-mL syringe
10. Local anesthetic
11. Large and small pledgets
12. Periodontal stent



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STEP-BY-STEP PROCEDURE







Figs 9-73 to 9-75 A 3.0-mm-deep Miller Class I recession is located around the maxillary left canine. The width of keratinized tissue apical to the recession is only about 1.5 mm. The cervical defect was repaired with composite resin before root coverage.







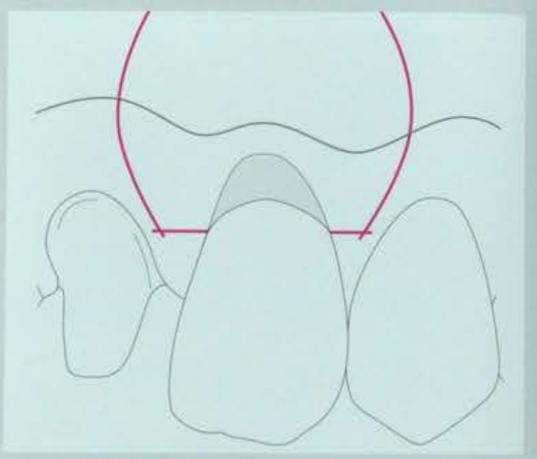
Figs 9-76 to 9-78 Once the root surface has been cleaned, the flap can be elevated. Starting on the mesial side, 1 to 2 mm coronal to the CEJ reconstructed with composite resin, a horizontal incision is made with the microblade. The incision must end at least 1 mm from the gingival margin of the adjacent tooth. To facilitate elevation of the partial-thickness flap, it is crucial that the scalpel be held perpendicular to the tissue surface and that the intersecting lines of the vertical incisions be distinctly overcut.

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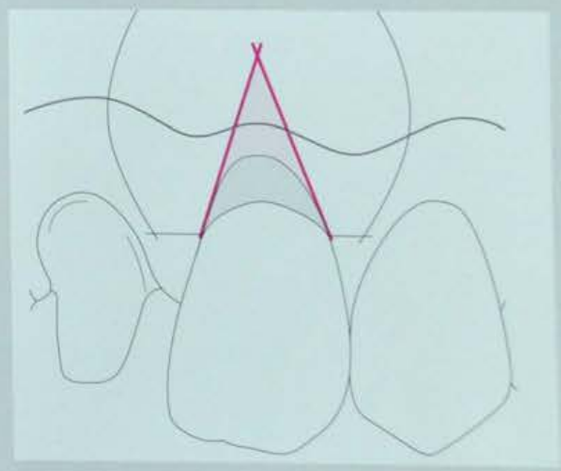
Figs 9-79 to 9-82 The No. 15 macroblade is used to extend the vertical incision in a C-shaped curve toward the vestibule; there must be a safety margin of at least 1 mm from the marginal gingiva of the adjacent tooth. Afterward, the same procedure is repeated on the distal side.





Figs 9-83 and 9-84 To move the two lateral flaps toward each other and suture them together, it is necessary to remove a small wedge of tissue apical to the recession. Two symmetric vertical incisions are extended from the two horizontal incisions and made to meet apical to the recession with slight overlap.





Figs 9-85 and 9-86 The wedge of tissue between the two vertical incisions is removed by sharp dissection. Care must be taken to avoid unnecessary damage to the periodontal fibers on the root surface and to the periosteum on the bone.

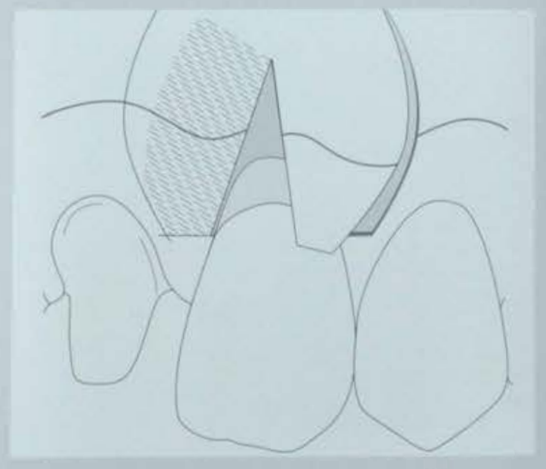
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Figs 9-87 and 9-88 Preparation of the first partial-thickness flap is begun with a No. 15 macroblade. To avoid perforation, the operator's eyes should always be focused on the blade working beneath the flap. Tissue pliers are not used until the coronal part of the flap starts to move and obstructs the view of the outer mucosal surface. The incision is continued apically until the flap has adequate mobility, enabling its placement in the desired lateral position without tension. It is crucial to leave enough connective tissue on the periosteum in the apical region to allow the CTG to be stably secured later.





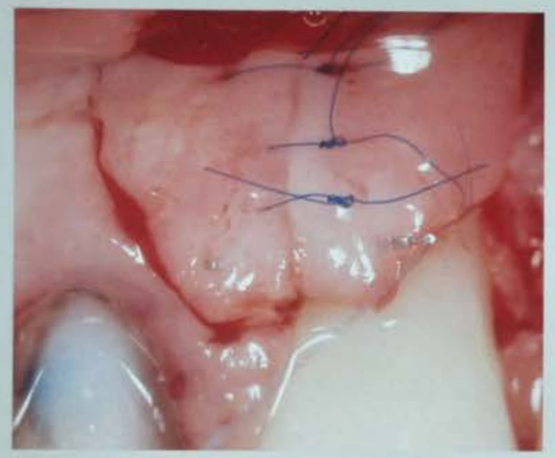
Figs 9-89 and 9-90 To make it easier to suture the two small flaps together later, the second small flap should initially remain immobilized. Therefore, the partial-thickness flap is only partly completed, beginning from the mesial aspect.

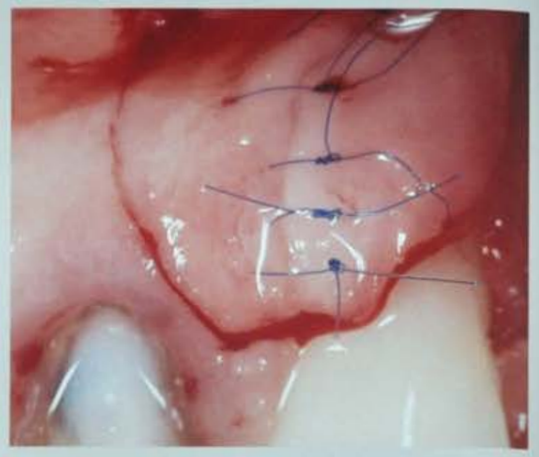




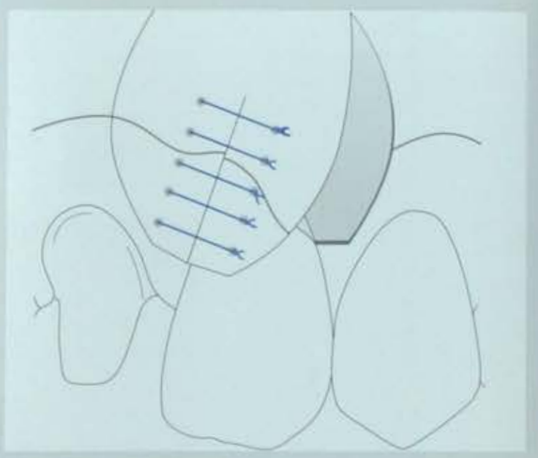
Figs 9-91 and 9-92 The two small flaps are now approximated and sutured with interrupted sutures (7-0 Seralene DS-12). Experience has shown that it is better to start suture placement with the second suture from the top. Suturing should always be performed from mobile to immobile tissue. To enhance the predictability of primary healing, the goal should be to achieve perfect approximation of the wound margins. Ideally, the sutures should be oriented perpendicular to the incision line.

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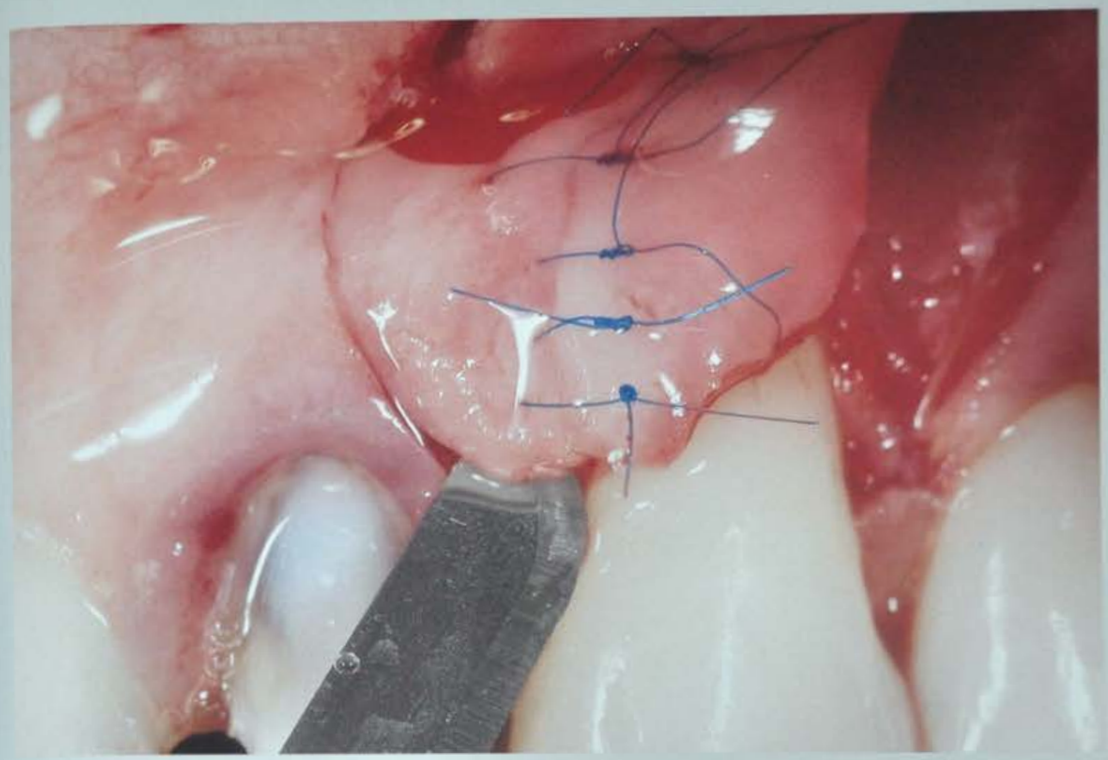


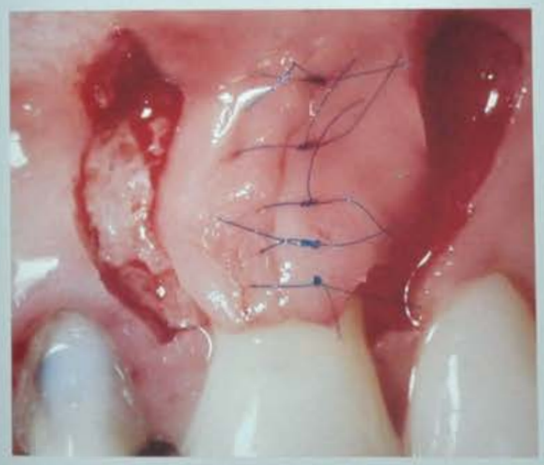


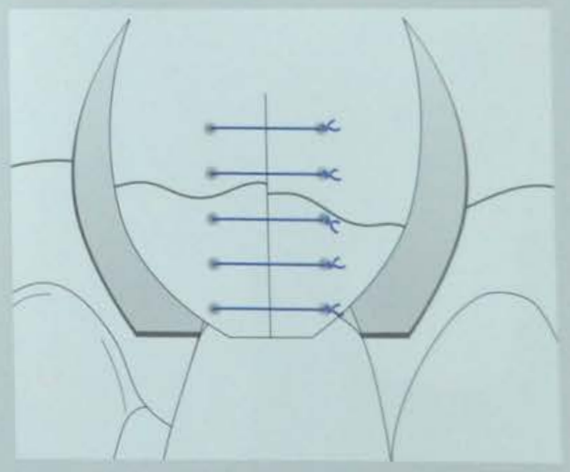




Figs 9-93 to 9-96 The most coronal suture is placed last. It can be used to make final corrections to achieve virtually perfect approximation. The knots are placed lateral to the incision line.







Figs 9-97 to 9-99 The second small flap is mobilized the same way as the first. After the second flap is completed, it is important to ensure that the two flaps have adequate mobility to enable placement over the exposed root surface without tension.

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Figs 9-100 and 9-101 Once the donor graft has been harvested from the palate, it is thinned and trimmed so that it fits precisely over the recipient site.

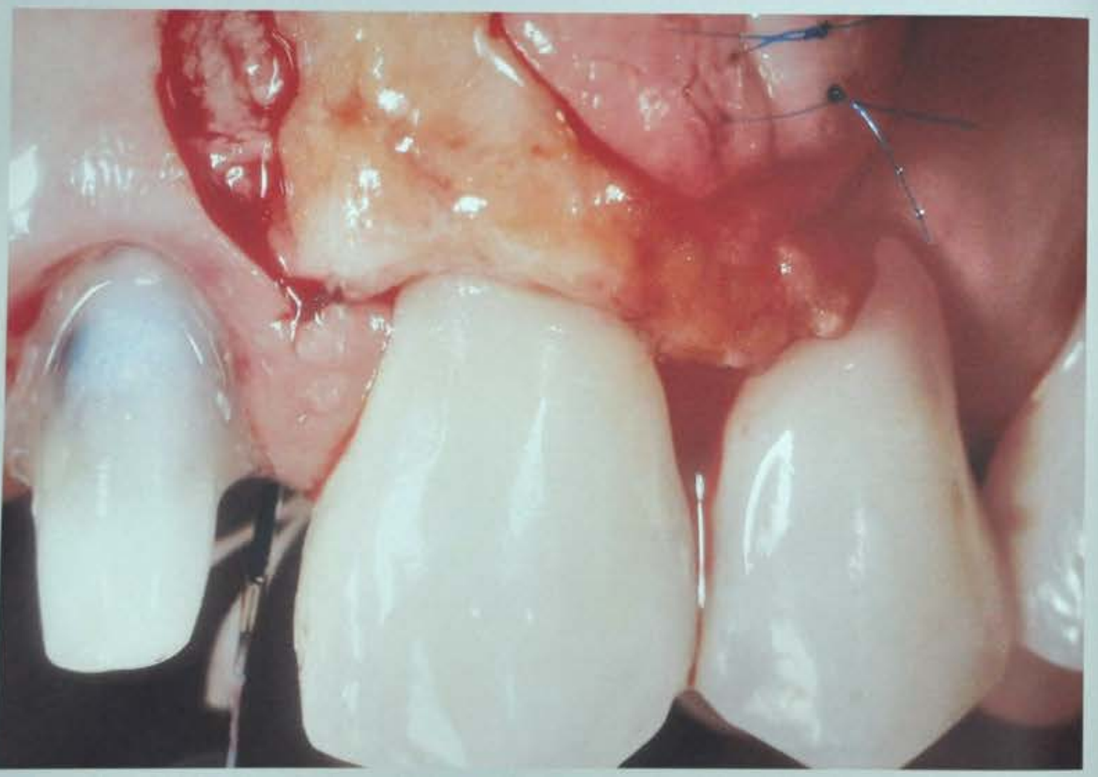


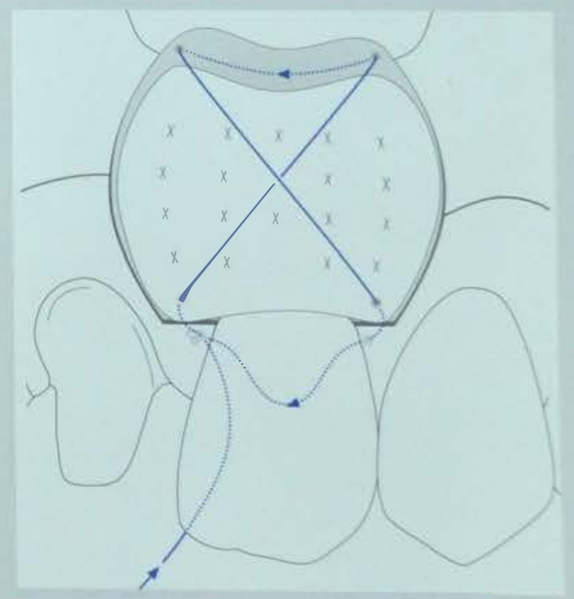
Fig 9-102 The graft is fixed to the recipient site with crossed horizontal sling sutures made of absorbable material (6-0 Serafit DS-12). The needle should enter the mesial papilla on the palatal side, emerge from the papillary base in the area of the prepared recipient bed on the buccal side, and engage the CTG. The graft is aligned in the desired position on the root surface in a way that allows for the required amount of overcompensation.





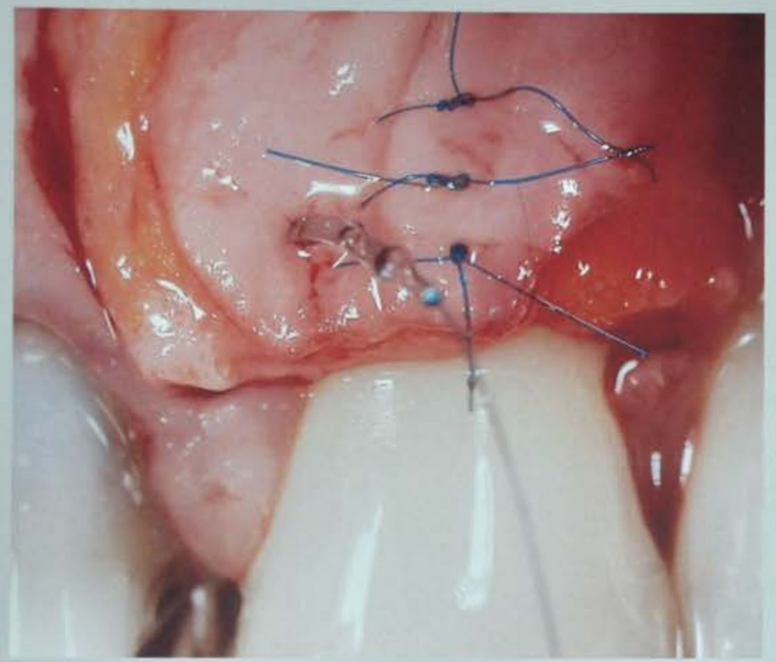
Figs 9-103 and 9-104 From distal to mesial, the horizontal sling suture passes through the periosteum apical to the graft and crosses over the graft. From the distal side, it passes through the graft and the base of the papilla and back to the palatal side.

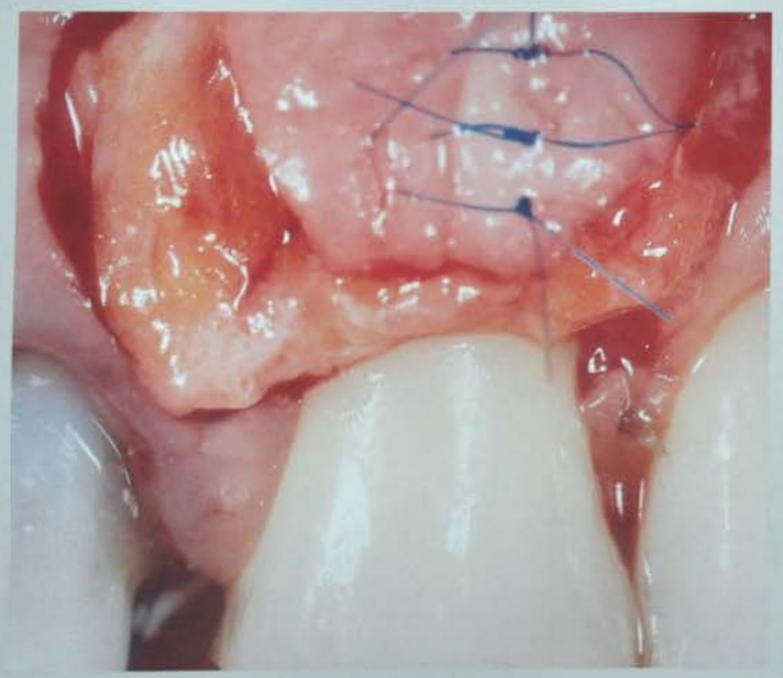




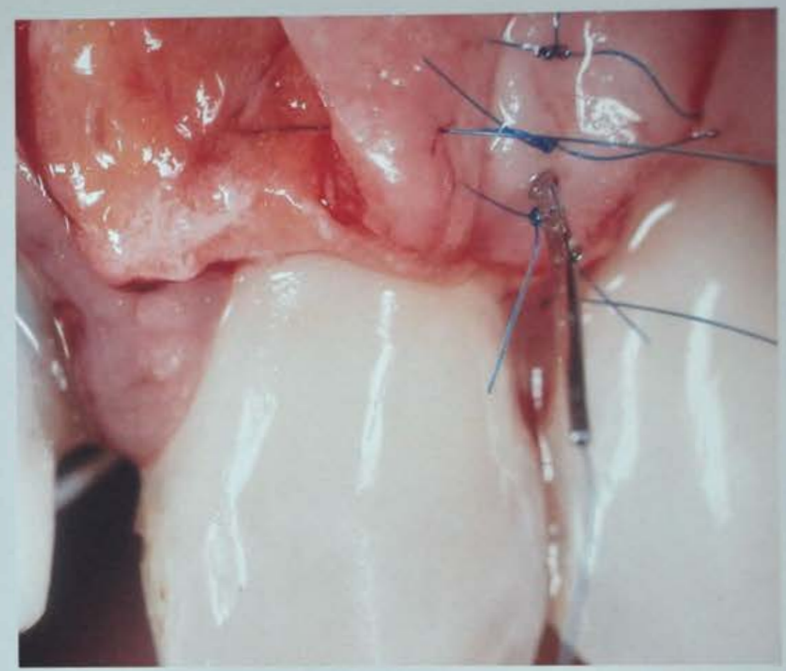
Figs 9-105 and 9-106 Once the suture has been tied on the palatal side, the suture over the graft serves not only to stabilize the wound area but also to compress the graft against the root surface and recipient bed. If distinct alveolar eminences (juga alveolana) are present, it may be necessary to perform a second sling suture, placing a parallel thread over the graft to achieve immobilization.

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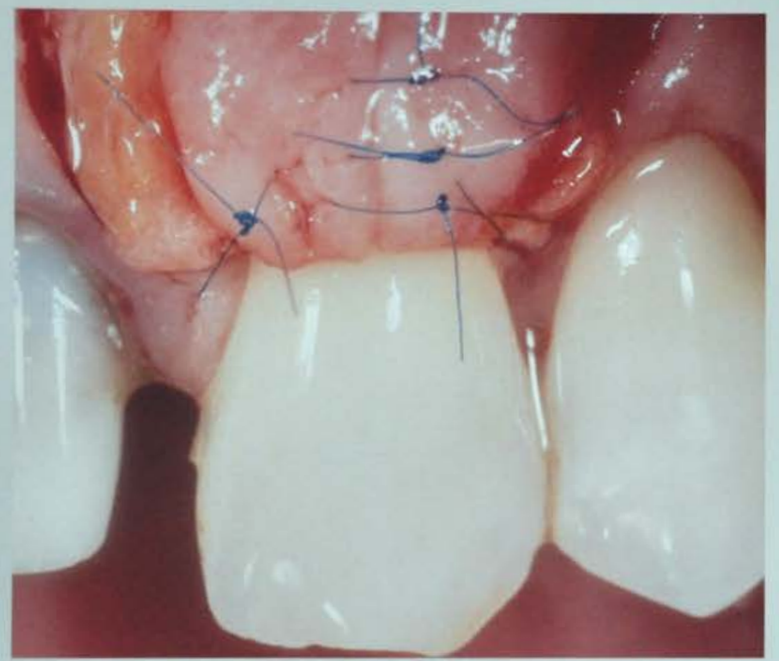
Figs 9-107 and 9-108 Two parallel horizontal sling sutures are used to immobilize the connected flaps over the graft on the root surface. From the mesial side, about 3 mm apical to the coronal flap margin, the suture (6-0 Seralene DS-15) is passed through the flap, graft, and base of the papilla to the palatal side to adapt the flap and graft to the root surface in the desired position. On the distal side, the needle passes palatally through the papilla and buccally through the center of the papilla coronal to the surgical site, where it emerges.

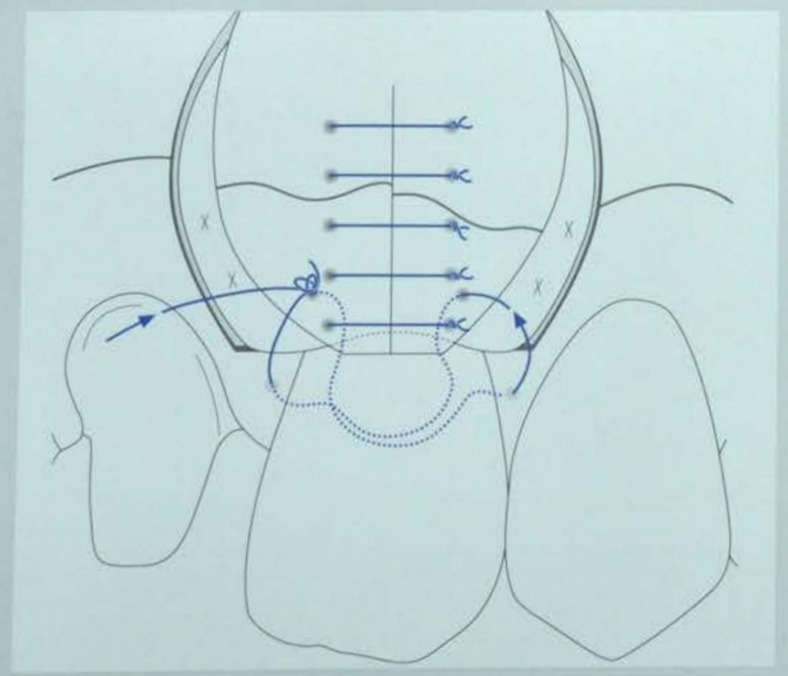




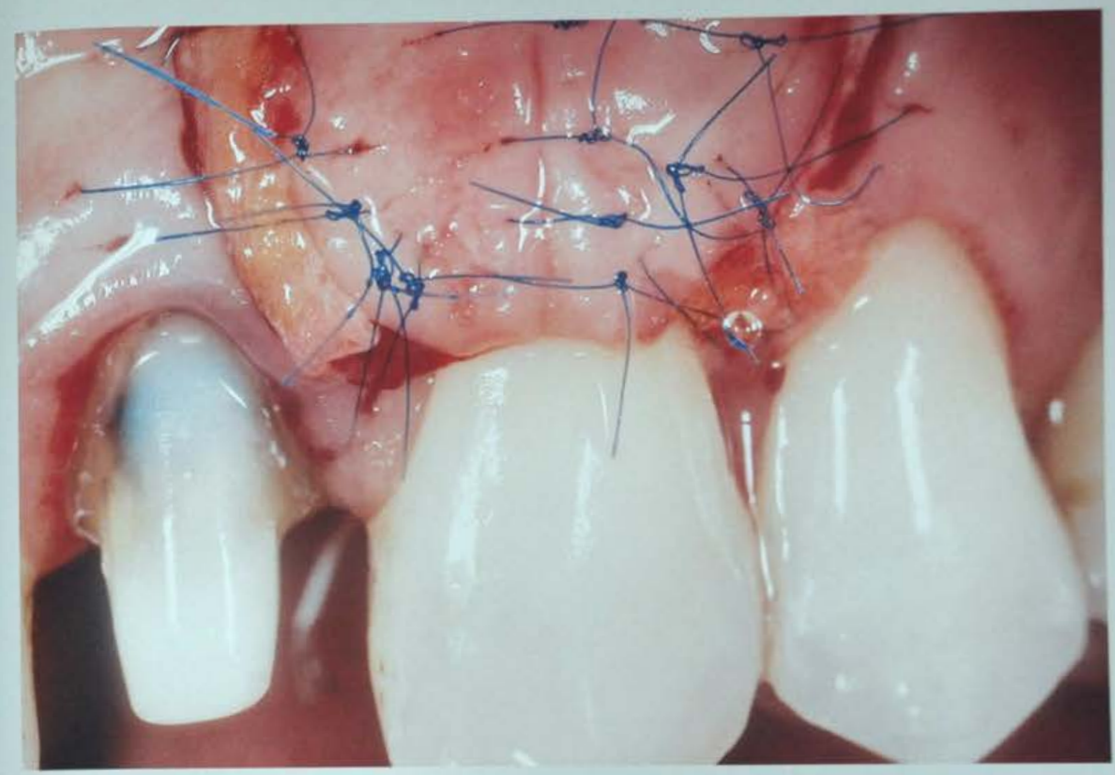
Figs 9-109 and 9-110 On the distal side, the needle is passed from buccal to palatal, analogous to the procedure on the mesial side. From the palatal side, it is passed through the center of the papilla and back to the buccal starting point on the mesial side.

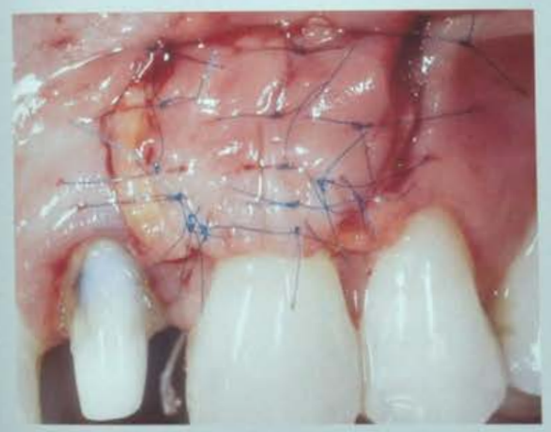
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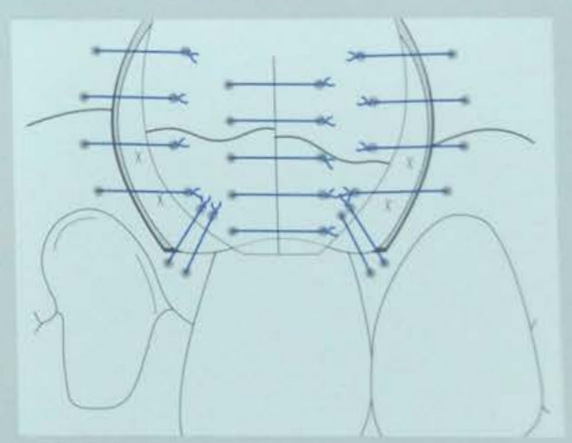




Figs 9-111 and 9-112 The objective of this suturing technique is to establish wound stability to enhance wound healing during the initial postoperative period. It secures the flap and graft in the desired coronal position and compresses the soft tissue onto the root surface and recipient bed.







Figs 9-113 to 9-115 Interrupted sutures (7-0 Seralene DS-12) are used to suture the lateral flap margins. Perfect flap coaptation is not the goal this time. Here, it is sufficient to gently stabilize the flap onto the underlying surface and to allow the open wound areas between the flaps to heal by secondary intention. To facilitate suturing, a papilla elevator is used to gently raise the immobile wound margin (about 0.5 to 1.0 mm from the edge) as a full-thickness flap. Suturing should always be performed from mobile to immobile tissue. Once the suture has been tied, the knot is placed lateral to the incision line. The recession should be covered with about 1.0 mm of overcorrection. The procedure is completed after gentle pressure is applied to the wound for several minutes.

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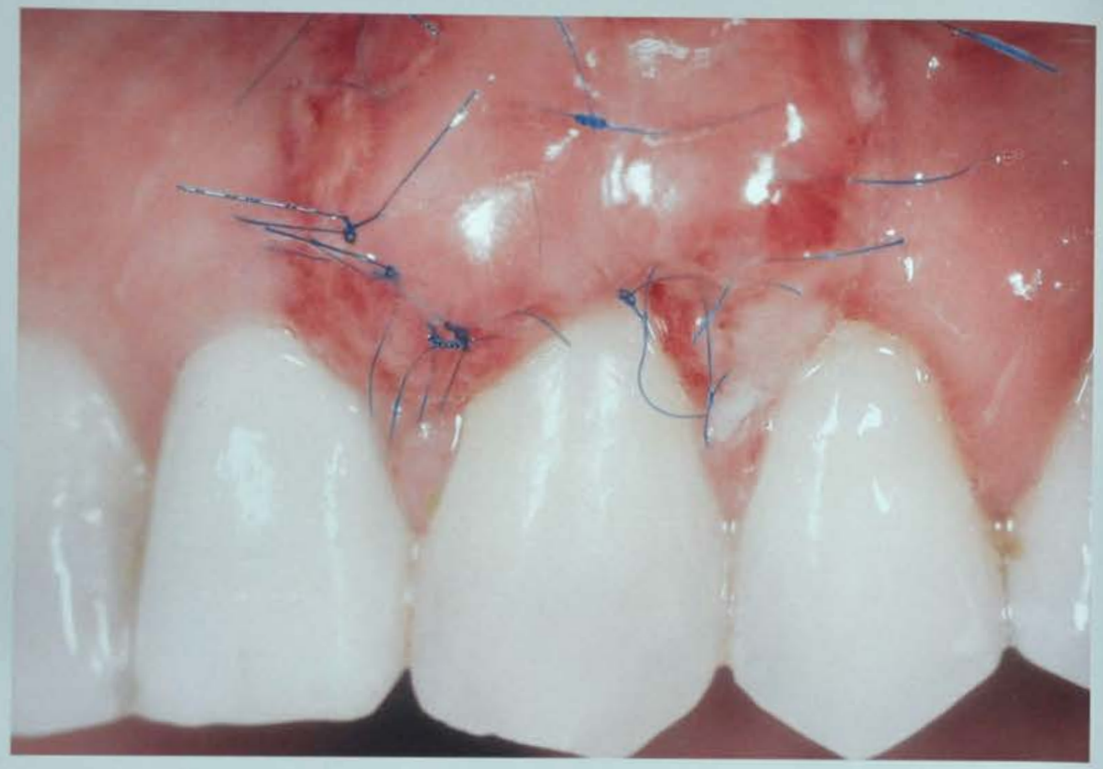
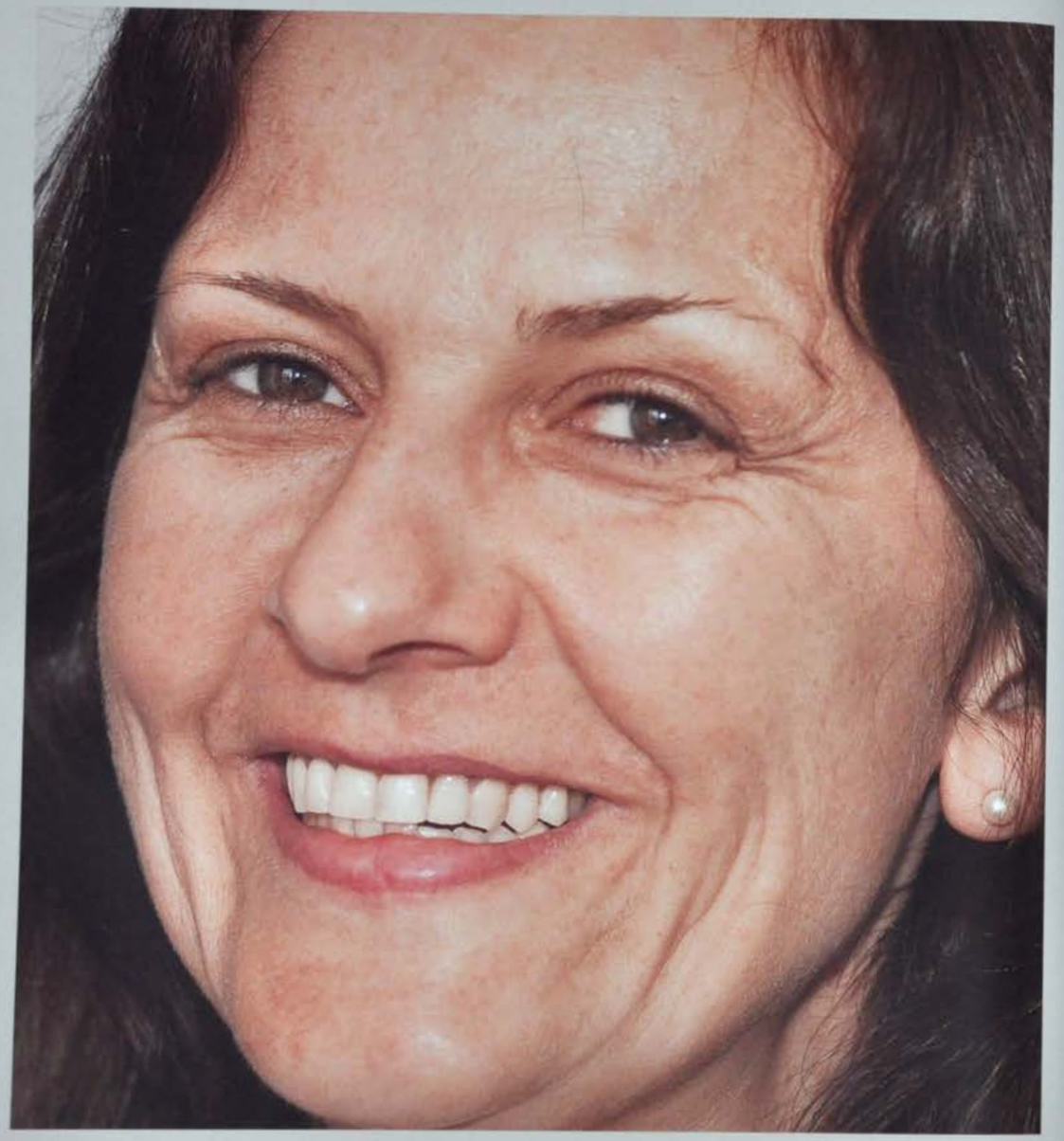


Fig 9-116 Result 1 week after surgery, just before suture removal.





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Figs 9-117 to 9-119 Final result 5 months after surgery. (Composite resin restoration: *Bärbel Hürzeler*, Munich, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 3, Chapter 2: Double Lateral Bridging Flap with Connective Tissue Autograft for Treatment of Localized Gingival Recession."

9.2.3 Modified Tunnel Technique with Connective Tissue Autograft for Treatment of Localized Gingival Recession

KEY POINTS

01. Select the procedure based on the *recession depth* and the *amount of keratinized tissue* apical to the recession defect.

02. Clean the root surface *before the procedure* is started.

03. *Splint* the contact points with flowable composite resin, if necessary.

04. Elevate a partial-thickness flap/tunnel:
- Extend it *coronally* to the base of the papilla
- Extend it *apically* beyond the mucogingival line.
- Extend it *laterally* at least one tooth wider than the recession.

05. Elevate a full-thickness flap:
- *Dissect the periosteum* at the base of the papilla.
- Reflect the *buccal papilla.*

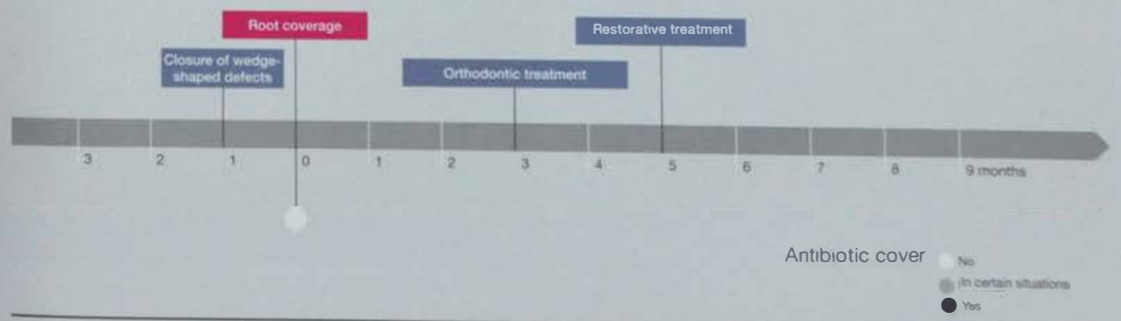
06. Harvest a subepithelial connective tissue graft:
- *Maximum thickness*: 1.0 to 1.5 mm
- Ensure that the *size is adequate.*

07. Use vertical double-crossed sutures *to secure the flap and graft.*

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive *postoperative instructions.*

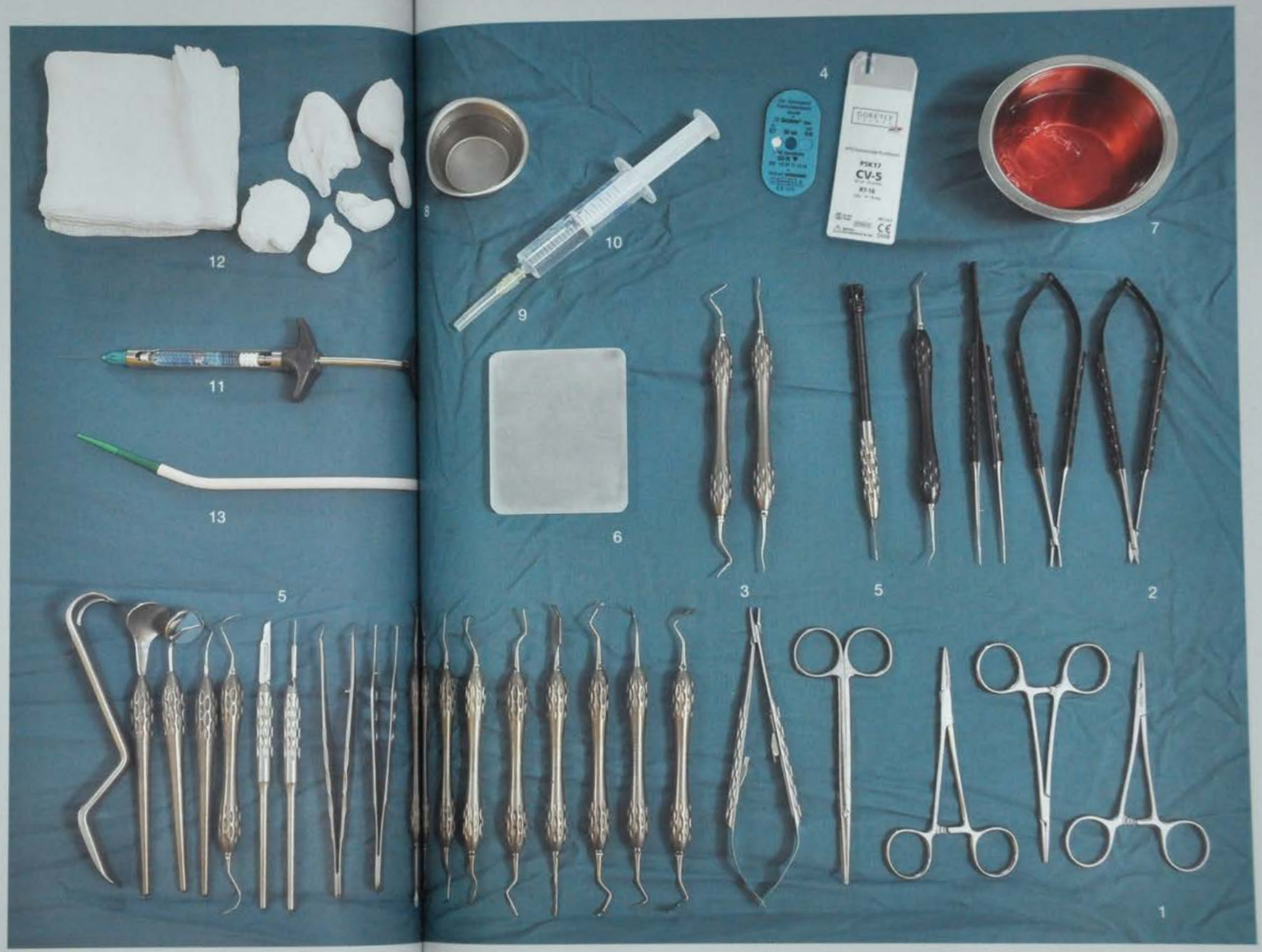
TIME MANAGEMENT



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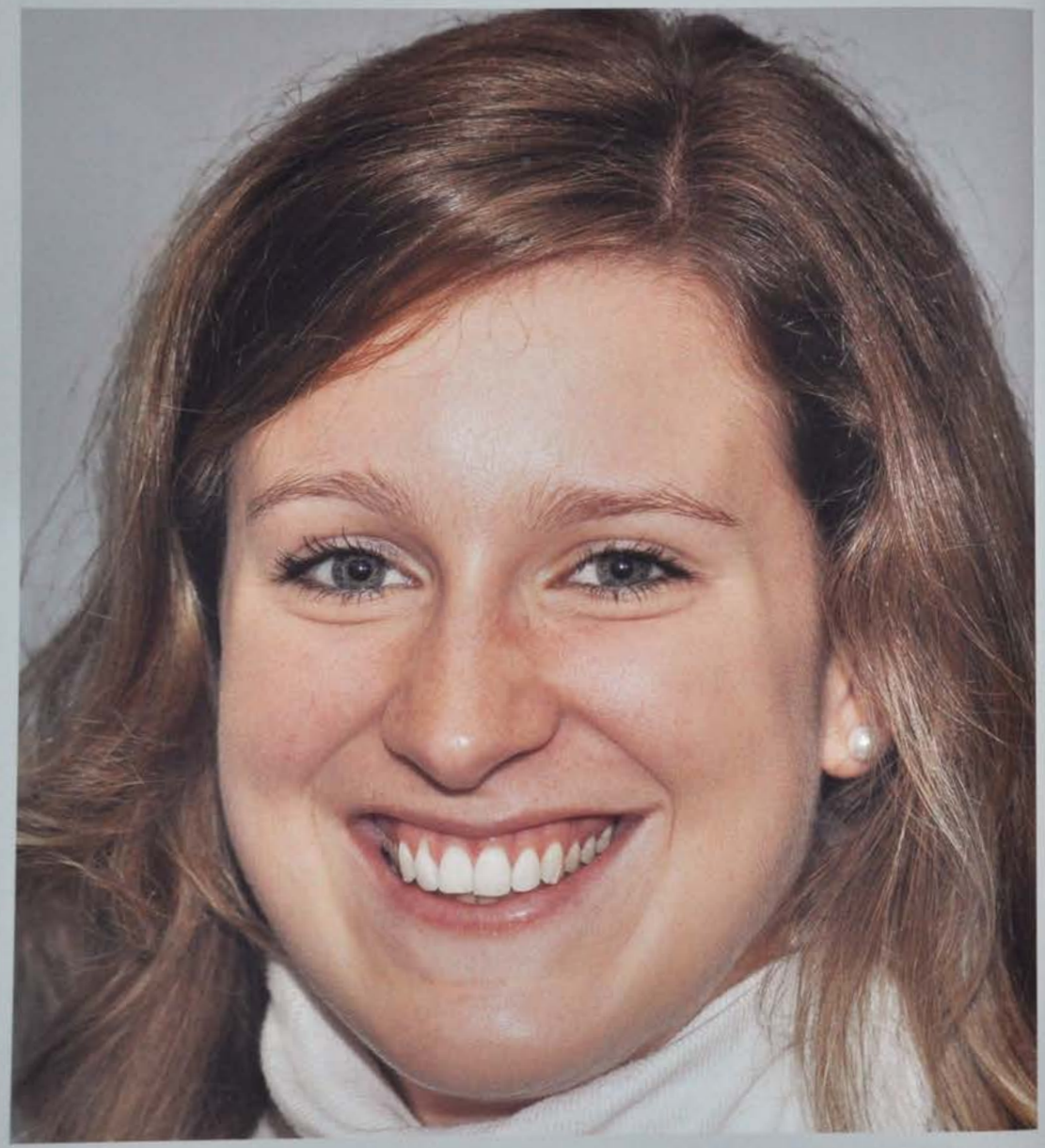
WORKPLACE PREPARATION CHECKLIST

1 Macrosurgical instrument set
2 Microsurgical instrument set
3 Tunneling Knives I and II
4 Suture materials: Gore-Tex CV-5 and 6-0 Seralene DS-15
5 No. 15 macroblade and Keydent microblade
6 Glass slab
7 0.1% chlorhexidine solution in a metal dish
8 Sterile water in a metal dish
9 Blunt cannula
10 10-mL syringe
11 Local anesthetic
12 Large and small pledgets
13 Periodontal stent



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STEP-BY-STEP PROCEDURE









Figs 9-120 to 9-123 The treatment site is a 3.0-mm *Miller* Class I defect with a keratinized tissue width of 1.5 mm, located on the maxillary right lateral incisor.

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Figs 9-124 and 9-125 The exposed root surfaces are cleaned with a rubber cup and polishing paste, and the contact points with the adjacent teeth are splinted with flowable composite. Enamel etching is not necessary.





Figs 9-126 and 9-127 To start the partial-thickness flap dissection and tunneling procedure, a marginal intrasulcular incision is made with the microblade.



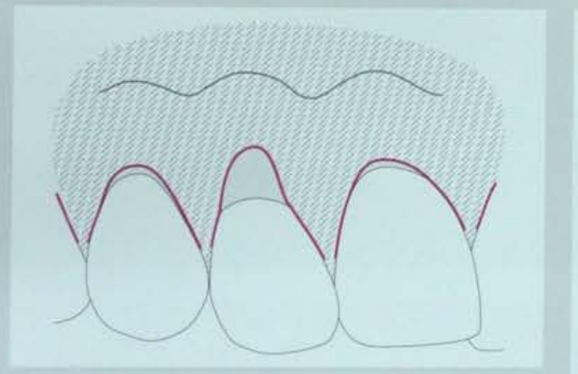


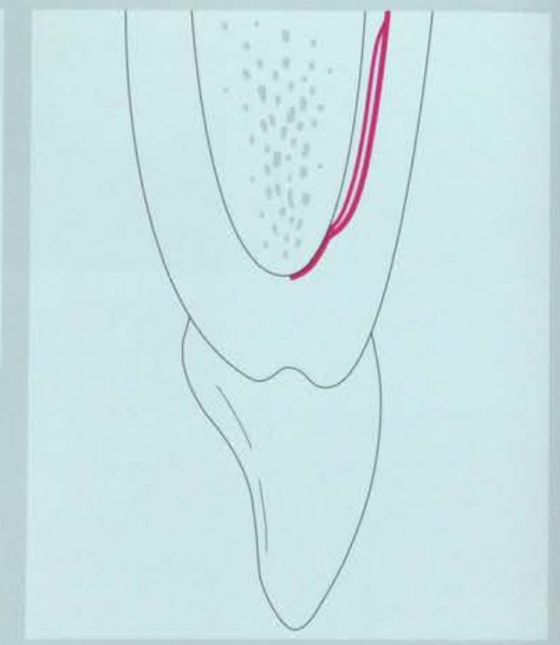
Figs 9-128 and 9-129 Technically, it is much easier to prepare the tunnel if papillary elevation is performed as early as possible, preferably before the Tunneling Knives come into play. The periosteum at the base of the papilla is sharply dissected with the microblade, and a papilla elevator is used to raise a full-thickness papilla base flap. To avoid the loss of papillary tissue, only the buccal half of the papilla, and not the entire papilla, should be elevated.

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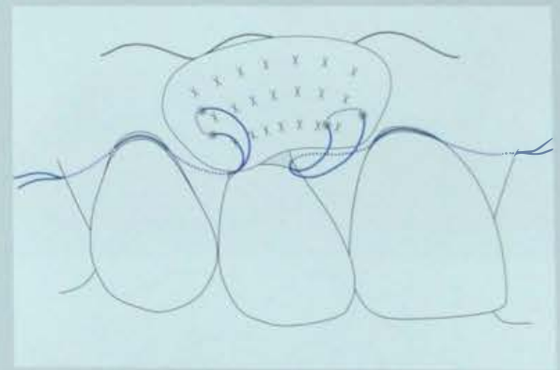
Figs 9-130 to 9-133 To minimize the risk of perforation, tunnel preparation should be completed with the Tunneling Knives instead of the microblade. With rounded movements, the incision is extended apically beyond the mucogingival junction. To achieve adequate flap mobility, the incision is extended at least one tooth mesial and distal to the recession. The CTG can now be harvested from the palate. Before the graft is placed, the operator should ensure that the incision was made in a single plane, ie, that the tunnel is open and unobstructed.



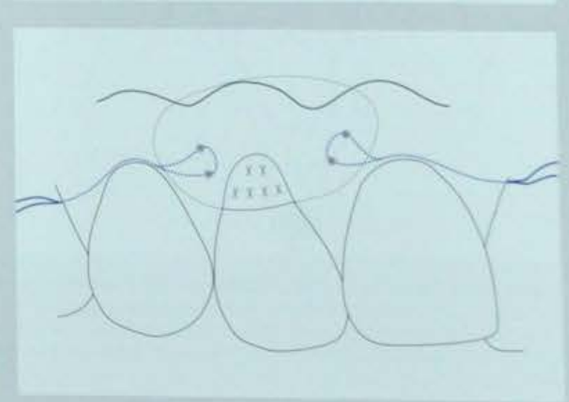


Figs 9-134 and 9-135 The use of positioning sutures made of Gore-Tex CV-5 has proved to be an effective way to insert and position the graft in the tunnel. The needle is inserted bluntly (back-first) into the tunnel one tooth width lateral to the recession and is made to exit marginal to the affected tooth. The needle engages the CTG laterally, from the inside out, and then, slightly more apically, from outside in. The needle is then passed back through the tunnel and returned to the starting point.







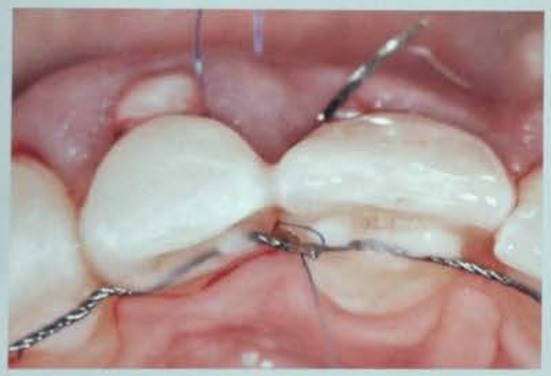


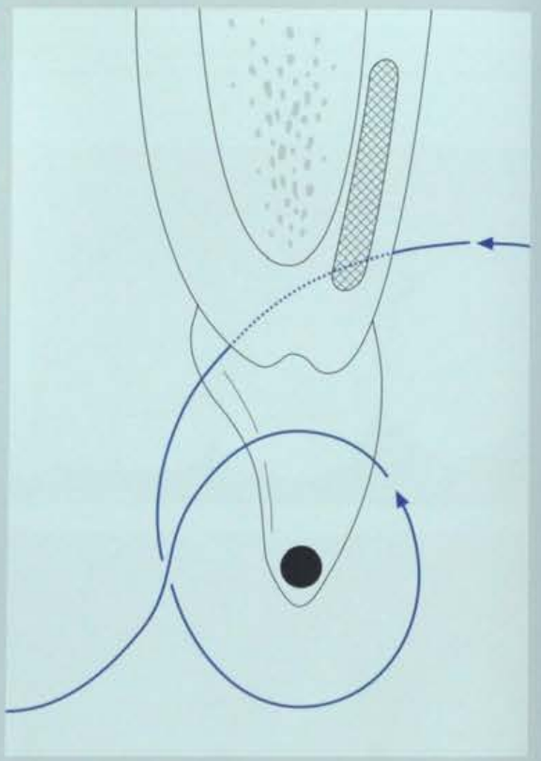
Figs 9-136 to 9-139 The graft is then drawn into the tunnel and maneuvered into the desired position by gentle pulling of the positioning sutures.

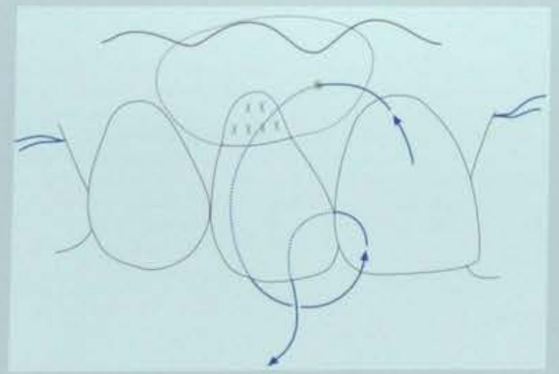
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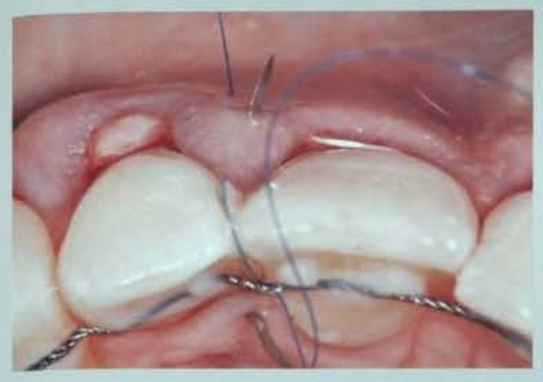




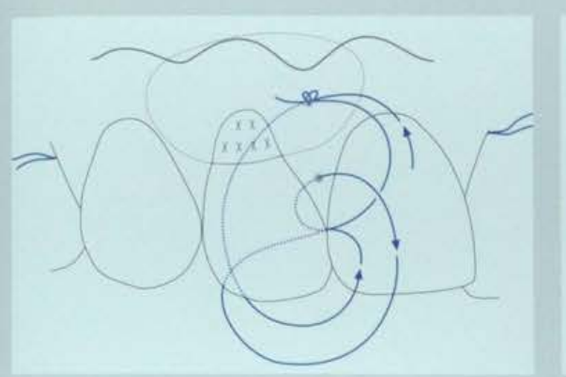


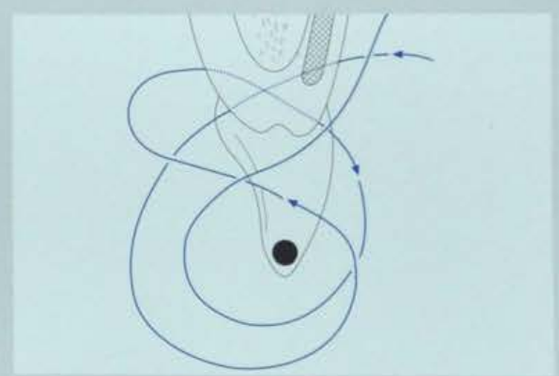


Figs 9-140 to 9-144 Two vertical double-crossed sutures (6-0 Seralene DS-15) are used for suture closure. First suture: Starting on the buccal side, the needle enters at the level of the mucogingival junction, engages the CTG, passes beneath the splinted contact point, engages the tissue, and exits on the palatal side, slightly apical to the tip of the papilla. The needle then returns over the incisal edges of the teeth to the buccal side, passes back-first beneath the splinted contact point without engaging the tissue, and exits again on the palatal side.

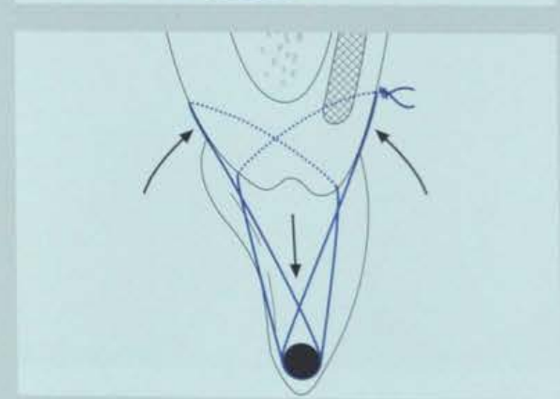












Figs 9-145 to 9-150 Second suture: Starting from the palatal side, the needle enters the base of the papilla and exits slightly apical to the tip of the papilla on the buccal side (without engaging the graft). The needle must exit the tissue in the region of the elevated flap to prevent folds from forming at the base of the papilla. Next, the needle is guided back to the palatal side and is again passed beneath the splinted contact point, back-first so as not to engage the tissue, and is returned to the buccal side. After the suture has been tied and the second suture is completed, the positioning sutures are removed. Gentle pressure is then applied to the wound for several minutes.

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Figs 9-151 and 9-152 The dual effects of the vertical double-crossed suture are to immobilize the flap and the graft in the desired coronal position and to compress them against the root surface. A small portion of the SCTG is left uncovered to increase the width of keratinized gingiva in the course of healing.





Figs 9-153 and 9-154 Result 1 week after surgery, immediately prior to suture removal.







Figs 9-155 to 9-157 Result 5 months after surgery.

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Fig 9-158 Patient after completion of treatment.

9.2.4 Coronally Advanced Flap with Enamel Matrix Derivative for Treatment of Multiple Gingival Recessions

KEY POINTS

01. Select the procedure based on the *recession depth* and the *amount of keratinized tissue* apical to the recession defect.

02. Clean the root surfaces *before the procedure* is started.

03. Elevate a partial-thickness flap:
- Elevate a flap of *uniform thickness without beveled edges*.
- Ensure that the flap lies flat and firm in the desired position *without tension*.
- *Completely de-epithelialize* the papillae.

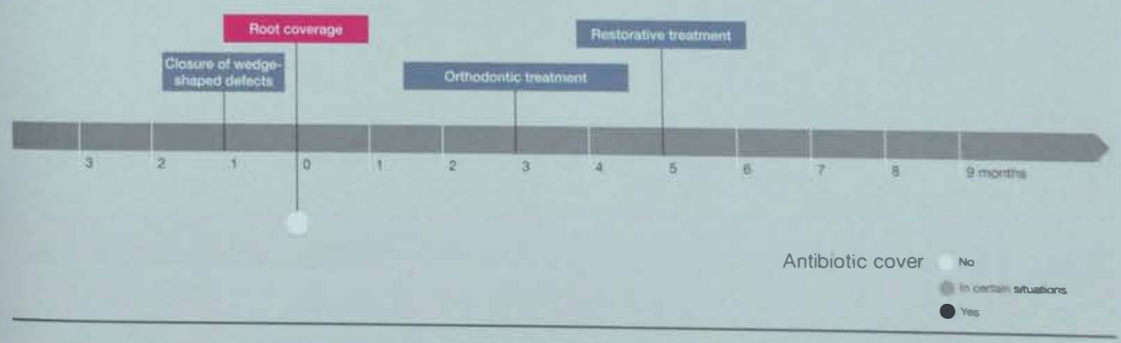
04. Apply *enamel matrix derivative* to the cleaned and dried root surfaces after conditioning with EDTA.

05. Place sutures:
- Ensure *stable fixation* of the flap to the root surface.
- Allow 1.0 to 1.5 mm of *overcorrection* in the vertical direction.
- Ensure *perfect flap coaptation* in the papillary region and in the coronal part of the vertical releasing incisions.

06. Apply *gentle pressure* to the wound for several minutes.

07. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 3, Chapter 3: Modified Tunnel Technique with Connective Tissue Autograft for Treatment of Localized Gingival Recession."

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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Suture materials: 6-0 Seralene DS-15, 7-0 Seralene DS-12 (and Seralene HS-8, if needed)
4. Conventional No. 15 and 12D macroblades and Keydent microblade
5. Enamel matrix derivative and EDTA
6. Sterile water in a metal dish
7. Blunt cannula
8. 10-mL syringe
9. Local anesthetic
10. Large and small pledgets
11. Periodontal stent



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STEP-BY-STEP PROCEDURE







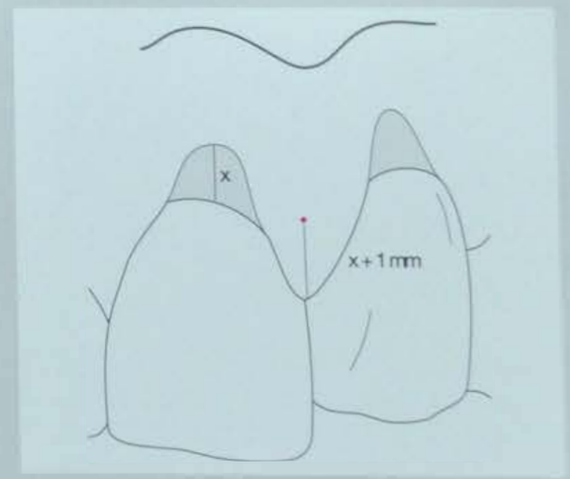
Figs 9-159 to 9-161 Multiple *Miller* Class I recession defects are present in the maxillary anterior region.

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Figs 9-162 to 9-164 Old composite resin restorations in the cervical region are removed and replaced. The composite restorations should not extend beyond the CEJ unless absolutely necessary. Root coverage should be performed on the natural root surfaces as far as possible. Figure 9-164 (bottom) shows the site after placement of the cervical composite restorations.





Figs 9-165 to 9-169 Mechanical root cleaning is performed before the surgical procedure is started. Primary incision planning follows. A periodontal probe is used to transfer the recession depth (x) to the adjacent papilla. The surgical markings are placed at a distance of x + 1 mm apical to the tip of the papilla to allow for the desired overcompensation. Markings are done for all affected teeth.

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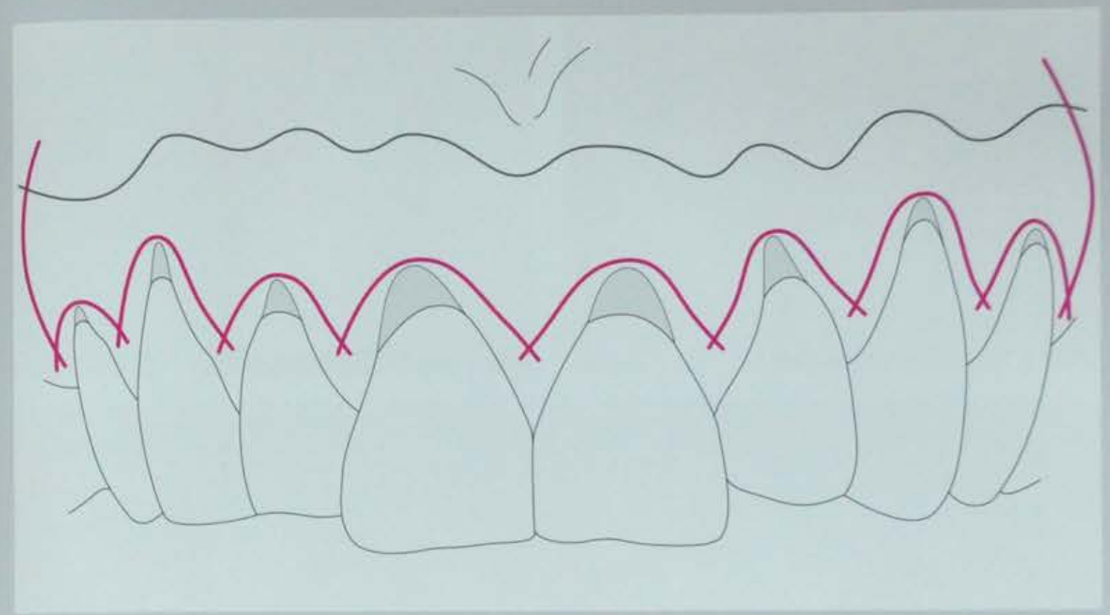






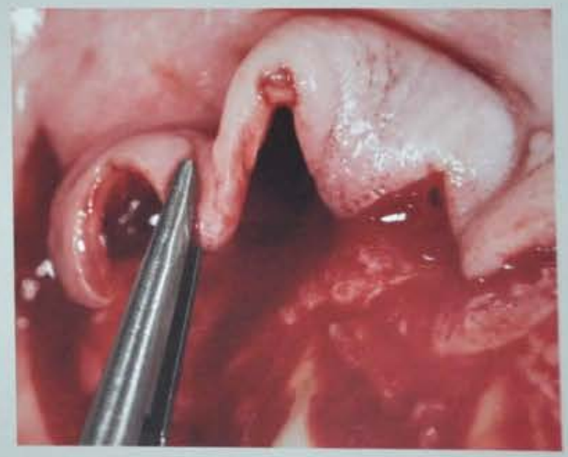






Figs 9-170 to 9-175 The initial incision curves to connect the individual markings over the gingival zeniths of the affected teeth. To achieve a partial-thickness flap of uniform thickness, the blade must be held perpendicular to the tissue surface, and there should be distinct overlap of the incision lines at the marked points. Next, two C-shaped vertical releasing incisions are made distal to the last recession defects.





Figs 9-176 and 9-177 Starting from the overlapping marked points in the papillary region, the No. 15 macroblade is used to make the partial-thickness incision. To obtain a flap of uniform thickness and to avoid perforation, the operator's eyes should always be focused on the blade working beneath the flap. The incision is continued apically until the flap has adequate mobility to enable its placement in the desired coronal position without tension while allowing for sufficient overcompensation.

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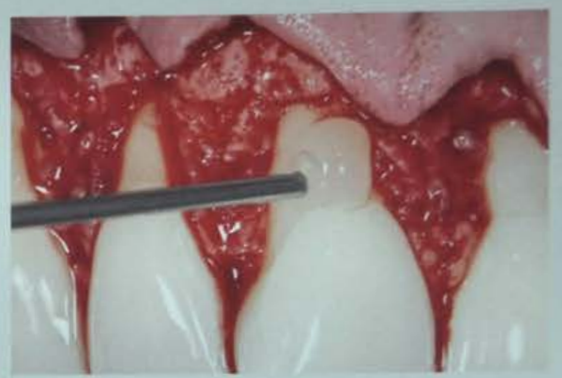






Figs 9-178 to 9-180 For optimal approximation of the wound margins, soft tissue remaining coronal to the primary incision after flap elevation must be carefully and completely de-epithelialized with microscissors or a No. 12D macroblade. Two additional vertical incisions directed toward the adjacent tooth distal to the last recession defect must be made in the area of the vertical releasing incisions for this purpose. Figure 9-180 (bottom) shows the site after flap elevation.





Figs 9-181 and 9-182 The cleaned and dried root surfaces are treated with EDTA for 2 minutes. EMD (Emdogain) is applied to the root surfaces after they have been thoroughly rinsed with saline to remove the gel residue and dried.





Figs 9-183 and 9-184 Horizontal sling sutures (6-0 Seralene DS-15) are used to close the site. From the mesial side, slightly coronal to the mucogingival junction, the needle is passed through the flap and base of the de-epithelialized papilla to the palatal side to adapt the flap to the root surface in the desired position. On the distal side, the needle coming from the palatal aspect is passed buccally through the tip of the papilla and made to engage the flap from the inside out at a relatively high coronal position.

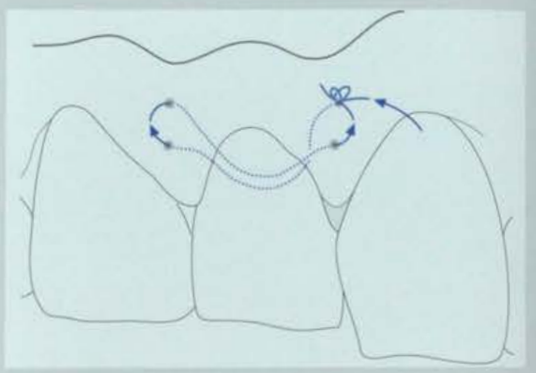
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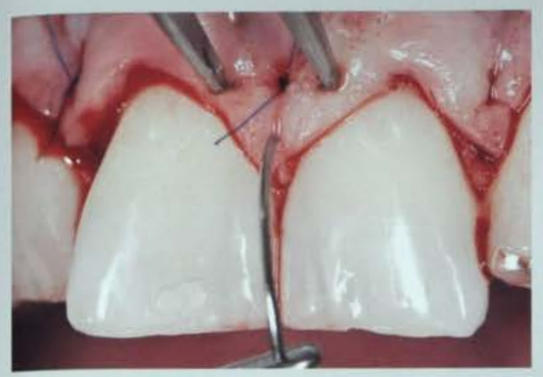
Figs 9-185 and 9-186 From the distal side, the suture is now passed palatally and, from there, back to the buccal starting point on the mesial side.



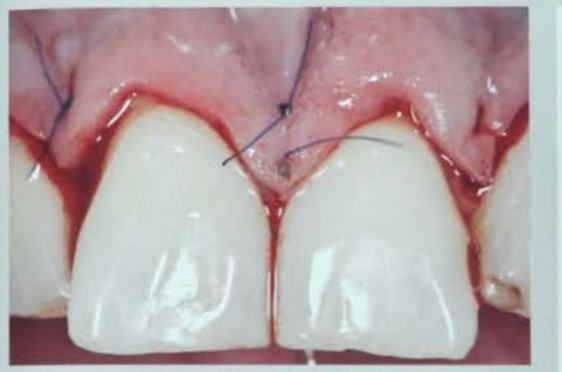




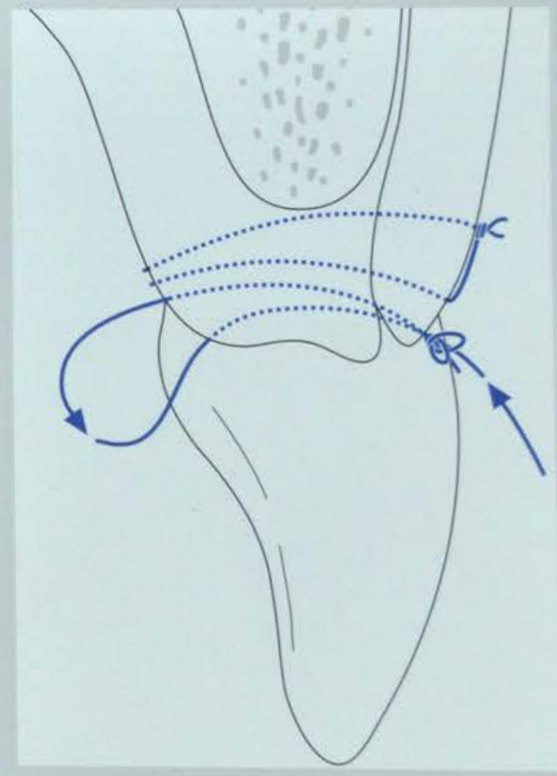
Figs 9-187 to 9-189 Once the suture has been tied, it immobilizes the soft tissue in the desired coronal position and compresses the flap against the root surface. It is sufficient to place sling sutures at every second tooth treated. This provides adequate stabilization of the wound during the early healing phase.







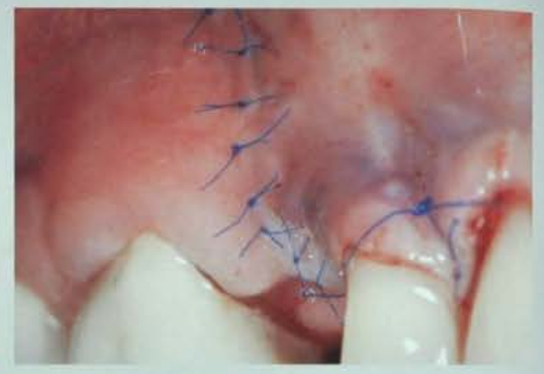




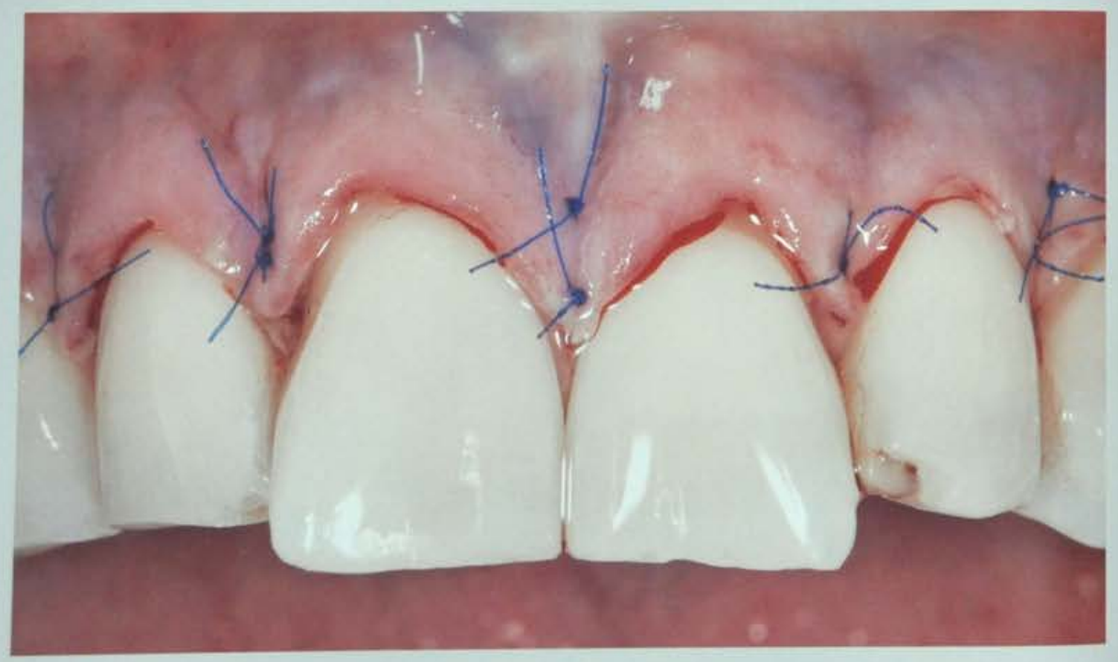
Figs 9-190 to 9-194 Additional vertical mattress sutures should be placed in the papillary region to securely close the site. The needle is first inserted in the buccal flap and must be inserted very close to the papilla to achieve close adaptation of the flap. Then, from a slightly more apical position, the needle is passed back from the palatal side to the buccal side, and the suture is loosely tied over the first insertion site.

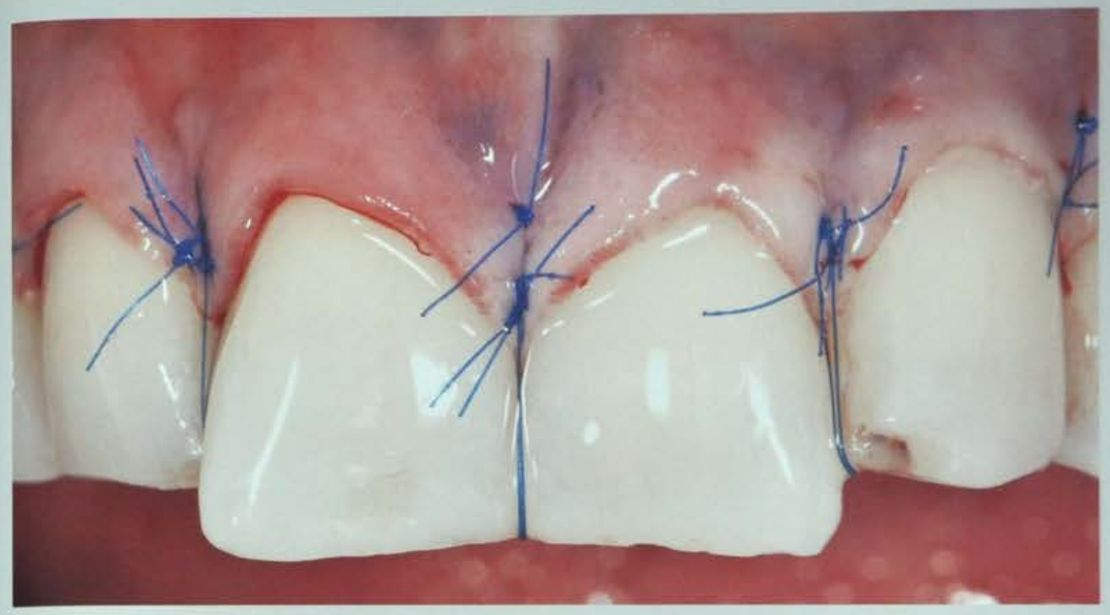
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Figs 9-195 and 9-196 The vertical releasing incisions are closed next. Perfect approximation of the wound margins is needed for predictable primary wound healing. Interrupted sutures (7-0 Seralene DS-12) are used to suture mobile flap tissue to the immobile wound margin. To facilitate suturing, a papilla elevator is used to gently raise the immobile wound margin (about 0.5 to 1.0 mm from the edge) as a full-thickness flap. To improve the coronal orientation of the flap, the needle can be made to exit through the immobile wound margin at a slightly more coronal position. The sutures are tied, and the knots are placed lateral to the incision line. Experience has shown that it is better to begin suture placement with the second suture from the top. The vertical incisions in the keratinized gingiva must be sutured with special care to prevent visible scarring.





Figs 9-197 and 9-198 Stable wound closure has been achieved. Primary wound closure has been achieved, and the recession is covered with about 1 mm of overcorrection. Three vertical double-crossed sutures have been additionally used in this case because of the prominent position of the two central incisors. After suturing, gentle pressure is applied for several minutes.

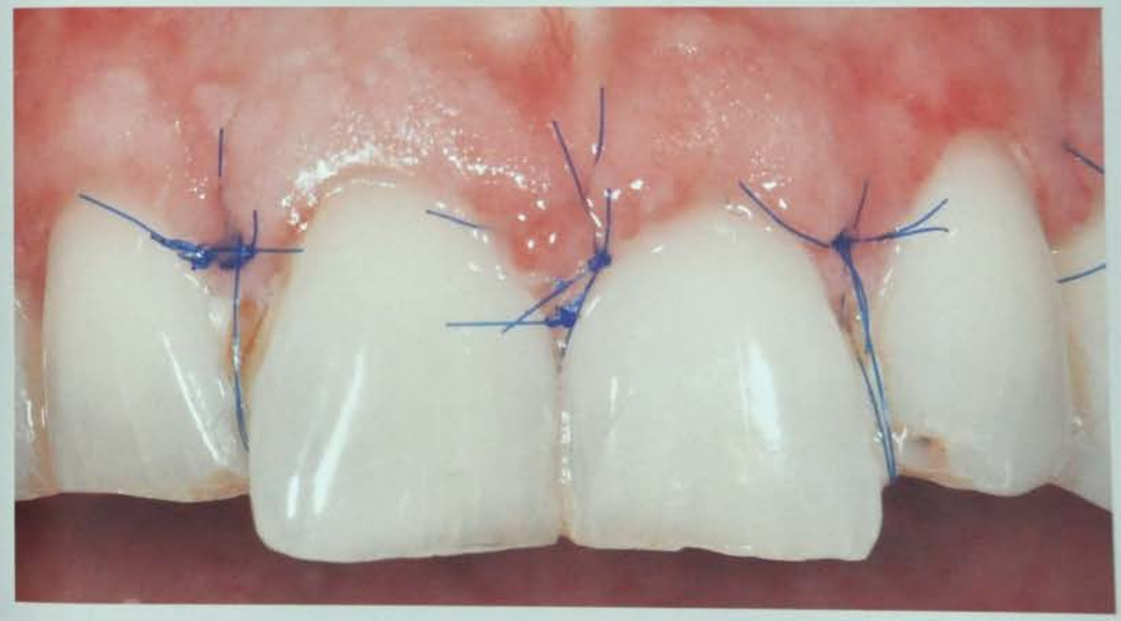


Fig 9-199 Result 1 week after surgery, just before suture removal.

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Figs 9-200 to 9-203 Final result 5 months after surgery.

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Fig 9-204 Patient after completion of treatment. (Composite resin restoration: *Bärbel Hürzeler*, Munich, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 4, Chapter 1: Coronally Advanced Flap with Enamel Matrix Derivative for Treatment of Multiple Gingival Recessions."

9.2.5 Modified Tunnel Technique with Subepithelial Connective Tissue Graft for Treatment of Multiple Gingival Recessions

KEY POINTS

01. Select the procedure based on the *recession depth* and the *amount of keratinized tissue* apical to the recession defect.

02. Clean the root surface *before the procedure* is started.

03. *Splint* the contact points with flowable composite resin if necessary.

04. Elevate a partial-thickness flap/tunnel:
- Extend it *coronally* to the base of the papilla.
- Extend it *apically* beyond the mucogingival line.
- Extend it *laterally* at least one tooth wider than the last recession defect.

05. Elevate a full-thickness flap:
- *Dissect the periosteum* at the base of the papilla.
- Reflect the *buccal papilla*.

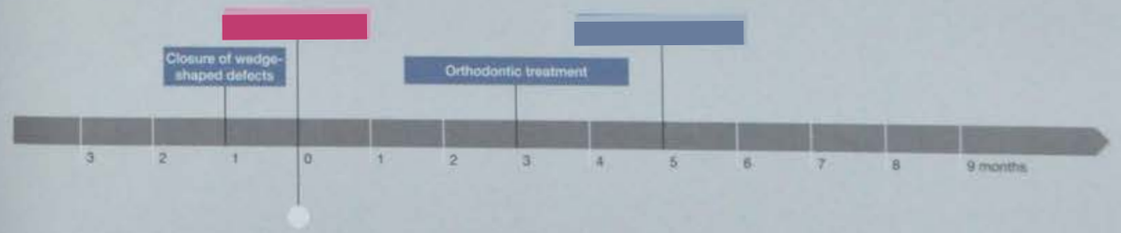
06. Harvest a subepithelial connective tissue graft:
- *Maximum thickness:* 1.0 to 1.5 mm.
- Ensure that the *size is adequate*.

07. Use vertical double-crossed sutures *to secure the flap and graft*.

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive postoperative *instructions*.

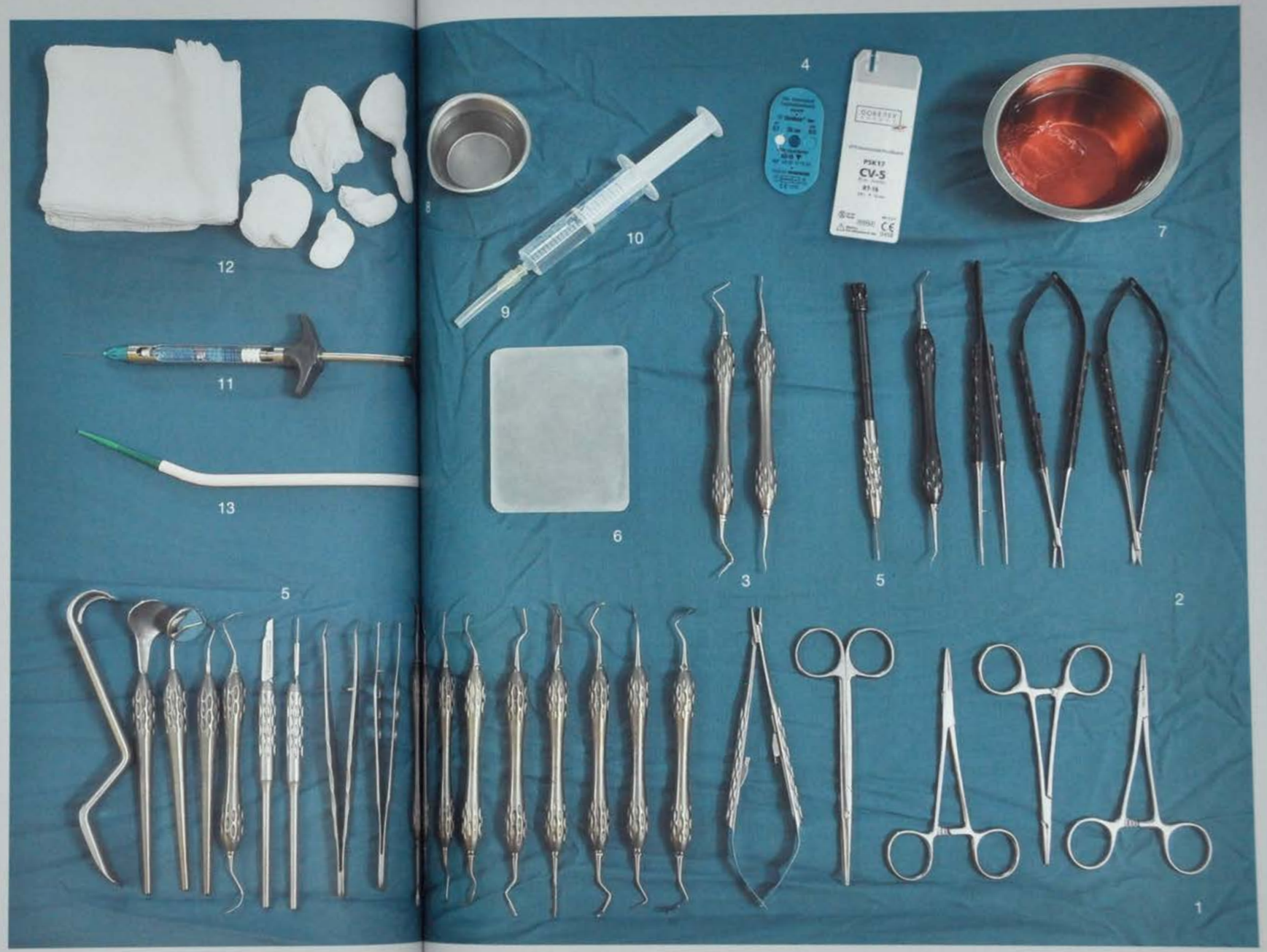
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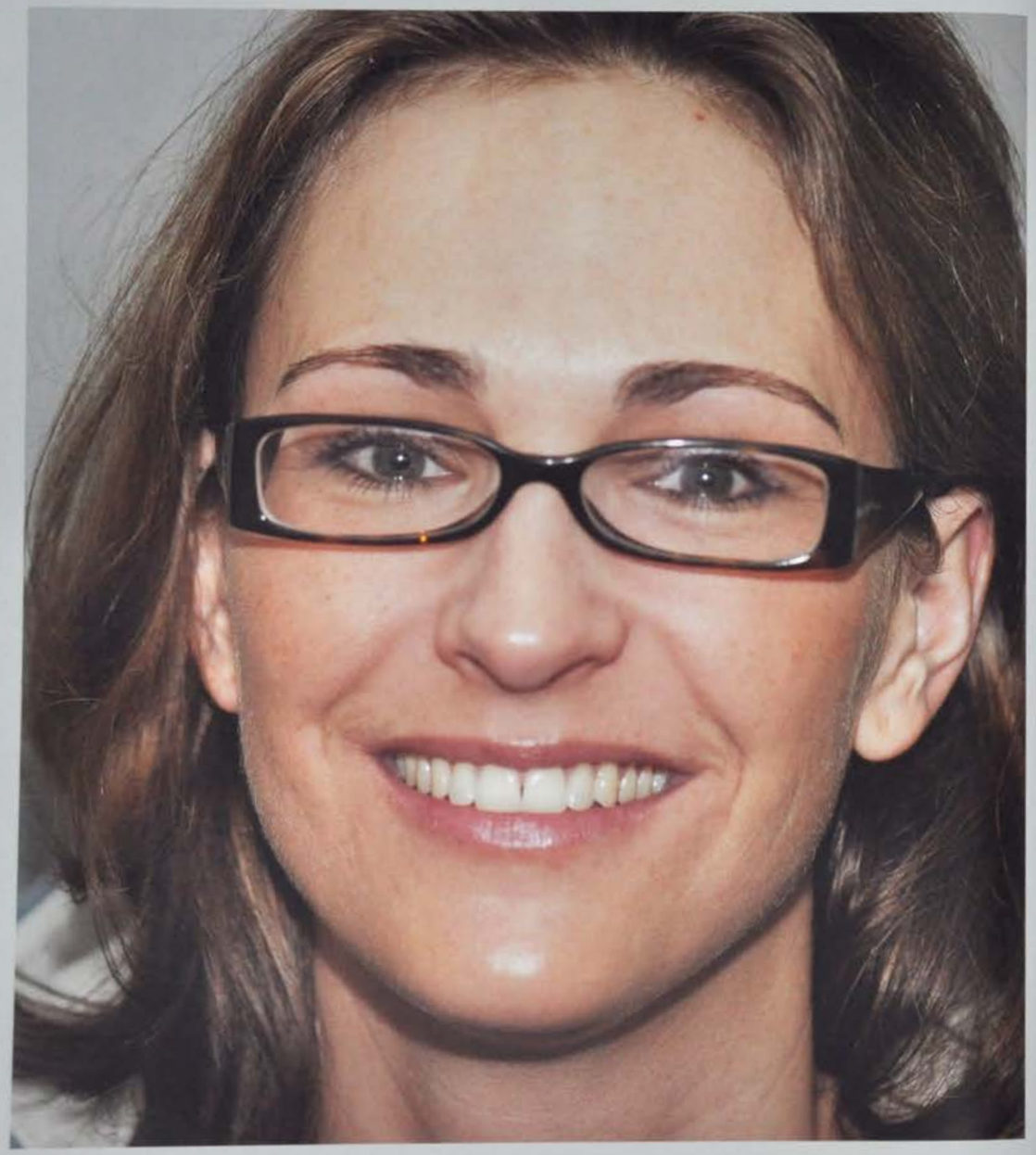
WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Tunneling Knives I and II
4. Suture materials: Gore-Tex CV-5 and 6-0 Seralene DS-15
5. No. 15 macroblade and Keydent microblade
6. Glass slab
7. 0.1% chlorhexidine solution in a metal dish
8. Sterile water in a metal dish
9. Blunt cannula
10. 10-mL syringe
11. Local anesthetic
12. Large and small pledgets
13. Periodontal stent



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STEP-BY-STEP PROCEDURE





Figs 9-205 and **9-206** Multiple *Miller* Class I recession defects in the maxillary anterior region are to be treated using the modified tunnel technique.

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Figs 9-207 to 9-211 Old composite resin restorations in the cervical region are removed and replaced before the scheduled surgery. As surgical root coverage should ideally be restricted to the natural root surfaces, the composite should not extend below the CEJ borders more than is absolutely necessary. Immediately prior to surgery, the root surfaces are cleaned with a rubber cup and pumice, and the interdental areas are splinted with flowable composite without enamel etching. Figure 9-211 (bottom) shows the treatment site after completion of splinting, just before the start of surgery.




Figs 9-212 and 9-213 To start the partial-thickness dissection and tunneling procedure, a marginal intrasulcular incision is made with the microblade.





Figs 9-214 to 9-216 The papilla should be elevated as early as possible to facilitate tunnel preparation with the Tunneling Knives. Inside the flap, the microblade is rotated slightly and passes against bone to sharply dissect the periosteum at the base of the papilla.

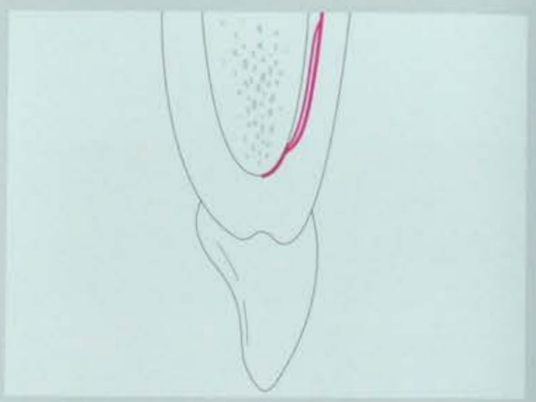
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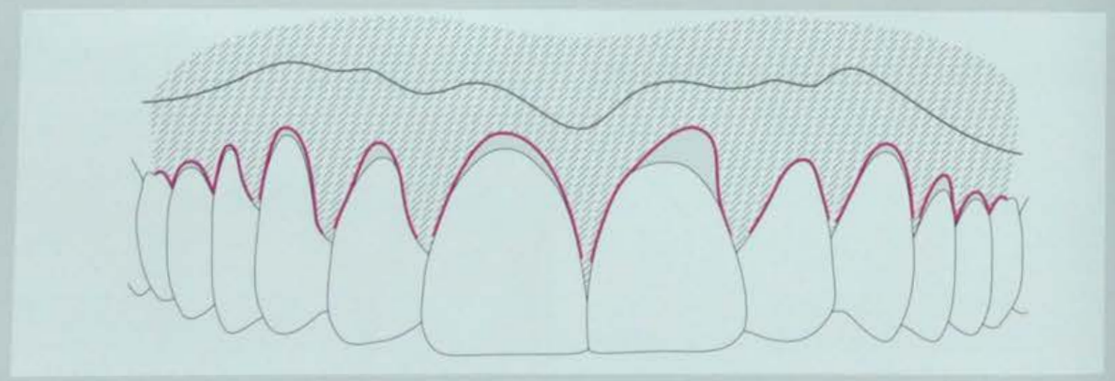




Figs 9-217 and 9-218 The papilla elevator is used to elevate the papilla as a full-thickness flap. To avoid the loss of papillary tissue, only the buccal half of the papilla, and not the entire papilla, should be elevated.







Figs 9-219 to 9-221 To prevent perforation, the Tunneling Knives should be used to complete tunnel preparation. In circular movements, the Tunneling Knife is guided down beyond the mucogingival line until adequate flap mobility has been achieved. The tunnel must be at least one tooth wider than the last recession defect.





Figs 9-222 and 9-223 The site is checked to ensure that the incision was made in a single plane, ie, that the tunnel is open and unobstructed, and that the flap and the papillae have adequate mobility.

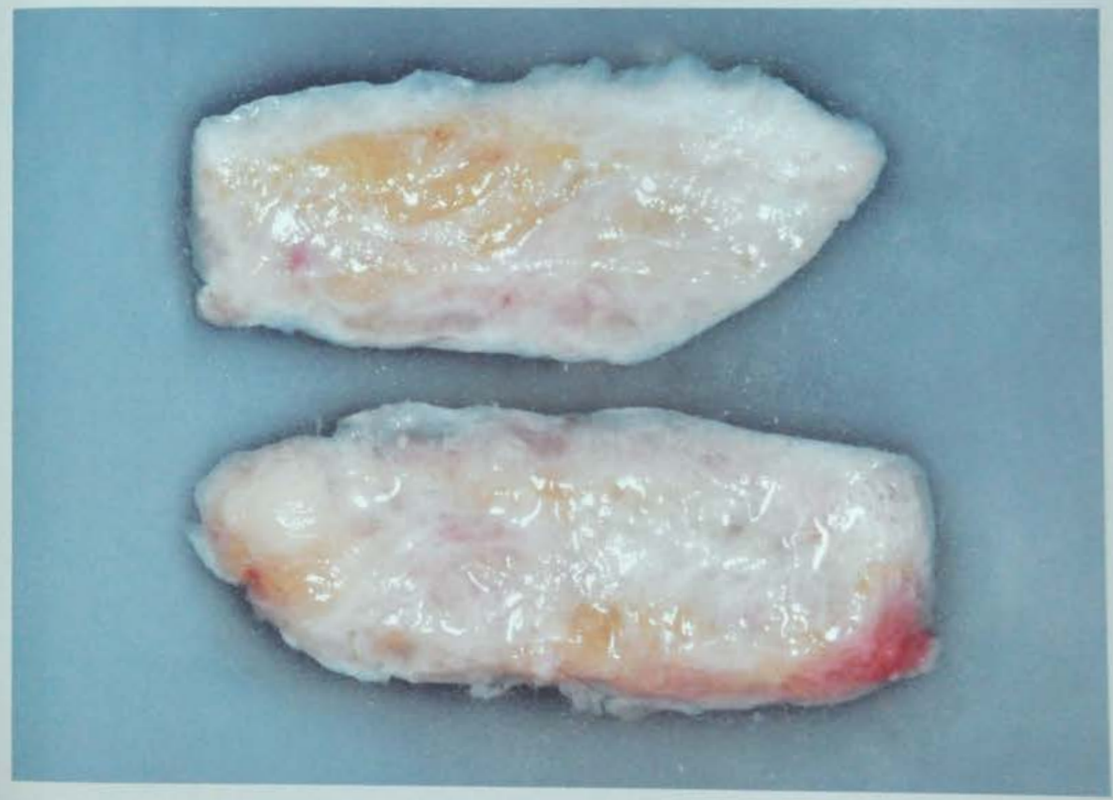
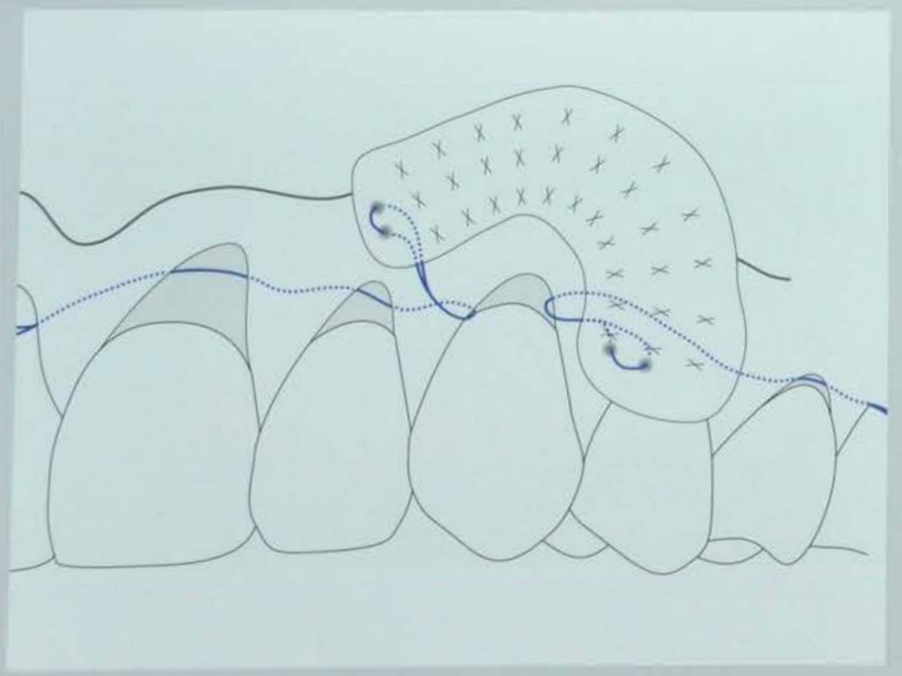


Fig 9-224 SCTGs are now harvested from both sides of the palate.

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Figs 9-225 and 9-226 The teeth with the largest circumference are used to insert the grafts into the tunnel (in this case, the two canines). The use of positioning sutures made of Gore-Tex CV-5 has proved to be an effective way to safely control the positioning of the graft within the tunnel. The needle is inserted bluntly (back-first) into the tunnel mesial and distal to the canines and is made to exit marginal to the canines. The needle engages the CTG laterally, from the inside out, and then, slightly more apically, from outside in. The needle is then passed back through the tunnel and returned to the starting point.



Fig 9-227 While the flap is carefully raised with the papilla elevator, the graft is drawn into the tunnel by gentle tugging on the positioning sutures and gentle pushing on the graft with a second instrument.

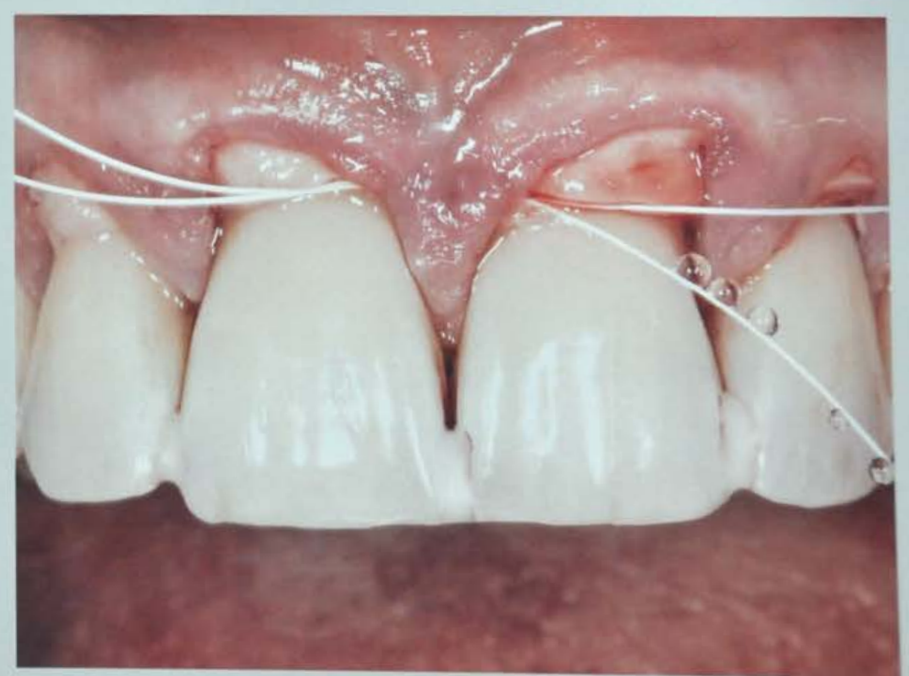
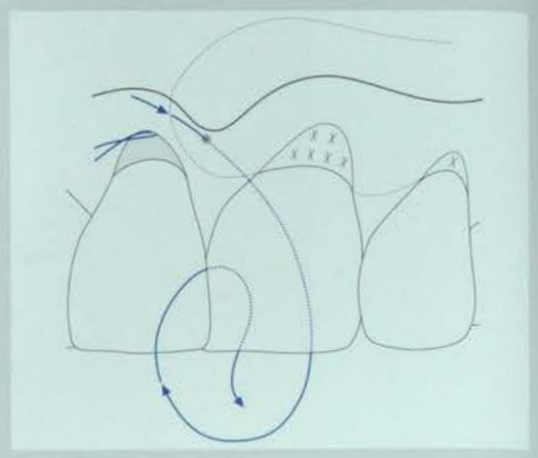
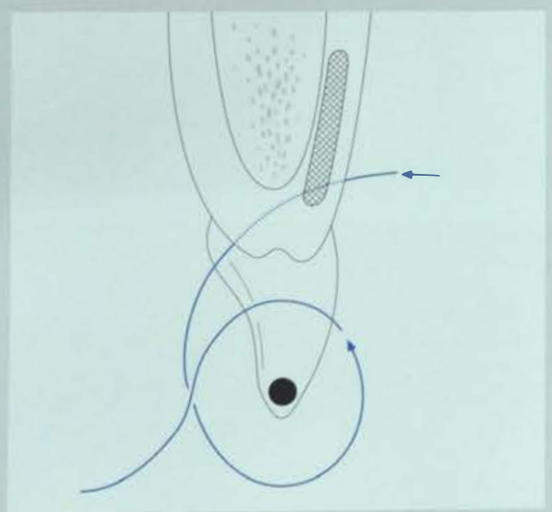


Fig 9-228 The two grafts have been inserted into the tunnel. The positioning sutures are removed after suture closure.

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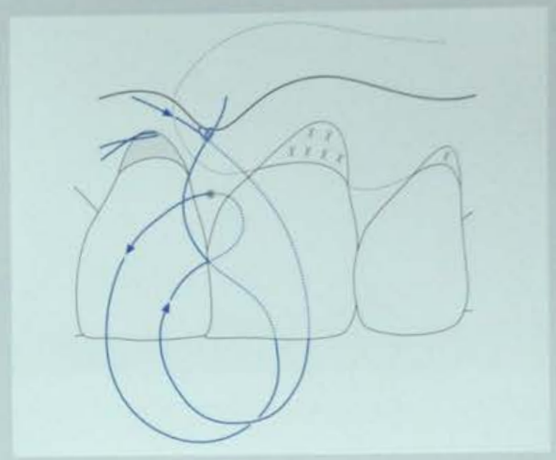


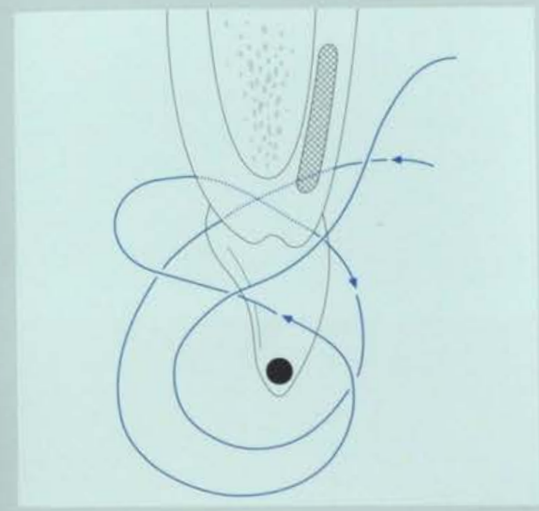




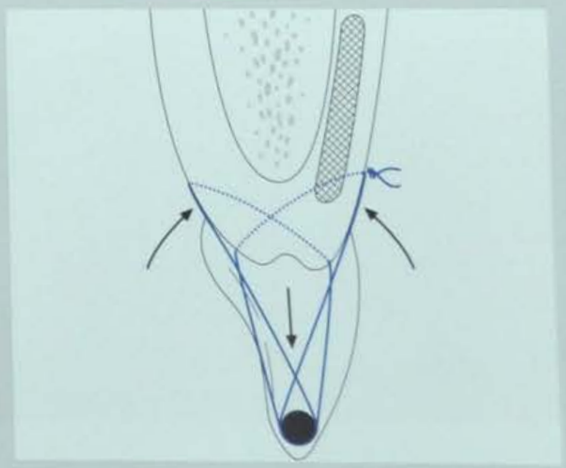
Figs 9-229 to 9-231 Vertical double-crossed sutures (6-0 Seralene DS-15) are used to close the site. First suture: Starting on the buccal side, the needle enters at the level of the mucogingival junction and engages the CTG at the desired position. The needle then passes beneath the splinted contact point, engaging the tissue, and exits on the palatal side slightly apical to the tip of the papilla. The needle is then guided over the incisal edges of the teeth and returned to the buccal side. It now passes beneath the splinted contact point again, but back-first so as not to engage the tissue, and exits on the palatal side.











Figs 9-232 to 9-236 Second suture: Starting on the palatal side, the needle is inserted through the base of the papilla and is made to exit on the buccal side, slightly apical to the tip of the papilla. The needle must exit the tissue in the region of the elevated flap to prevent folds from forming at the base of the papilla. The needle is then returned to the palatal side and is guided beneath the splinted interproximal contact point, back-first so as not to engage the tissue, and is returned to the buccal side. The suture is tied, and the positioning sutures are removed. The vertical double-crossed sutures have two effects: They immobilize the flap and the graft in the desired coronal position, and they compress the soft tissues against the root surface.

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Figs 9-237 to 9-239 The flap broadly covers the CTGs. In addition, adequate overcompensation was achieved.



Fig 9-240 Result 1 week after surgery.





Figs 9-241 and 9-242 Result 5 months after surgery.

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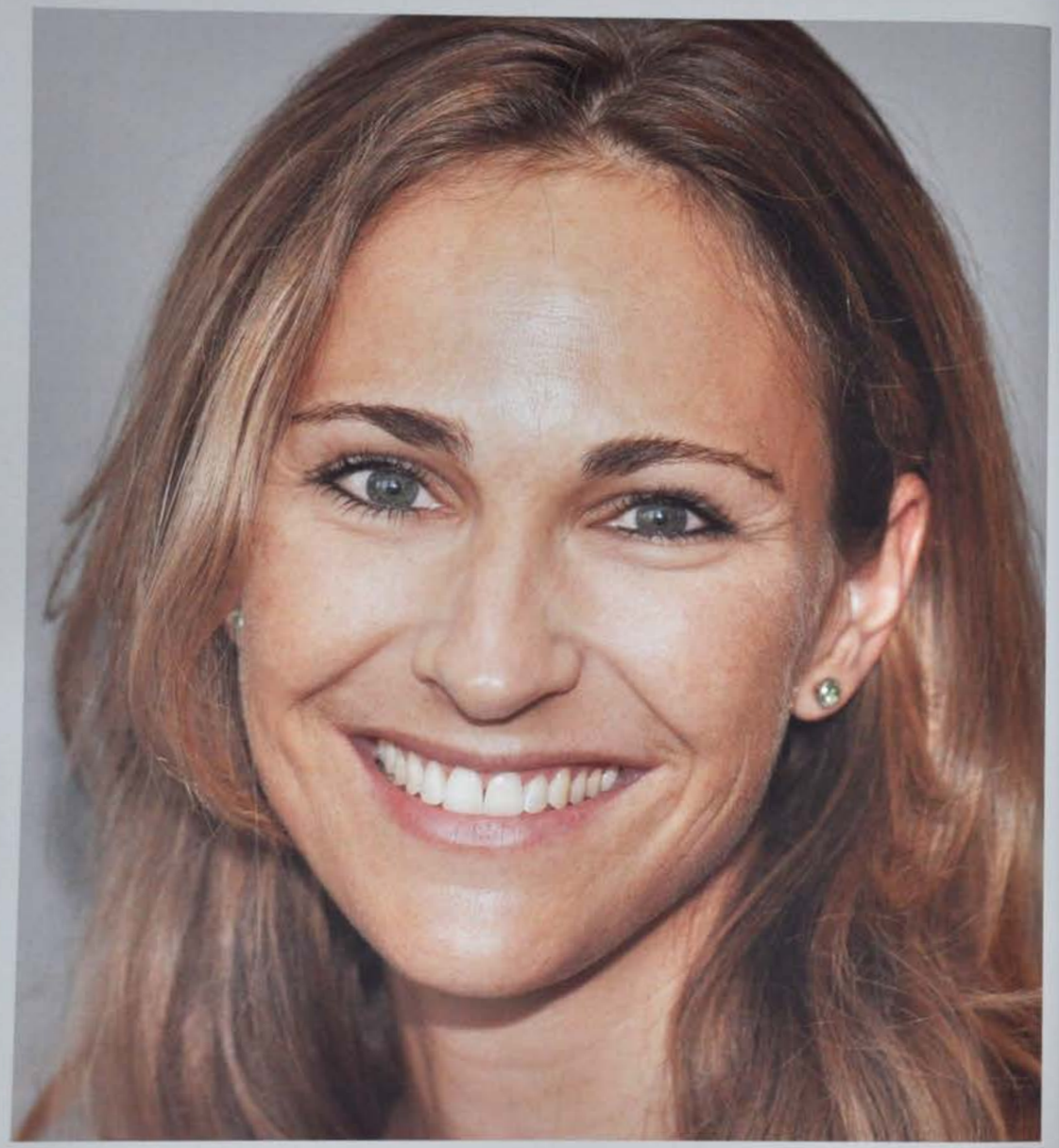


Fig 9-243 Patient after the completion of treatment. (Composite resin restorations: *Bärbel Hürzeler*, Munich, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 4, Chapter 2: Modified Tunnel Technique with Subepithelial Connective Tissue Graft for Treatment of Multiple Gingival Recessions."

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CHAPTER 10

ESTHETIC CROWN LENGTHENING

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Fig 10-1 From an esthetic perspective, it is considered ideal if no more than 1 to 2 mm of gingiva is visible when a person smiles.



Fig 10-2 Patients with gummy smiles have excessive gingival display around all of the maxillary anterior teeth when smiling. Vertical maxillary excess is a common cause of gummy smile.

10.1 Theory

10.1.1 Etiology

From an esthetic perspective, it is considered ideal if no more than 1 to 2 mm of gingiva is visible when a person smiles (see chapter 5) (Fig 10-1).

Some individuals have excessive gingival display around *all of their maxillary anterior teeth* when smiling. This is referred to as a *gummy smile*. Apart from the causes of gummy smile related to tooth eruption (discussed later), *vertical maxillary excess* (long face syndrome) is another main cause associated with an above-average length of the lower half of the face, indicative of a dentobasal compensated dolichofacial growth pattern.[1] Hypermobility of the upper lip can also result in excessive gingival display when an individual is smiling[2] (see chapter 5) (Fig 10-2).

Localized areas of excessive gingival display *around individual anterior teeth* or *anterior segments* result in *irregularity of the gingival margin*, which can be a problem from an esthetic point of view. The most common causes of gummy smile are described in the following sections.

Altered passive eruption

Altered passive eruption (overgrown gingivae) occurs when the teeth fully erupt during growth but the gingival tissues fail to recede to the normal apical level. The *incisal edges are not worn*, and the alveolar crest has a normal relationship with the cementoenamel junction (CEJ). The only abnormality is the coronal displacement of gingival margin position.[3] This results not only in *excessive gingival display* when the individual is smiling but also in *short clinical crowns* (Fig 10-3).

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Fig 10-3 (a and b) Clinical example of altered passive eruption of both maxillary central incisors. The clinical crowns are too short, although the incisal edges are not worn. In both teeth, the CEJ is more than 1 mm apical to the gingival margin.

Altered active eruption

Altered active eruption is characterized by overeruption of the teeth during development. Affected individuals exhibit excessive gingival display, although their clinical crown lengths are normal and the alveolar crest and gingiva have a normal relationship with the CEJ. The incisal edges are too coronal in the occlusal plane. Increased overjet during the development of the permanent teeth could play a causal role[4] (Fig 10-4).

In other cases, altered active eruption may reflect incomplete eruption of the affected teeth: The incisal edges fail to reach their vertical end position, resulting in incomplete eruption of the teeth through the alveolar bone and gingiva. Consequently, the alveolar bone and the gingiva of the affected teeth are in a coronally displaced position relative to the CEJ. Affected individuals exhibit short clinical crowns and incisal edges that are too apical in the occlusal plane. Decreased overjet during the development of the permanent teeth could play a causal role in this variant.[4]

Abrasion and overeruption

Particularly in older individuals, teeth with worn incisal edges can overerupt, resulting in occlusal contact with their opposing teeth. The alveolar bone and gingiva follow the coronal movement of the teeth but remain in a normal position relative to the CEJ. Affected individuals exhibit short clinical crowns and areas of excessive gingival display. Height differences between abraded and nonabraded teeth can usually be detected along the gingival margin (Fig 10-5).

10.1.2 Indications for Treatment

There are many factors to consider when the clinician is choosing between esthetic crown lengthening and other options for correction of a gummy smile. Selection of the treatment is based mainly on the cause of the gummy smile. Clinical crown lengthening always results in a loss of healthy periodontal tissue. This drawback must be weighed against the potential benefits of the procedure.

Correction of gummy smile

If the patient's gummy smile is caused by vertical maxillary excess, orthognathic surgery in combination with orthodontic treatment is the only viable option for correction. If it is caused by altered active eruption, orthodontic treatment is the method of choice. If it is caused by altered passive eruption, periodontal surgery can be considered.





Fig 10-4 Clinical example of altered active eruption with excessive vertical growth of the maxillary central incisors. (a) The incisal edges are too coronal, whereas the crown lengths and the relationship of the gingival margin to the CEJ are normal. (b) Excessive overjet during tooth eruption could play a causal role.







Fig 10-5 (a to c) This patient presented with an irregular gingival margin in the maxillary anterior region. Incisal edge abrasion resulted in overeruption of the maxillary right central incisor and its surrounding hard and soft tissues. Despite the short clinical crown, the relationship of the gingival margin to the CEJ is normal.

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It is important to note that the alveolar bone is located at a distance of about 1 to 2 mm apical to the CEJ of the teeth after tooth eruption, while the gingiva recedes along the tooth crowns until it lies about 1 to 2 mm coronal to the CEJ (see chapter 1). This process is often completed by late adolescence but may be delayed by several years in individuals with a thick gingival biotype.[5] Consequently, altered passive eruption is most commonly diagnosed in young adults. Although it is possible to intervene and fully expose the anatomical crowns by surgical means (eg, gingivectomy), it is advisable to wait because, in most cases, the gingiva will gradually recede to a normal position on its own accord over time.

Correction of irregular gingival margins

When patients with irregular gingival margins are evaluated, it is necessary to make a distinction between natural teeth and prosthetically restored teeth.

Irregular gingival margins around natural teeth

If irregular gingival margins around natural teeth are caused by altered active eruption, orthodontic treatment is the only way to correct the situation. If the irregularity is associated with altered passive eruption and abrasion-related overeruption, harmonization of the gingival margins can be achieved by orthodontic treatment, periodontal surgery, or a combination of the two.

Kokich[5] illustrated the factors to be considered when selecting the treatment approach of irregular gingival margins around natural teeth. A hypothetical case is described to explain the thought process: A periodontally healthy patient presented with gingival asymmetry around the maxillary central incisors. The gingival margin of the left central incisor was 1 mm more coronal than that of the right central incisor. In such cases, accurate problem analysis and diagnosis require an initial evaluation of the *buccal probing depths of the two teeth.* If the probing depth of the left central incisor is about 1 mm deeper than that of the right central incisor and the incisal edges of both central incisors are aligned and intact, the vertical distance between the CEJ and the gingival margin of the left central incisor is 1 mm greater than that of the right central incisor. Altered passive eruption of the left central incisor was therefore diagnosed in the aforementioned patient.

The options for harmonization of the irregular gingival margins are either *periodontal surgery*[5] or simply watching and waiting in the case of young patients. If the probing depths are uniform and the CEJ is about 1 mm below the gingival margin of both teeth, the gingival margins of the adjacent lateral incisors must be evaluated to determine which treatment is needed. If the gingival margins of the adjacent lateral incisors are coronal to that of the left central incisor, 1 mm of orthodontic extrusion and 1 mm of incisal edge reduction of the right central incisor are needed to correct the problem. If the gingival margin positions of the lateral incisors are equal to or apical to that of the left central incisor, incisal abrasion and subsequent overeruption of the left central incisor is the probable cause. Treatment would then consist of 1 mm of orthodontic intrusion of the left central incisor in combination with 1 mm of lengthening of the incisal edge with composite resin.

The three main variables to consider during evaluation and treatment planning for patients with irregular gingival margins around natural teeth are (1) the *incisal edge position relative to the upper lip* at rest, (2) the *location of the gingival margin relative to the CEJ*, and (3) the presence or absence of *incisal edge abrasion.*[6]

Irregular gingival margins around teeth that are or will be prosthetically restored

There are many more indications for periodontal surgery to correct gingival margins around prosthetically restored teeth than around natural teeth. Should the CEJ or a small portion of the roots of the affected teeth become exposed by surgical crown lengthening, the planned restorations can be made so as to cover or mask these areas (Fig 10-6).

If prosthetic rehabilitation of all maxillary and mandibular anterior teeth is planned, it may be possible to change the incisal edge contour to a certain extent, making additional treatment options feasible. In cases where outcome of root coverage surgery is not predictable because of *Miller* Class III to Class IV recession, it is sometimes possible to harmonize the gingival contour by using resective procedures to apically shift the incisal edge position. Furthermore, surgical crown lengthening can be performed for indirect papillary reconstruction as a means of eliminating "black triangles" (see chapter 11).



Fig 10-6a An irregular gingival margin is present around a tooth that is to be prosthetically restored. Because discoloration of the left central incisor could not be completely eliminated despite internal bleaching, the tooth is to be restored with a crown. Due to abrasion and overeruption, the gingival margin around this tooth is about 1.5 mm more coronal than that of the right central incisor. The CEJ of both central incisors is located about 1 mm apical to the gingival margin.

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Fig 10-6 (b and c) Because about 1 mm of gingival tissue and tooth-bearing bone were removed in periodontal resective surgery, part of the root surface is visible now but will be covered by the crown later.



Fig 10-6d Final result after placement of an all-ceramic crown on the left central incisor 6 months after periodontal surgery. (Dental technician: *Rainer Janousch*, Munich, Germany.)



Fig 10-7 The fact that a band of at least 2 mm of keratinized gingiva must remain on the root surfaces after surgical crown lengthening determines which type of procedure can be used.

10.1.3 Technical Aspects

The goal of esthetic crown lengthening must be to achieve the planned clinical crown lengths as accurately as possible. A number of factors must be considered during treatment planning and execution to obtain a natural and harmonious gingival contour without scarring. It is rarely necessary to revise the entire tooth circumference during esthetic crown lengthening. In most cases, the clinical crown is lengthened only on the buccal aspect. The two main factors to consider during treatment planning are the width of keratinized gingiva and the dimension of the dentogingival complex.

Width of keratinized gingiva

A band of keratinized gingiva of adequate width must remain on the treated root surfaces after surgical crown lengthening (see chapter 1) (Fig 10-7). From an esthetic perspective, the necessary width depends on the width of keratinized gingiva around the adjacent teeth but should never be less than 2 mm. Whether performed with or without osseous surgery, esthetic crown lengthening by gingivectomy is indicated only in cases where an adequate width of keratinized gingiva will remain after soft tissue resection[7] (Fig 10-8a). If the width of keratinized tissue is inadequate, esthetic crown lengthening must be accomplished via apically positioned flap for apical repositioning of the entire dentogingival complex[8] (Fig 10-8b).

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Fig 10-8a Regardless of whether it is performed with or without osseous surgery, gingivectomy is indicated for crown lengthening only if an adequate width of keratinized gingiva will remain after soft tissue resection.



Fig 10-8b If there is an inadequate width of keratinized tissue, esthetic crown lengthening must be achieved via apically positioned flap for apical repositioning of the entire dentogingival complex.



Fig 10-9 The type of procedure used for surgical crown lengthening depends not only on the width of keratinized gingiva but also on the dimension of the dentogingival complex. If at least 3 mm of soft tissue will remain coronal to bone after crown lengthening, removal of sound tooth structure will not be required.

Dimension of the dentogingival complex

Under healthy periodontal conditions, the dentogingival complex is a mean of 4.5 to 5.0 mm interproximally and 3.0 mm facially (see chapter 1) (Fig 10-9). Complete removal of supra-alveolar soft tissue by gingivectomy or repositioning of the supra-alveolar soft tissue to bone level by apically positioned flap results in formation of the biologic width (ie, regeneration of the dentogingival complex) following crown lengthening. Evidence has shown that once healing is completed, interproximal dimensions (3.2 to 4.3 mm above bone level) are slightly smaller than the pretreatment dimensions,[9,10] whereas the original soft tissue height of about 3.0 mm is completely reestablished at buccal sites.[9,11]

In one prospective clinical study, *Pontoriero* and *Carnevale*[9] performed apically positioned flap surgery with osseous resection and connective tissue attachment resection in 30 patients prior to prosthetic rehabilitation. The bone was recontoured to fit the restoration margins. periodontal attachment was thoroughly removed from the root surfaces, and periosteal sutures were used to immobilize the flap at bone level. Twelve months after surgery, coronal displacement of the gingival margin was observed, amounting to a mean postsurgical soft tissue regrowth of 3.2 mm and 2.9 mm at interproximal and buccal sites, respectively. The extent of coronal displacement of the gingival margin was greater in patients with a thick gingival biotype than in those with normal or thin gingival biotypes.

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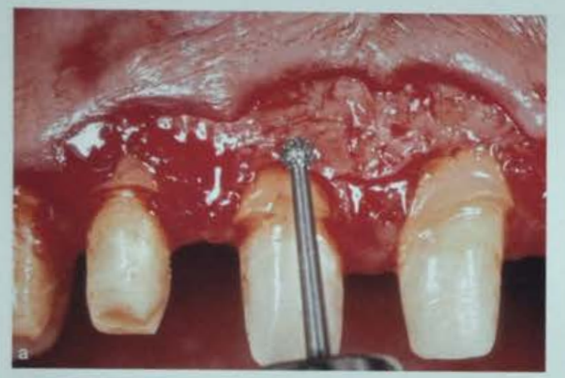


Fig 10-10a Interproximal recontouring is also required to prevent coronal migration of the soft tissue margin beyond the planned level. Rotating round diamond burs are well suited for this purpose.



Fig 10-10b Surgical instrument tray containing two round diamond burs of different diameters for instrumentation of the bone as well as a conical diamant bur that is used in different indications (see chapter 12).

This information can be useful for esthetic crown lengthening if the planned crown lengths can be predictably achieved by modeling the buccal bone crest to a level that is 3 mm from the planned gingival margin. However, both clinical experience and scientific evidence[9,12] have shown that the main complication of esthetic crown lengthening is coronal displacement of the dentogingival complex beyond the intended 3 mm. Two important factors must be considered in this context.

First, the gingiva has a tendency not to directly follow abrupt variations in bone contour but rather to form a soft indentation over these gaps. For the soft tissue to remain in the planned apical position, *gentle and harmonious bone contours* must be created during bone reduction. Consequently, adjacent teeth may also have to be contoured slightly. Buccal ostectomy should not be too narrow. The buccal bone contours must be broadly and harmoniously shaped in the interproximal spaces. In addition, the remaining marginal alveolar bone must be thinned.

Second, the *affected root surfaces must be denuded during surgery by removing all periodontal ligament fibers.* Therefore, reestablishment of the biologic width takes place partly in the apical direction in conjunction with resorption of the most marginal parts of the alveolar bone.[13–17] This prevents coronal migration of the soft tissue margin beyond the planned level to a certain degree (Fig 10-10).

Key points:

If the dimension of the dentogingival complex is normal *(3 mm or less)* at the time of esthetic crown lengthening, the results of soft tissue resection or apical repositioning will be short term. To prevent relapses, tooth-bearing bone should be resected to the same extent as the soft tissue. If the dimension of the dentogingival complex is *greater than 3 mm*, soft tissue surgery is the only way to achieve esthetic crown lengthening provided at least 3 mm of soft tissue will remain coronal to the alveolar bone after surgery.

Clinically, three different pretreatment situations can be distinguished, and three different approaches are required to treat them.





Fig 10-10 (c and d) Hand instruments should be used for resection of tooth-bearing bone to prevent damage to the root surfaces.

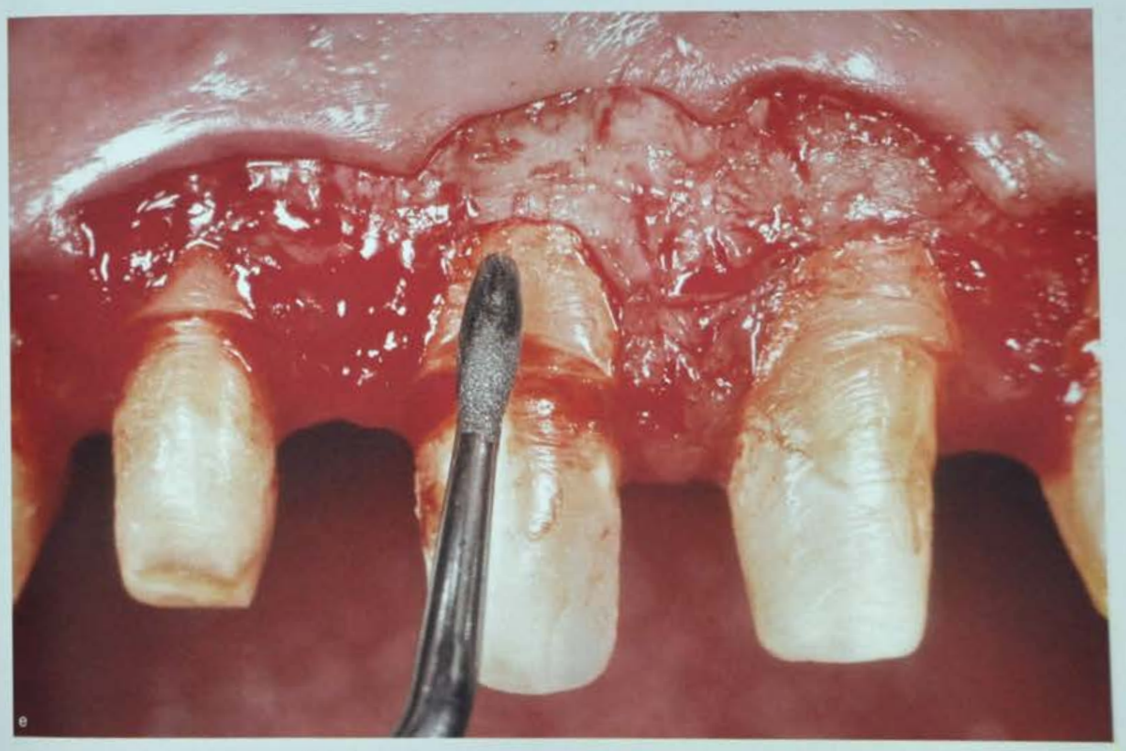


Fig 10-10e All periodontal ligament fibers must be removed from the root surfaces to prevent coronal migration of the dentogingival complex beyond the planned 3-mm level following crown lengthening.

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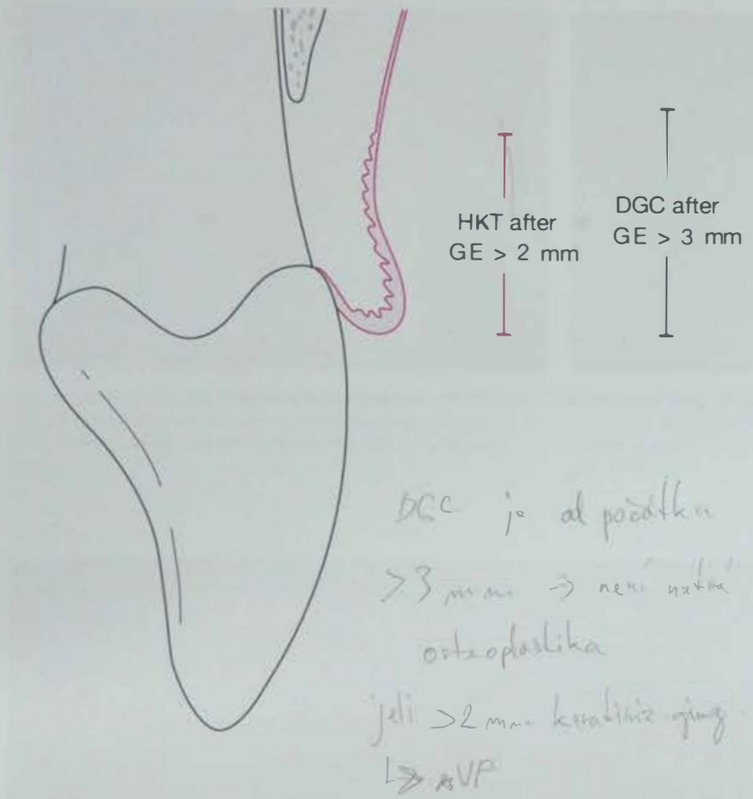


Fig 10-11 Situation 1. The dimension of the dentogingival complex is sufficient for crown lengthening *without osseous resection*, and the width of keratinized gingiva is sufficient for *gingivectomy*. HKT = height of keratinized tissue; GE = gingival excision; DGC = dentogingival complex.

Situation 1: The dimension of the dentogingival complex is sufficient for crown lengthening *without osseous resection*, and the width of keratinized gingiva is sufficient for *gingivectomy* (Fig 10-11).

Either a scalpel or electrocautery can be used for excision. Electrocautery devices of the latest generation allow very precise, brushlike work and are therefore preferred. To ensure that the electrocautery device does not touch the root surface, a thin layer of soft tissue should be left on the root surface and removed with a scalpel. The gingival zenith must be positioned relative to the angle position of the axis of the affected tooth (Fig 10-12).

Instrumentation of the root surfaces to about 3 mm subgingivally is performed to prevent coronal growth of the gingiva during healing. Good results have been achieved when a microblade is used to perform an intrasulcular incision, which allows for controlled removal of periodontal ligament fibers from the root surfaces of the affected teeth. The gingiva remaining on the root surfaces after excision usually forms a horizontal ledge, which should be reduced with a coarse diamond bur to achieve a more esthetic result (Fig 10-13).

Sutures are not required. The expected degree of soft tissue retraction is minimal. Prosthetic treatment can be started after a 3-month healing period.

Situation 2: The dimension of the dentogingival complex is not sufficient for crown lengthening without *osseous resection*, but the width of keratinized gingiva is sufficient for *gingivectomy* (Fig 10-14).



Fig 10-12 (a to c) Electrocautery devices of the latest generation allow very precise, brushlike work and are thus ideal for gingivectomy. To ensure that the electrocautery device does not touch the root surface, a thin layer of soft tissue should be left on the root surface and removed with a scalpel.

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Fig 10-13 (a to c) Coarse, bud-shaped diamond burs are very good for reducing the marginal soft tissue after gingivectomy.

A flap of adequate size must be elevated to enable the resection of buccal alveolar bone under vision. Minimally invasive procedures in which only the buccal gingiva over the affected root surfaces is elevated without the adjacent papillae are not recommended because they rarely allow for controlled recontouring of the alveolar bone, including interproximal recontouring. To obtain an adequate view, it will usually suffice to extend the flap laterally. Vertical releasing incisions are not needed in most cases. A partial-thickness flap design is recommended because the elevation of a full-thickness mucoperiosteal flap could result in more pronounced resorption of the exposed alveolar bone (see chapter 4). The surgery can be performed in either one or two sessions.

In the *single-session approach*, soft tissue excision is performed as described for situation 1. The flap is then elevated, the bone contoured, and the site closed with sutures. At least 6 months of healing are required before the start of prosthetic rehabilitation.[9,11,14,18]

The *two-session approach* yields more precise and predictable results. In the first session, a flap is elevated without gingivectomy, the bone is contoured, and the flap is sutured in its original position. Three months later, conventional gingivectomy (external gingivectomy) is performed as described for situation 1. Prosthetic rehabilitation can be initiated after another 3 months of healing.

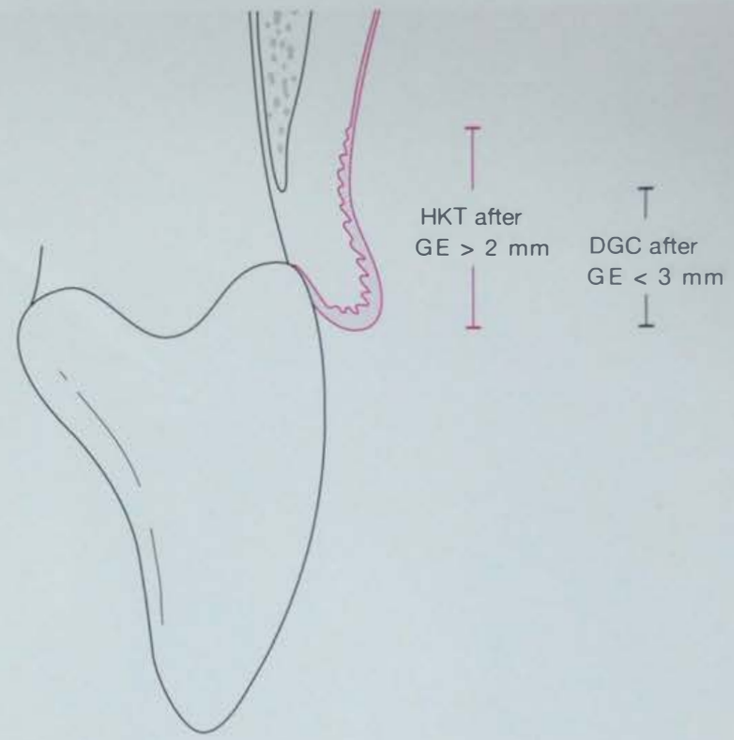


Fig 10-14 Situation 2. The dimension of the dentogingival complex is not sufficient for crown lengthening without *osseous resection*, but the width of keratinized gingiva is sufficient for *gingivectomy*. HKT = height of keratinized tissue; GE = gingival excision; DGC = dentogingival complex.

Situation 3: The height/width of the keratinized gingiva makes it necessary to perform crown lengthening by *apically positioned flap*. Technically, the question of whether crown lengthening must be performed *with or without osseous resection* due to the dimension of the dentogingival complex is of secondary importance in this situation (Fig 10-15).

The goal of achieving scar-free results with no visible lines between the flap and the adjacent tissues dictates which type of procedure will be used. If the flap was created via an intrasulcular incision, the former free gingiva would represent the coronal flap margin. Any remnants of the former oral sulcular epithelium on the inner aspect of the flap could result in horizontal scarring in the papillary region after apical repositioning. Therefore, the basic difference between this and the second flap elevation method is that the initial incision is a slightly paramarginal incision. To create a flap of uniform thickness, the blade must be held perpendicular to the gingival surface during incision, and the interproximal incisions must overlap. If the keratinized tissue width is only 2 mm or less before treatment, a marginal incision should be performed instead (see chapter 4).

Interproximal areas coronal to the initial incision should be superficially de-epithelialized with a sharp blade or microsurgical scissors (Fig 10-16). Epithelialization of

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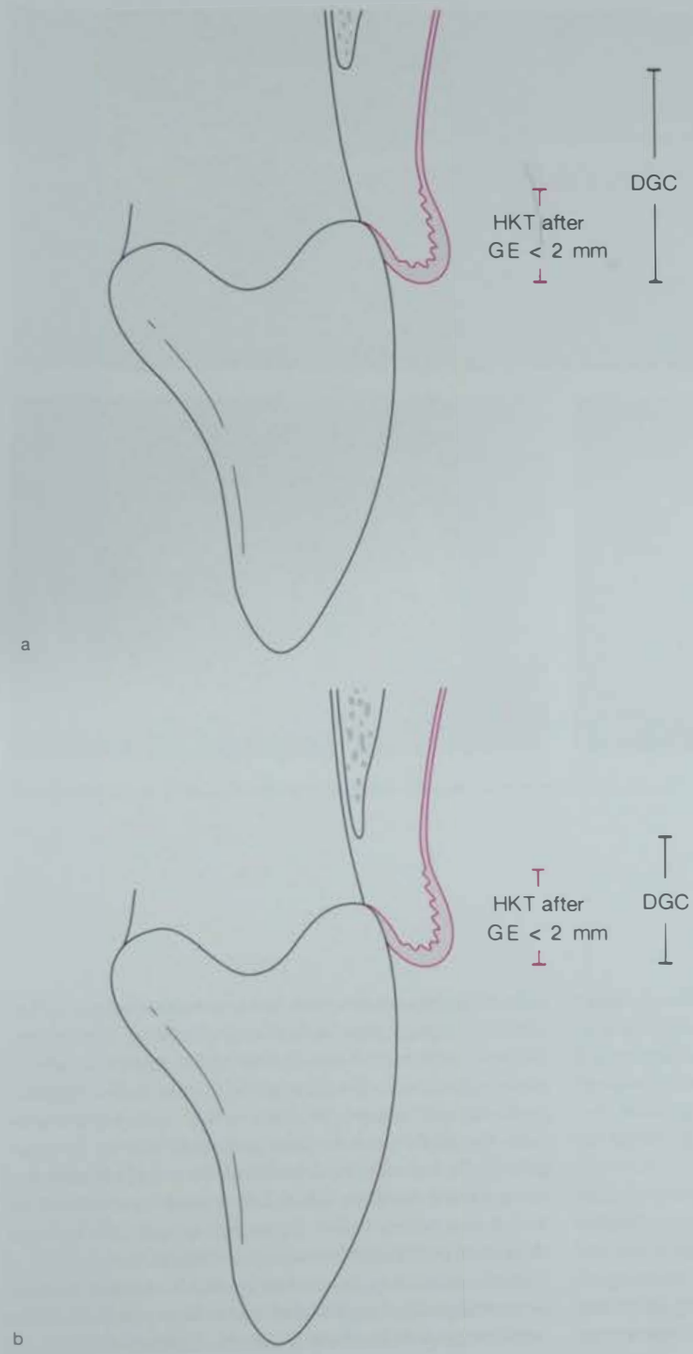


Fig 10-15 (a and b) Situation 3. The height/width of the keratinized gingiva makes it necessary to obtain crown lengthening via an *apically positioned flap*. Technically, the question of whether crown lengthening must be performed *with or without osseous resection* due to the dimension of the dentogingival complex is of secondary importance in this situation. HKT = height of keratinized tissue; GE = gingival excision; DGC = dentogingival complex.

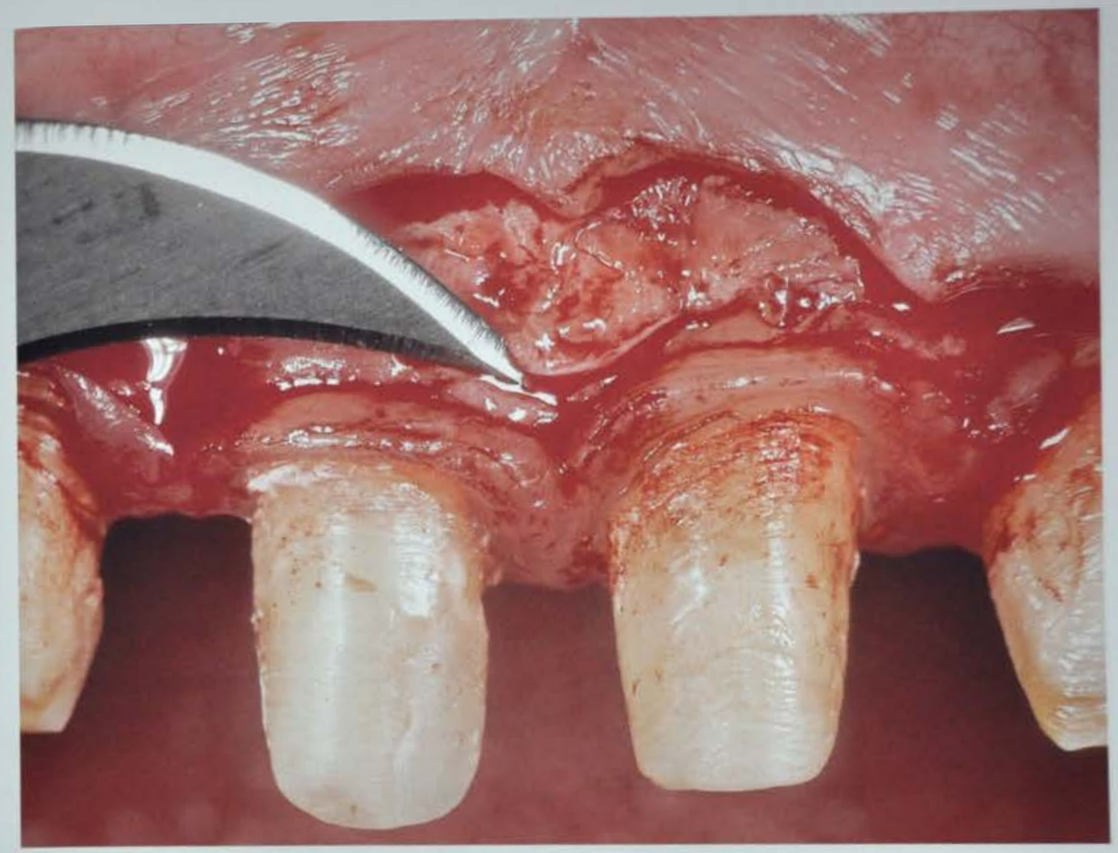


Fig 10-16 The papillary region coronal to the initial incision is completely de-epithelialized to prevent scar formation after apically positioned flap surgery.

these areas by secondary intention healing will proceed from the flap margins and the periodontal ligament space (see chapter 9). As a result, there will be no visible lines between the flap and the adjacent tissues.

Lateral extension of the flap may be necessary to ensure adequate mobility without vertical releasing incisions. Bone contouring (if necessary) and thorough instrumentation of the affected root surfaces are then performed. Periosteal sutures are used to fix the flap in the desired apical position. The flap should be secured 3 mm above bone level. This ensures that only part of the dentogingival complex must undergo regeneration, resulting in more rapid restoration of soft tissue stability.[14,19] A periodontal dressing is not required after surgery. The site should be stable after 6 months of healing.

Clinical factors for the practitioner to consider when planning the approach to the different clinical situations are summarized in Table 10-1.

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Table 10-1

Clinical factors to consider when planning the technical approach to crown lengthening

Sounding (S)	Width of the keratinized gingiva after planned crown lengthening	Procedures
S – V ≥ 3 mm	≥ 2 mm	Gingivectomy
	< 2 mm	Apically positioned flap
S – V < 3 mm	≥ 2 mm	Gingivectomy and ostectomy combined
	< 2 mm	Combination apically positioned flap without ostectomy

V = planned lengthening

10.1.4 Predictability

Esthetic crown lengthening procedures are predictable periodontal surgical techniques. Coronal growth of the dentogingival complex beyond the planned level is the main reason for complications. To avoid these problems and to achieve the planned tooth lengths with maximum precision, the clinician must consider a number of factors, particularly when surgical crown lengthening is to be performed in connection with prosthetic rehabilitation.

Unplanned coronal growth of the soft tissue can lead to an intrasulcular position of the restoration margin and problems related to the biologic width. Because these are serious complications, the planned 3-mm soft tissue height must be established surgically so that no changes in the dentogingival complex are likely 6 months postoperatively. Therefore, it is essential to perform thorough instrumentation of the affected root surfaces and to create gentle and harmonious bone contours. The flap should not be positioned at bone level but rather 3 mm coronal to the bone. Then, only part of the dentogingival complex must be regenerated, and stable soft tissue conditions can be established sooner.

10.1.5 Long-Term Stability

Studies of long-term stability of the gingival margin position after surgical crown lengthening suggest that mild coronal migration of the gingival margin occurs up to 1 year after the procedure.[9,20–22] The gingival margin position appears to remain stable in subsequent years.[23,24] even after the completion of coronal growth. This can be problematic because the vertical implant position must be precisely aligned to the point of emergence of the implant-supported crown from the soft tissue. It can be assumed that apical migration of the gingival margin position will eventually occur around the teeth affected by altered passive eruption. Therefore, treatment should be designed to prevent irregularity of the gingival margin over the long term.

There are two ways to do this. First, the vertical implant position should be established based on the CEJ of the adjacent teeth rather than on the current gingival margin position. Second, gingivectomy can be performed on the adjacent teeth before implantation to ensure that the soft tissues are stable at the time of implantation. The second approach provides a more predictable outcome.

10.1.6 Special Cases

Diagnostic provisional restorations

When esthetic crown lengthening procedures are performed on natural teeth, the CEJ serves as a reference point for the safe and precise removal of bone and soft tissue. However, in most cases where crown lengthening is performed before prosthetic restoration, natural reference points will be lacking if the affected teeth have already been prosthetically restored. Furthermore, if natural reference points exist but will be changed over the course of prosthetic rehabilitation, they cannot be used for intraoperative reference. These cases require the use of diagnostic provisional restorations or mock-ups which, ideally, should be checked in the patient's mouth and approved by the patient and the clinician prior to surgery. They allow reliable determination of the final incisal edge position and provide dependable intraoperative reference points for precise crown lengthening (see chapter 5).

Esthetic crown lengthening in young implant patients

Implant-supported restorations are now the standard of care in dentistry for young patients with traumatic tooth loss or congenital absence of the permanent teeth. However, the implants should not be placed until growth is completed and the permanent teeth have reached their final position (see chapter 13).

In certain cases (eg, altered passive eruption), the gingival margin adjacent to the edentulous space may not reach the final position, about 1 mm coronal to the CEJ.

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10.2 Procedures

10.2.1 Esthetic Crown Lengthening by Gingivectomy

KEY POINTS

01. Critically evaluate the *indications* for esthetic crown lengthening.

02. Determine the approach based on the *height of the dentogingival complex* and the *width of keratinized gingiva* relative to the extent of crown lengthening to be achieved.

03. Position the *gingival zenith* relative to the angle position of the axis of the affected tooth.

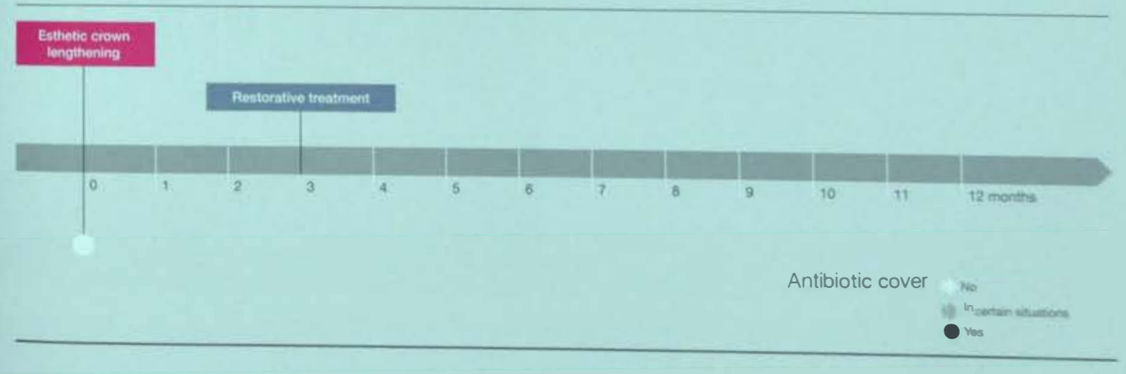
04. *Instrument the root surfaces* to a level 3 mm below the planned gingival margin position.

05. Use a coarse diamond bur to *thin the marginal gingiva.*

06. Apply *gentle pressure* to the wound for several minutes.

07. Give the *patient* complete and comprehensive *postoperative instructions.*

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. No. 15 macroblade and Keydent microblade
4. Sterile water in a metal dish
5. Blunt cannula
6. 10-mL syringe
7. Local anesthetic
8. Large and small pledgets
9. Electrocautery set
10. Coarse, bud-shaped diamond bur
11. Periodontal stent



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STEP-BY-STEP PROCEDURE







Figs 10-17 to 10-19 To replace two congenitally missing maxillary lateral incisors, two implants were placed. The teeth had been provisionally restored 5 months earlier. Altered passive eruption was diagnosed in the adjacent central incisors and canines. The chosen method of treatment is esthetic crown lengthening for full exposure of the anatomical crowns in combination with peri-implant soft tissue contouring and final prosthetic restoration.





Figs 10-20 and 10-21 To determine the extent of crown lengthening required, a cow horn–type periodontal probe is used to sound the CEJ of the affected teeth. As they will be located about 2 mm apical to the gingival margin, the crowns must be lengthened by about 1 mm.





Figs 10-22 and 10-23 To determine which procedure should be used in this case, the width of keratinized gingiva is measured and the dentogingival complex is sounded. Because the band of keratinized gingiva and the dentogingival complex (> 4 mm) are wide enough, crown lengthening can be performed through gingivectomy without the need for osseous surgery.

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Figs 10-24 to 10-26 The planned soft tissue outline is sketched with the electrocautery tip without touching the root surface. Correct positioning of the gingival zenith is crucial. The actual gingivectomy is performed with the microblade. The peri-implant tissue is adapted accordingly.





Figs 10-27 and 10-28 To prevent coronal displacement of the dentogingival complex, clinical experience has shown that it is best to sharply dissect and mechanically remove the periodontal ligament fibers from the affected root surfaces.









Figs 10-29 to 10-32 After gingivectomy, soft tissue contouring and thinning must be performed to obtain a natural gingival architecture. A coarse, bud-shaped diamond bur is recommended for this task.

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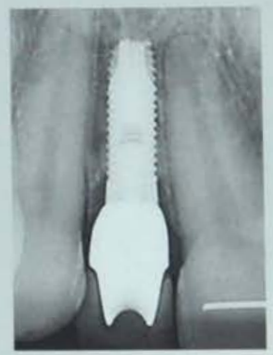


Fig 10-33 Result 1 week after gingivectomy, placement of the final abutment, and provisional implant restoration.













Figs 10-34 to 10-39 Clinical and radiographic results after placement of the final implant-supported crowns.

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Fig 10-40 Patient after the completion of treatment. (Dental technician: *Rainer Janousch*, Munich, Germany.)



See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 5, Chapter 1: Esthetic Crown Lengthening by Gingivectomy."

10.2.2 Esthetic Crown Lengthening by Gingivectomy and Ostectomy

KEY POINTS

01. Critically evaluate the *indications* for esthetic crown lengthening.

02. Determine the approach based on the *height of the dentogingival complex* and the *width of keratinized gingiva* relative to the extent of crown lengthening to be achieved.

03. *Define the tooth lengths* by external gingivectomy.

04. *Elevate a partial-thickness flap.*

05. Reduce and recontour the bone, including *interproximal recontouring.*

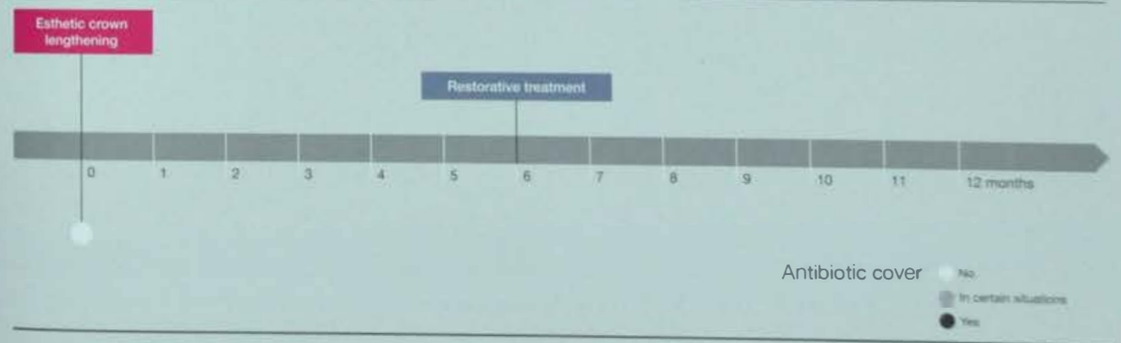
06. Perform thorough *instrumentation of the root surfaces.*

07. *Close* with vertical mattress sutures.

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive *postoperative instructions.*

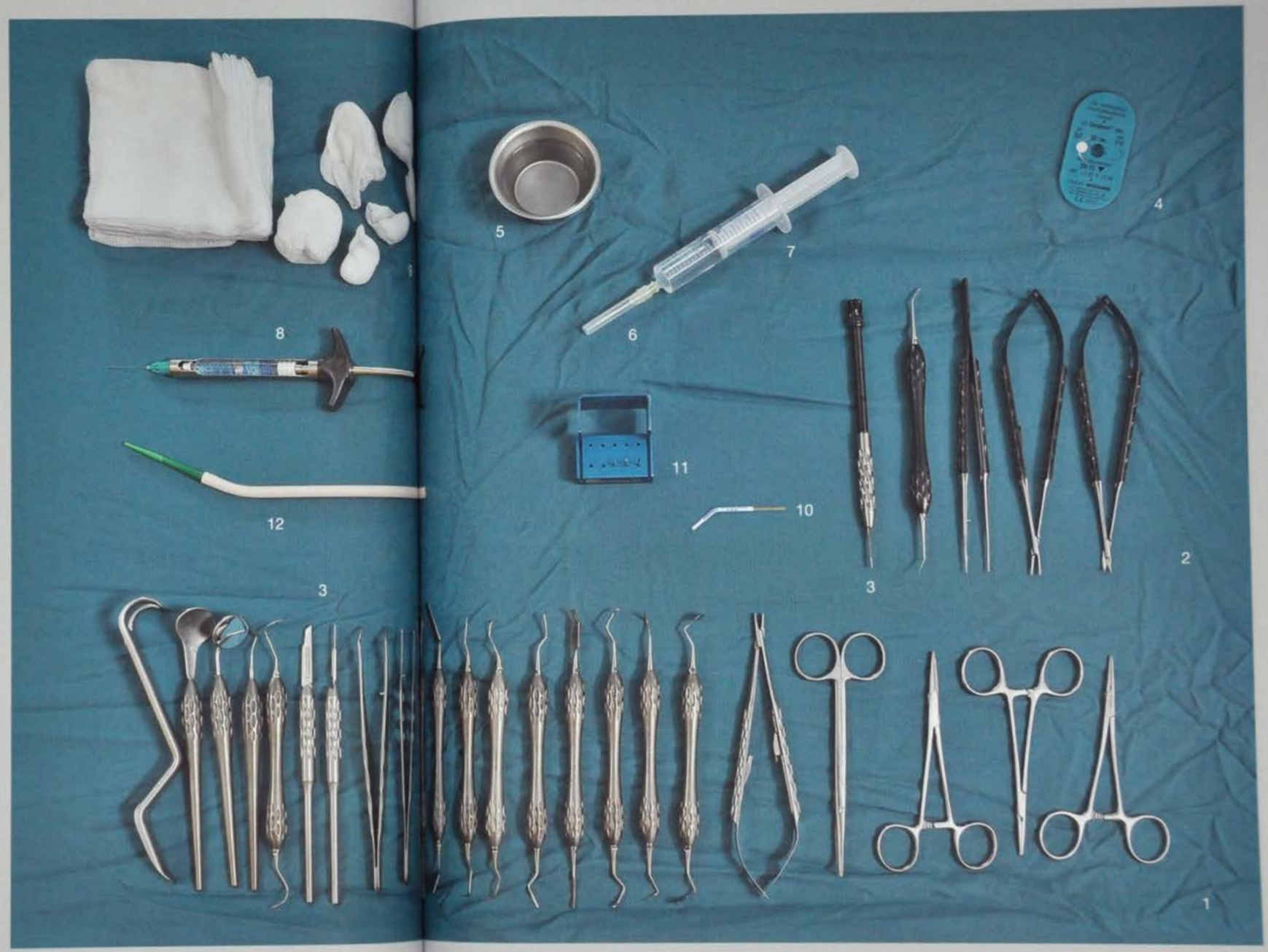
TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. No. 15 macroblade and Keydent microblade
4. Suture materials: 7-0 Seralene DS-12
5. Sterile water in a metal dish
6. Blunt cannula
7. 10-mL syringe
8. Local anesthetic
9. Large and small pledgets
10. Electrocautery set
11. Round diamond burs
12. Periodontal stent



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STEP-BY-STEP PROCEDURE









Figs 10-41 to 10-44 A crowned maxillary right central incisor appears overerupted, and its gingival margin is more coronal than that of the adjacent natural teeth. Esthetic crown lengthening will be performed, and a new crown will be placed for esthetic improvement.

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Figs 10-45 to 10-49 To determine the exact amount of crown lengthening required, the height of the incisal edge is reduced to achieve harmony with the adjacent teeth, upper lip, and lower lip.



Figs 10-50 and 10-51 Soft tissue correction can now be safely planned based on the adjusted incisal edge. About 1.5 mm of surgical crown lengthening is needed to achieve central incisors of uniform height.



Figs 10-52 and 10-53 The width of keratinized gingiva is greater than 5.0 mm. External gingivectomy can be performed because a sufficient width of keratinized gingiva will remain on the root surface after excision of 1.5 mm of soft tissue (see Fig 10-54). The sounding depth of the dentogingival complex is 3.0 mm. The amount of soft tissue excised determines how much bone must be removed.

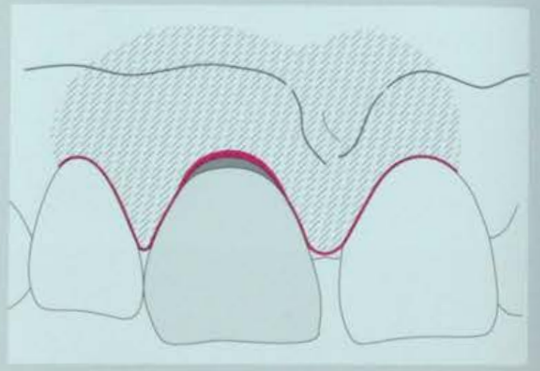
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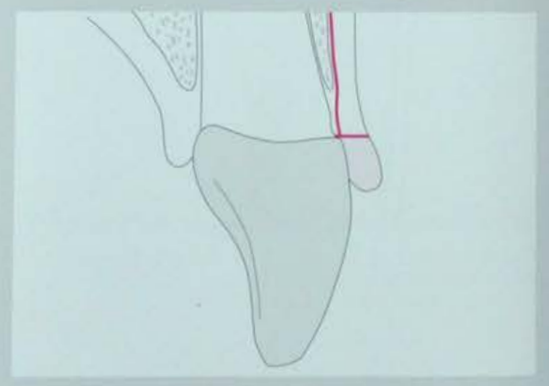


Figs 10-54 and 10-55 A microblade is used to perform the gingivectomy. The gingival zenith is positioned relative to that of the adjacent natural tooth.









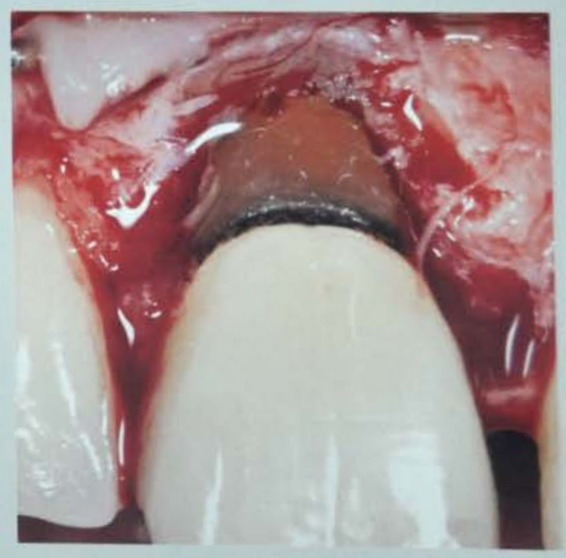
Figs 10-56 to 10-59 A No. 15 macroblade is used to dissect the adjacent papillae and elevate a partial-thickness flap. To create a flap of uniform thickness without beveled edges, the blade must be held perpendicular to the tissue surface during incision.





Figs 10-60 and 10-61 A round diamond bur is used to contour the bone in the areas where crown lengthening is to be performed. Hand instruments are then used to remove the tooth-bearing bone to ensure controlled bone removal and prevent damage to the root surface. Interproximal recontouring should also be performed.

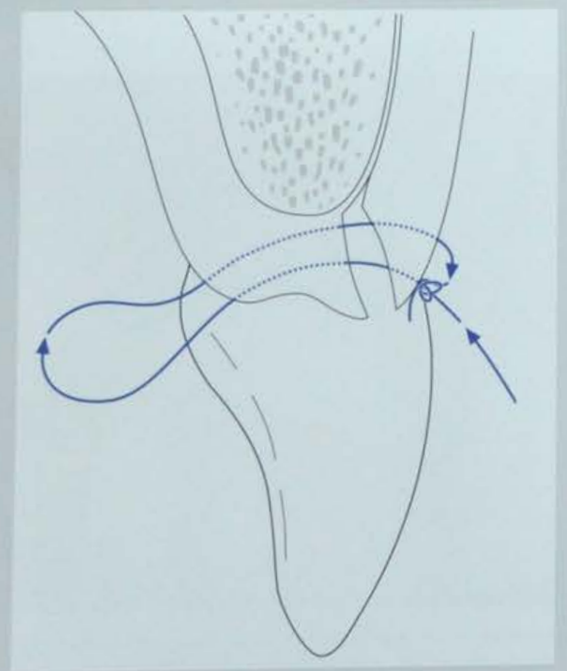




Figs 10-62 and 10-63 The periodontal ligament fibers on the root surface must be removed down to the bone. This can be done with either manual or power-driven instruments.

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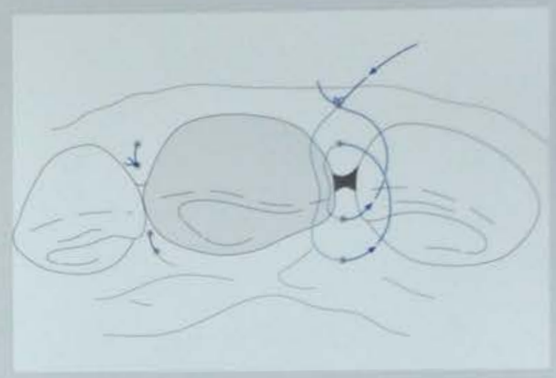


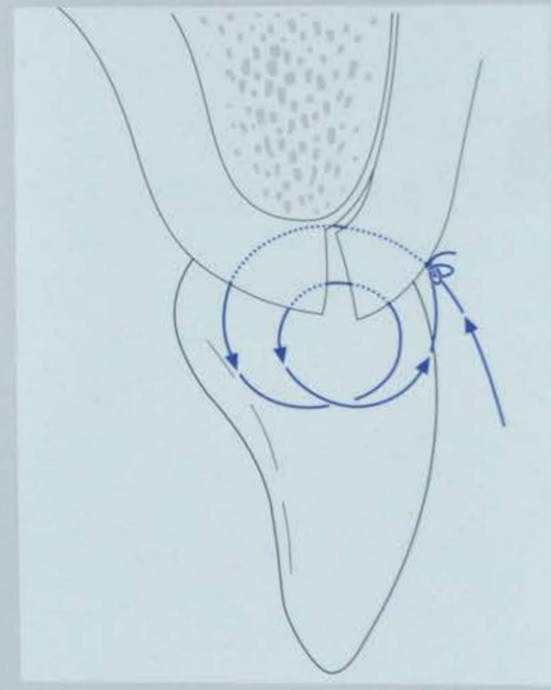


Figs 10-64 and 10-65 The flap is returned to its original position and sutured. A vertical mattress suture (6-0 Seralene DS-15) is used for this purpose. Near the papilla, the suture passes from buccal to palatal through the flap and the base of the papilla and, from a slightly more apical position, returns from palatal to buccal by the same route. Once the suture has been loosely tied over the first needle insertion site, the flap is precisely secured in its original position.









Figs 10-66 to 10-69 Because of the presence of the diastema, a double sling suture is used on the mesial aspect instead of a vertical mattress suture. On the buccal side, the needle enters about 3 mm apical to the flap margin, passes through the entire flap and papilla, and emerges about 3 mm apical to the incision line on the palatal side. Correct bite size is essential. Next, the needle returns to the buccal side, enters about 1 mm apical to the flap margin, passes through the flap and the papilla, and emerges about 1 mm apical to the incision line on the palatal side. The second suture is placed within the flap margins. Finally, the suture is tied on the buccal surface.

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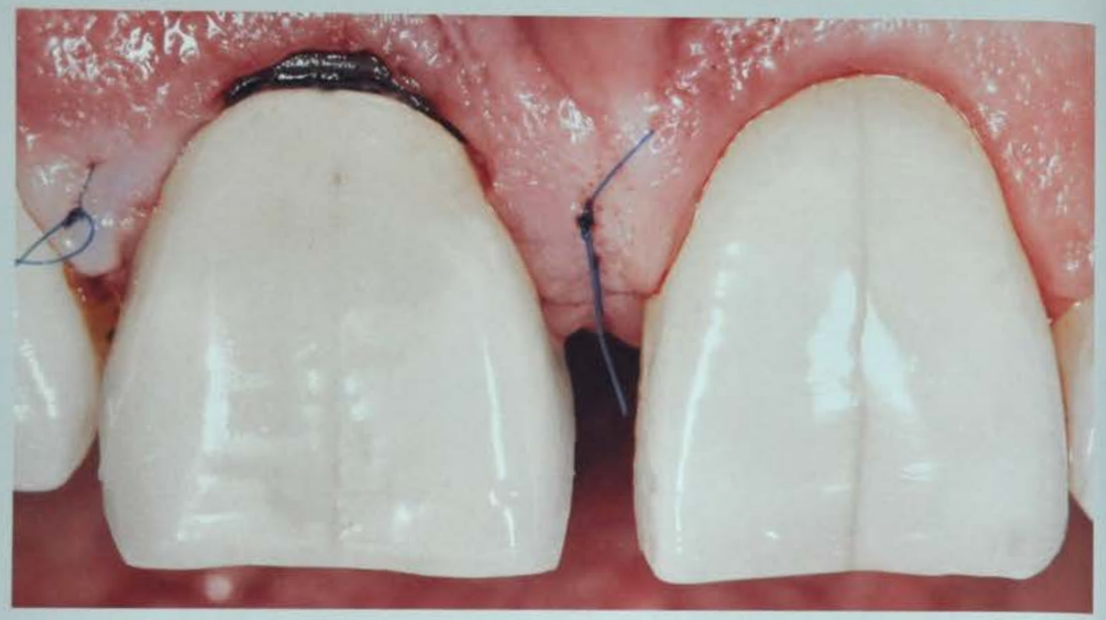


Fig 10-70 Symmetry of the gingival margins around both central incisors has been achieved.

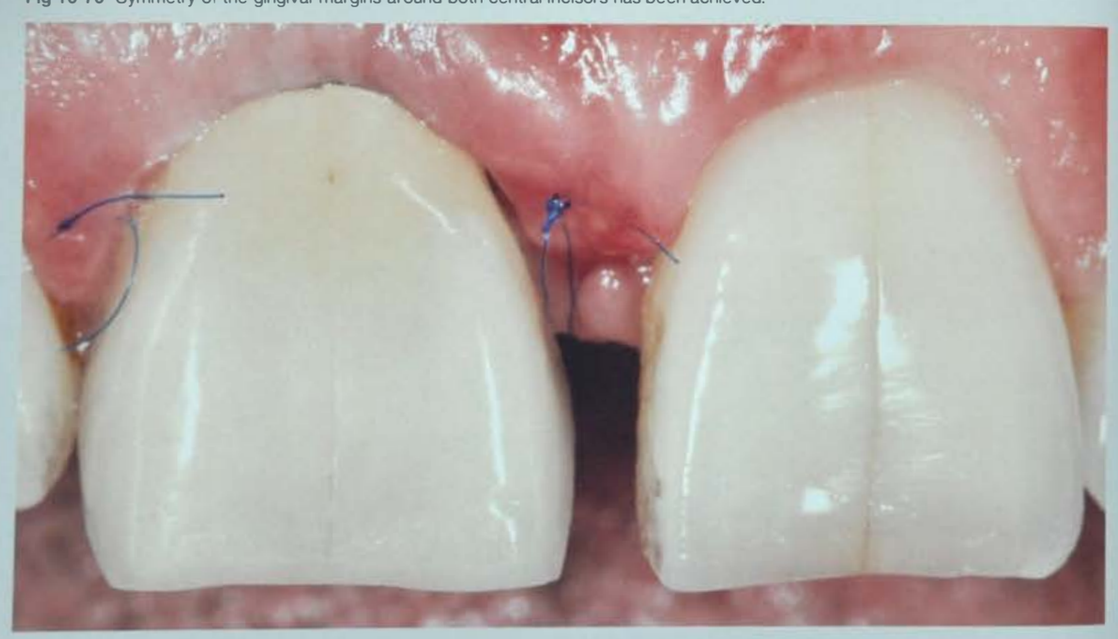


Fig 10-71 Result 1 week after surgery, just before suture removal. At least 6 months of healing is required before placement of the definitive crown. Predictable stability of the soft tissues can then be expected.





Figs 10-72 to 10-74 Orthodontic treatment for diastema closure was carried out during the healing penod. In addition, the root filling in the maxillary right central incisor was replaced, and internal bleaching was performed to lighten the discolored root.

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Figs 10-75 and 10-76 After 6 months of healing, the tissues are stable enough for intrasulcular restoration margins to be safely prepared and impressions for the definitive crown to be taken.









Figs 10-77 to 10-80 Clinical and radiographic results after completion of orthodontic treatment and placement of the definitive all-ceramic crown. The residual spaces between the central and lateral incisors were closed by placing composite resin on the lateral incisors.

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Fig 10-81 Patient after the completion of treatment. (Composite resin restorations: *Bärbel Hürzeler*, Munich; orthodontist: *Andi Barthelt*, Munich; endodontist: *Wolf Richter*, Munich; dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 5, Chapter 2: Esthetic Crown Lengthening by Gingivectomy and Ostectomy."

10.2.3 Esthetic Crown Lengthening by Apically Positioned Flap with or without Osseous Surgery

KEY POINTS

01. Critically evaluate the *indications* for esthetic crown lengthening.

02. Determine the approach based on the *height of the dentogingival complex* and the *width of keratinized gingiva* relative to the extent of crown lengthening to be achieved.

03. Make a *paramarginal incision* and elevate a partial-thickness flap.

04. Completely *de-epithelialize* the gingival tissue remaining in the coronal part of the interproximal area.

05. Reduce and recontour the bone, including *interproximal recontouring*.

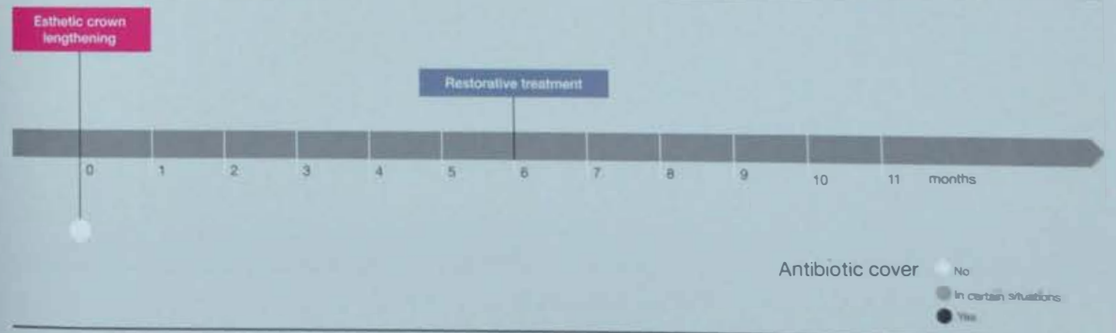
06. Perform thorough *instrumentation of the root surfaces*.

07. Use periosteal sutures *to secure the flap* 3 mm coronal to the osseous crest.

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. No. 15 and 12D macroblades and Keydent microblade
4. Suture materials: 6-0 Seralene DS-15
5. Sterile water in a metal dish
6. Blunt cannula
7. 10-mL syringe
8. Local anesthetic
9. Large and small pledgets
10. Round diamond burs
11. Periodontal stent



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STEP-BY-STEP PROCEDURE









Figs 10-82 to 10-85 The patient's maxillary anterior restorations are to be replaced while the gingival margins are simultaneously harmonized. Based on the evaluation with the diagnostic mock-ups, it was determined that esthetic crown lengthening of the two central incisors and right lateral incisor is needed. The required degree of lengthening is about 1.0 mm for the left central incisor and 2.5 mm for the right central and lateral incisors.

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Figs 10-86 and 10-87 After the old crowns are removed, the posts are removed, the root fillings are replaced, and immediate provisional restorations are prepared.



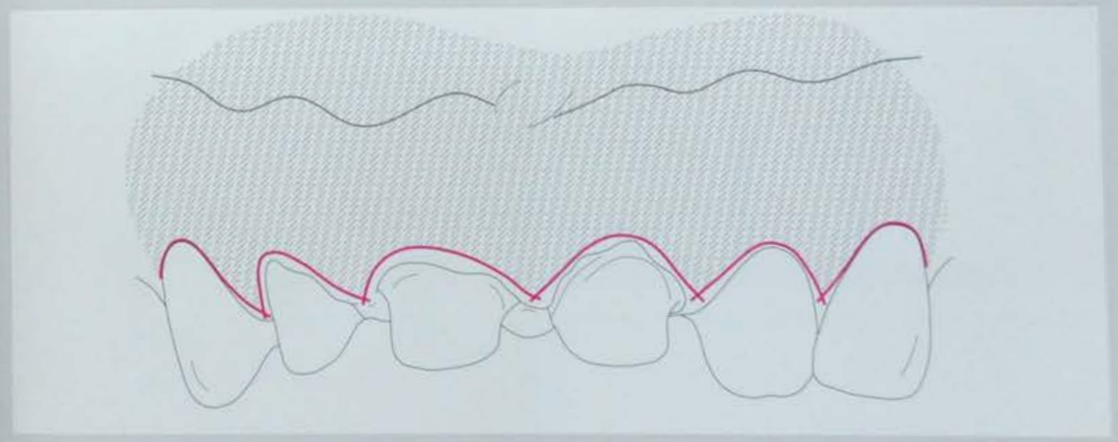


Figs 10-88 and 10-89 Subsequently, the site is evaluated to determine which type of crown lengthening procedure should be performed. An apically positioned flap is indicated for crown lengthening because the width of keratinized gingiva is not sufficient for gingivectomy. The tip of the periodontal probe indicates the planned bone contour as shown in Fig 10-89 (right).









Figs 10-90 to 10-93 Flap elevation begins with a paramarginal incision. To create a partial-thickness flap of uniform thickness, the blade must be held perpendicular to the gingival surface during incision, and the incisions in the papillary region must overlap.

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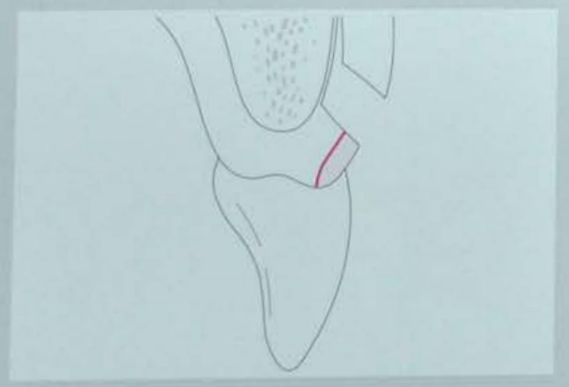




Figs 10-94 and 10-95 A No. 15 macroblade is used to elevate the flap in the area where the incisions in the papillary region overlap. To avoid perforation, the operator's eyes should always be directly focused on the scalpel working beneath the flap, and forceps should not be used to lift the flap.









Figs 10-96 to 10-99 Interproximal gingival tissue remaining coronal to the initial paramarginal incision should be de-epithelialized to prevent scar formation. A No. 12D macroblade or microscissors should be used for this task. It is important to ensure superficial de-epithelialization without reduction of papillary height.







Figs 10-100 to 10-102 The diagnostic provisional restoration can be placed on the prepared teeth to obtain an optimal reference for the subsequent osseous surgery.

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Figs 10-103 and 10-104 Ostectomy of the bone is performed using round diamond burs. The removal of tooth-supporting alveolar bone is performed last using hand instruments to prevent damage to the root surfaces. When the bone is contoured, it is important to include the interproximal areas and reduce the remaining marginal bone sufficiently with the diamond bur.

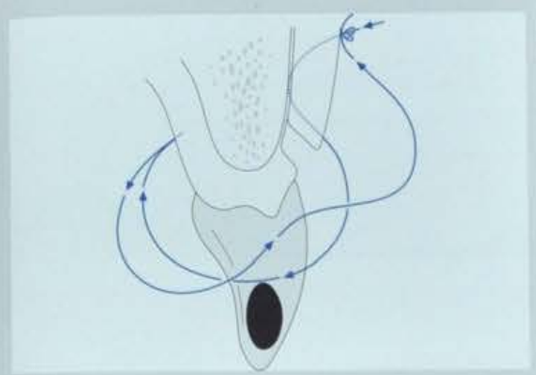




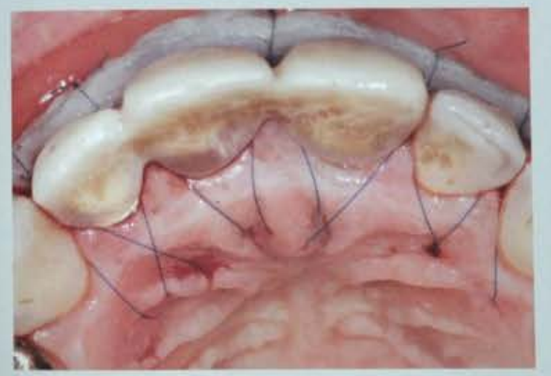
Figs 10-105 and 10-106 Periodontal fibers remaining on the root surface after bone contouring must be completely removed with hand- or power-driven instruments.

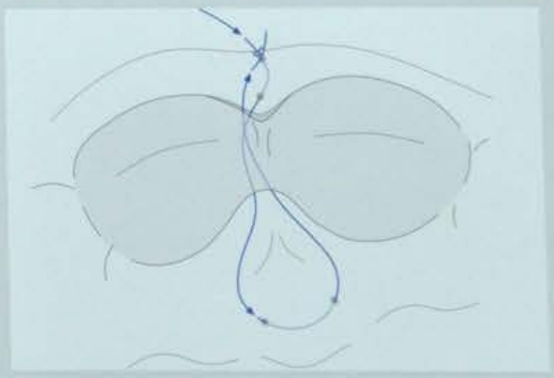






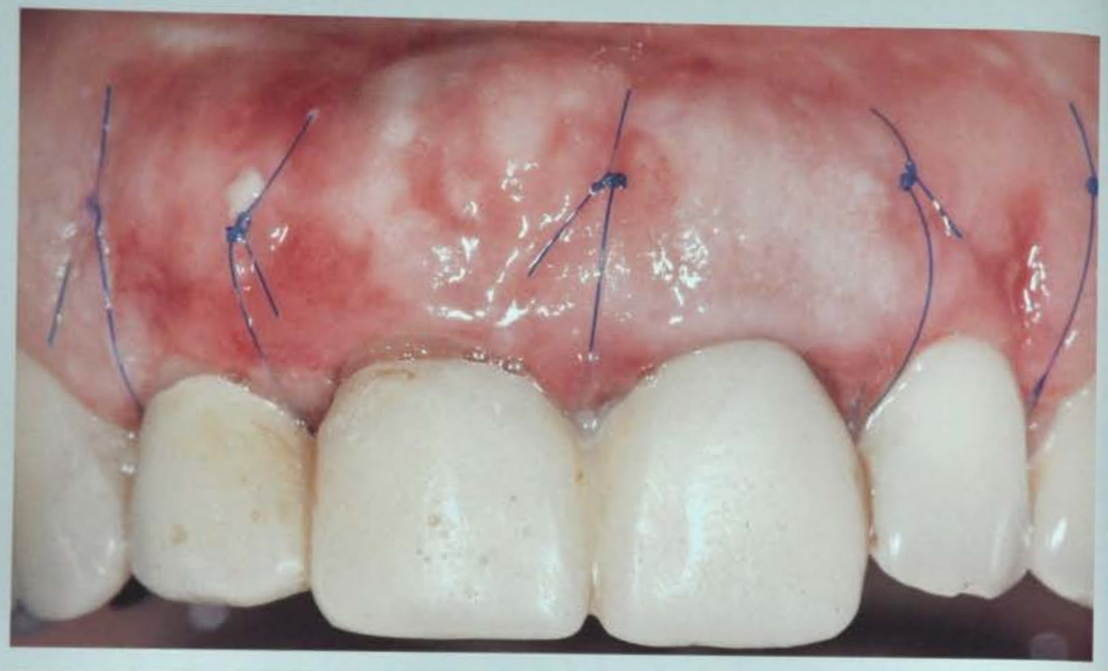


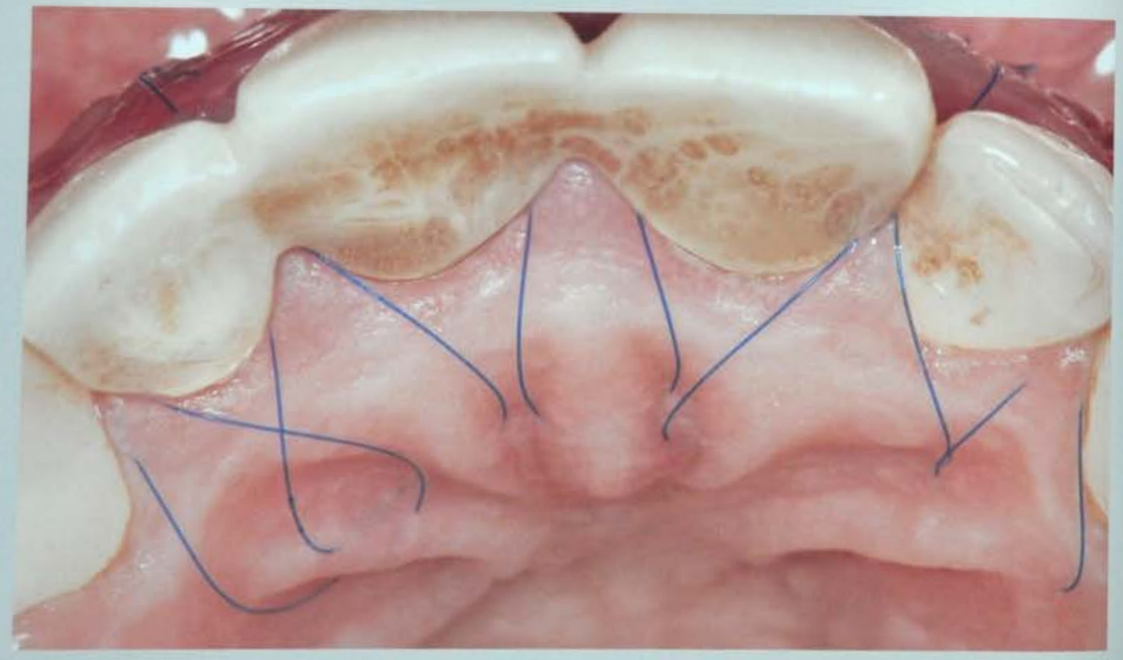




Figs 10-107 to 10-112 The flap is apically repositioned and sutured with periosteal sutures (6-0 Seralene DS-15). First, the flap is placed in the desired position 3 mm coronal to the alveolar bone. On the outer surface, at the level of the mucogingival junction, the needle passes through the flap and the connective tissue left on the periosteum after partial-thickness flap elevation. Once the needle has passed through the tip of the flap (from the inner to outer surface), it passes through the soft tissue on the palatal aspect (horizontal mattress suture) and emerges on the buccal side, where the suture is tied.

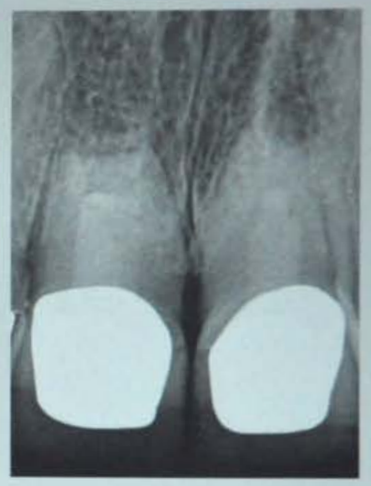
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Figs 10-113 and 10-114 Result 1 week after surgery, just before suture removal.







Figs 10-115 to 10-117 Intraoral result after completion of treatment.

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Fig 10-118 Patient after completion of treatment. (Endodontist: *Wolf Richter*, Munich; dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 5, Chapter 3: Esthetic Crown Lengthening by Apically Positioned Flap with or without Osseous Surgery."

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CHAPTER 11

PAPILLA RECONSTRUCTION

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Fig 11-1 The absence of interdental papillae can be an esthetic concern for some patients.

11.1 Theory

11.1.1 Etiology

Papilla loss may be localized or generalized and can be a major esthetic concern for some patients (Fig 11-1). Partial or complete loss of interdental papilla may develop for a number of reasons. *Tarnow* et al[1] determined that *interproximal bone loss* is a major factor in the development of open gingival embrasure spaces or black triangles. Their clinical study analyzing the effect of the vertical distance from the contact point to the crest of bone on the presence or absence of interproximal dental papillae revealed that the papilla was present at nearly 100% of sites where the distance from the contact point to the crest of bone was 5 mm or less, whereas partial or complete absence of the papilla was detected at the majority of sites where the distance was 6 mm or greater. The authors concluded that the height of the papilla is determined by the vertical height of the underlying alveolar bone (Fig 11-2 and Table 11-1).



Fig 11-2 Evidence suggests that the presence or absence of papillae is determined by the distance from the contact point to the crest of bone.

Table 11-1

Relationship between the distance from the most coronal point of the interdental alveolar crest (AC) to the apical edge of the interdental contact point area (ICP) and the presence or absence of interproximal dental papillae according to *Tarnow* et al[1]

AC–ICP distance (mm)	4	5	6	7	8
Intact papilla present (%)	100	98	56	27	10
Intact papilla absent (%)	0	2	44	73	90
Intact papilla present (n)	11	72	63	17	2
Intact papilla absent (n)	0	1	49	46	19

Interproximal bone loss secondary to periodontal disease is the main cause of the development of black triangles (Fig 11-3). *Soft tissue damage* can also bring about a loss of papillary height with or without involvement of the underlying bone. In an experimental study in 16 human subjects, *Holmes*[2] completely excised one papilla from the anterior region and one from the posterior region and performed re-excision of the regenerated papillary tissue after 32 to 86 days of healing. The subsequent histologic studies demonstrated that regeneration of the papillae was incomplete, resulting in failure of the papillae to return to their original height (Fig 11-4).

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Fig 11-3 (a and b) Interproximal bone loss secondary to periodontal disease is the main cause of black triangles.

Kohl and *Zander*[3] could not confirm these findings in an animal study, but clinical experience has shown that even minor soft tissue damage can lead to irreversible loss of papillary tissue. The damage may be self-inflicted from traumatic toothbrushing, pencil chewing, piercings, or other oral habits.

Iatrogenic causes include overcontoured restorations, subgingival scaling, and various prosthetic treatments and surgical procedures (Fig 11-5). Predictable prevention of additional soft tissue loss frequently is not possible with periodontal surgical procedures, particularly when they are performed as part of systematic periodontal therapy. However, the use of a microsurgical approach and special flap designs can minimize the risk of iatrogenic tissue loss[4–9] (Fig 11-6).

The *distance between the teeth* and the *angulation* of the roots of adjacent teeth are also important in this context. Because the teeth mechanically support the interproximal soft tissues, the dentogingival complex is higher interdentally than buccally or lingually (see chapter 1). The presence of diastemas or divergent roots implies a lack of mechanical support to the interdental soft tissues, resulting in reduced papillary height (Fig 11-7). *Overeruption of the teeth* is also an indirect cause of black triangles.

11.1.2 Indications for Treatment and Classification

Open gingival embrasure spaces (black triangles) between maxillary anterior teeth are a matter of esthetic concern for many patients with a medium or high smile line (see chapter 5). In addition to their cosmetic impact, these open spaces can also result in phonetic problems and food impaction.[10]

Nordland and *Tarnow*[11] proposed a classification for the loss of papillary height based on three anatomical landmarks: the interdental contact point, the coronal extent of the interproximal cementoenamel junction, and the apical extent of the facial cementoenamel junction. Four classes are distinguished:

- *Normal:* The interdental papilla fills the embrasure space to the extent of the contact point.
- *Class I:* The tip of the interdental papilla lies between the interdental contact point and the most coronal extent of the interproximal cementoenamel junction.
- *Class II:* The tip of the interdental papilla lies at or apical to the interproximal cementoenamel junction but coronal to the apical extent of the facial cementoenamel junction.
- *Class III:* The tip of the interdental papilla lies at the level of or apical to the facial cementoenamel junction (Fig 11-8).



Fig 11-4 (a to f) Damage to the papillae can result in irreversible soft tissue defects. This can lead to vertical and horizontal tissue loss and loss of the interdental col and, thus, lead to complete keratinization, giving the affected papilla a more pyramidal shape.

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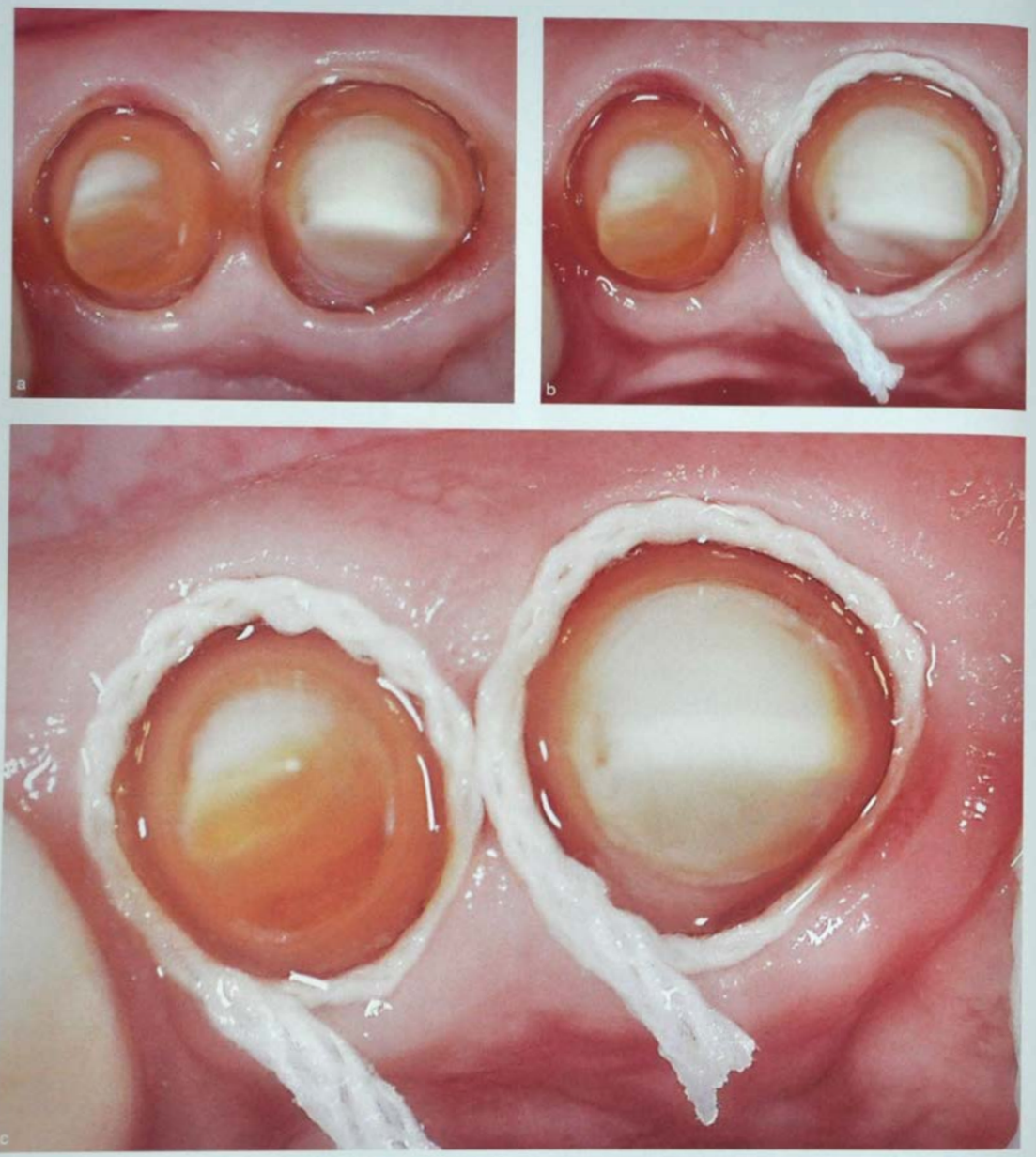


Fig 11-5 (a to c) Self-induced or iatrogenic soft tissue damage can lead to irreversible loss of papilla. For example, the placement of retraction cords can cause considerable injury to the papillary tissue, especially when two adjacent teeth are involved.



Fig 11-6 (a to c) Surgical periodontal therapy generally results in soft tissue loss, particularly in the papillary region, although the use of microsurgical and minimally invasive procedures can reduce the risk of postsurgical soft tissue defects.

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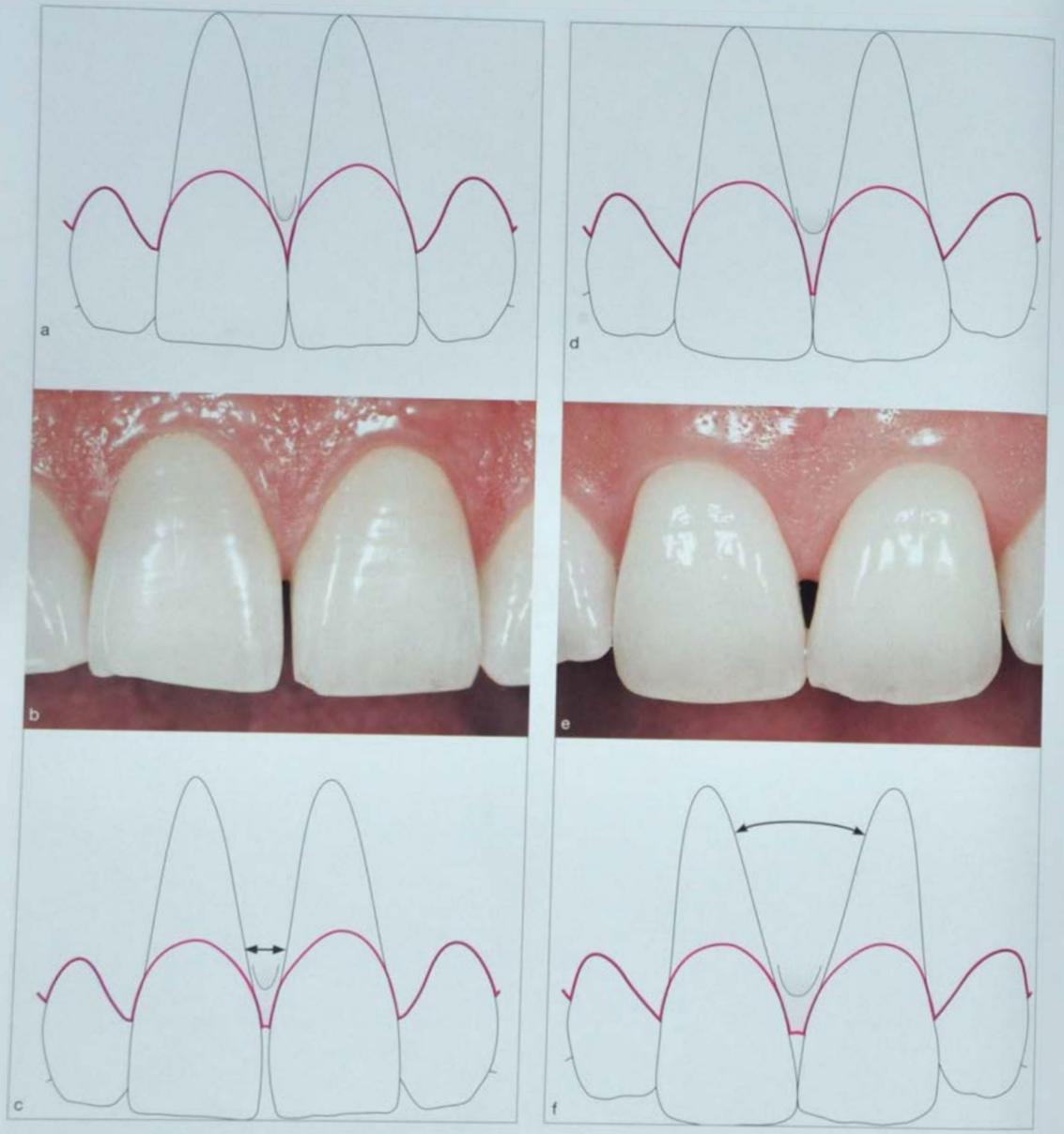


Fig 11-7 The presence of diastemas (a to c) or divergent roots (d to f) implies a lack of mechanical support to the interdental soft tissues, resulting in reduced papillary height.

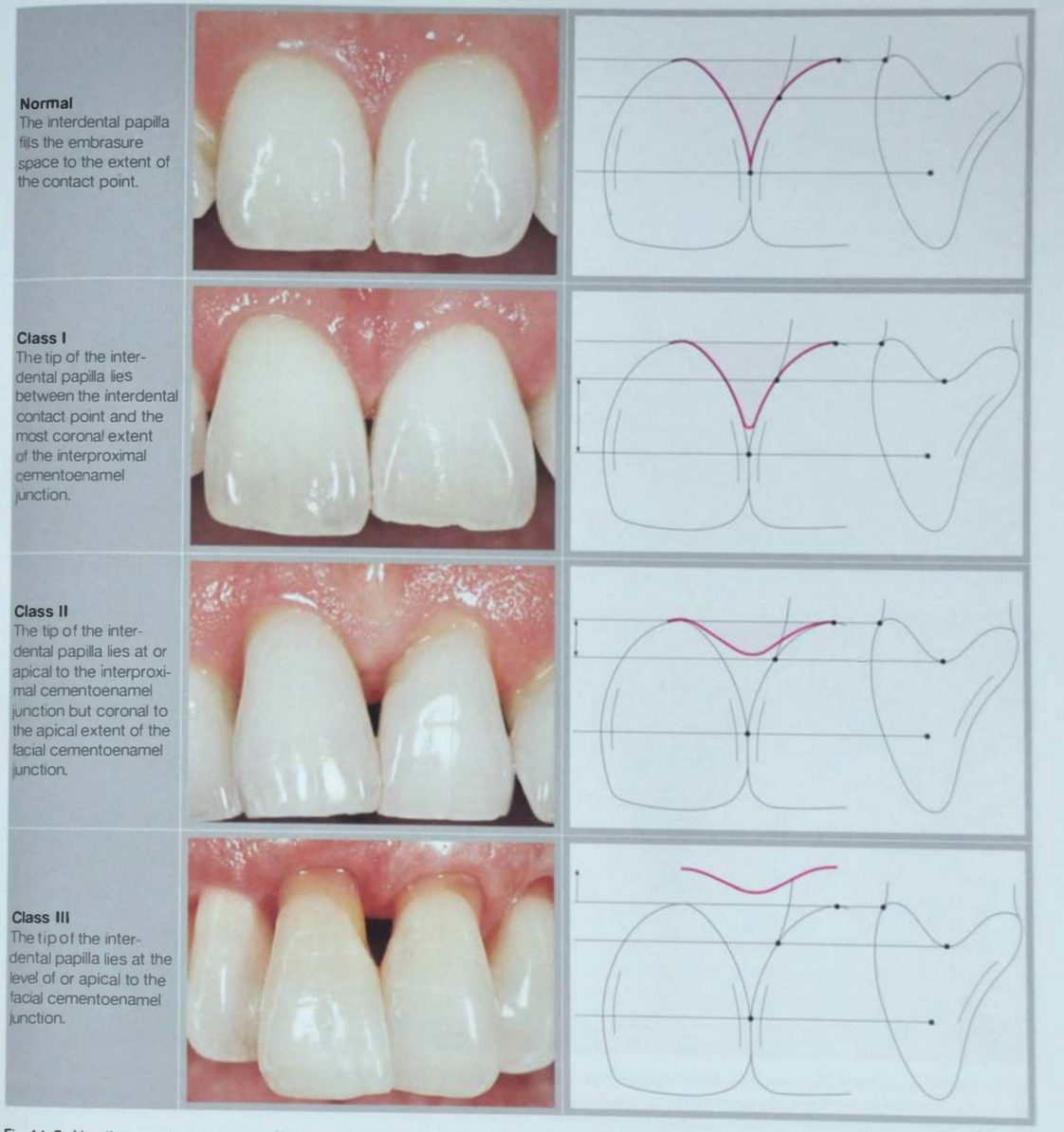


Fig 11-8 *Nordland* and *Tarnow* classification of loss of papillary height based on three anatomical landmarks: the interdental contact point, the interproximal coronal extent of the cementoenamel junction, and the facial apical extent of the cementoenamel junction.[11]

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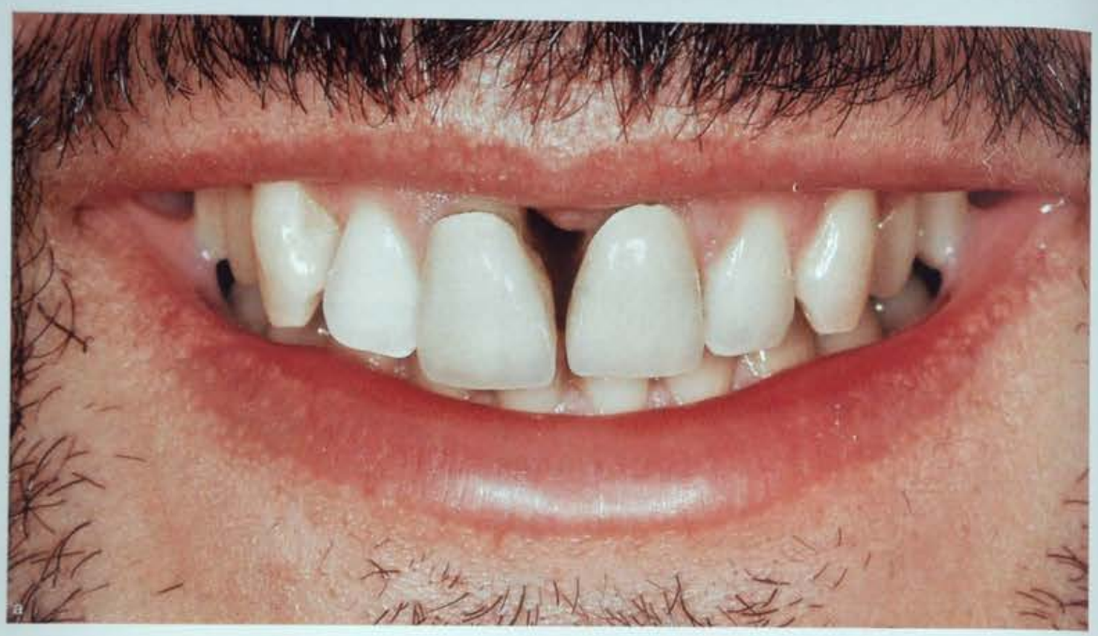






Fig 11-9 (a to c) None of the currently available surgical procedures for interdental papilla reconstruction provides predictable results, although successful outcomes have been achieved in isolated cases. An example is shown in this clinical case series. Pretreatment clinical photographs and radiographs reveal a Class II papillary defect that developed between the two maxillary central incisors secondary to periodontal surgery for treatment of aggressive periodontitis.

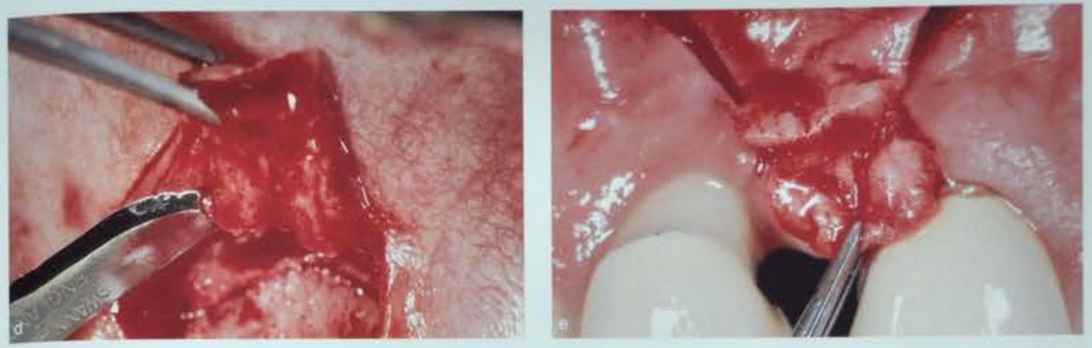


Fig 11-9 (d and e) The initial incision is placed so as to expose the alveolar bone apical to the papillary defect. After elevation of a full-thickness flap, an internal flap is created to achieve primary flap closure and closed healing of the augmentation site. The marginal soft tissue is not incorporated in the flap at this time.

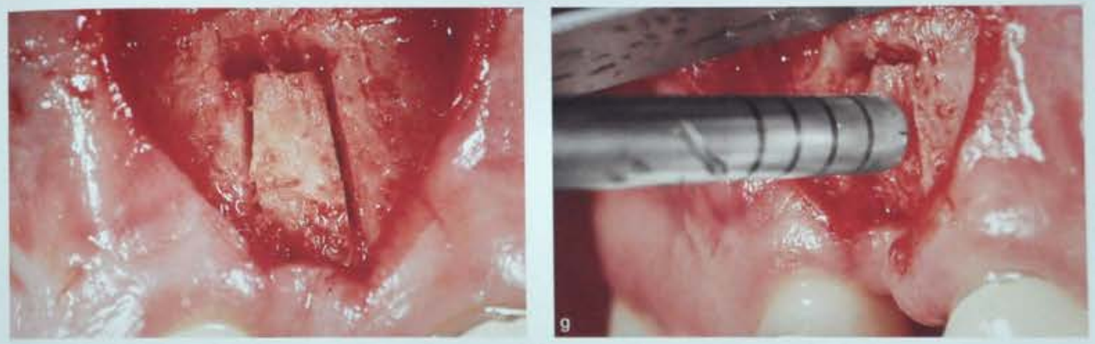


Fig 11-9 (f and g) Sandwich osteotomy. A bone fragment is resected apical to the papillary defect and carefully mobilized coronally. It is important that the mobilized bone fragment remain pedicled to the palatal mucosa.

11.1.3 Treatment Options

Various methods for treatment of open gingival embrasure spaces are described in the literature. The main approaches are surgical, orthodontic, and restorative. Noninvasive treatment techniques have also been described.[12,13]

Surgical approaches

Although cases of successful surgical reconstruction of the interdental papillae around teeth and implants have been described in the literature, clinical experience and the current data have shown that none of the currently available surgical procedures for interdental papilla reconstruction provides predictable results[14–24] (Fig 11-9). This could be due to a compromised blood supply to the affected region.[25]

Surgical crown lengthening can be used to restore gingival scallop in certain cases. Although not a method of papilla reconstruction per se, crown lengthening can achieve scalloping and apical repositioning of the buccal gingival margin. Resective techniques for indirect reconstruction of the interdental papilla may be used only in well-selected cases where prosthetic treatment is already planned (see chapter 10) (Fig 11-10).

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Fig 11-9 (h and i) A microblade is used to elevate and completely mobilize a partial-thickness flap from the marginal soft tissue around the papillary defect. Starting from an intrasulcular incision, the flap is extended apically to the area of the initial incision. An autogenous bone graft harvested from the retromolar region is then inserted in the space apical to the mobilized bone fragment.





Fig 11-9 (j and k) The site is covered with deproteinized bovine bone mineral and a xenogeneic collagen membrane barrier and then closed with sutures.





Fig 11-9 (l and m) Result 8 months after surgery, immediately before prosthetic retreatment. Orthodontic treatment has been performed during the healing period to restore root parallelism and thus to promote vertical development of papillary tissue between the two central incisors.







Fig 11-9 (n to p) Clinical and radiographic results after placement of the definitive restoration. (Orthodontist: *Andı Barthelt*, Munich; dental technician: *Uli Schoberer*, Seehausen, Germany.)

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Fig 11-10 (a to d) Clinical status before and after esthetic crown lengthening and placement of ceramic veneers in the mandibular anterior region. Scalloping and apical shifting of the buccal gingival margin were achieved without surgical reconstruction of the interdental papilla. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

Unlike vertical reconstruction of papillary defects, augmentation of the *horizontal* papillary tissue volume can be achieved predictably. If the highest point of the papilla is displaced palatally in the interproximal space and the base of the papilla is flattened in the palatal direction, subepithelial connective tissue grafting can result in predictable papilla augmentation in the horizontal plane. Clinical experience has shown that subepithelial connective tissue graft is an effective way of treating the loss of interdental papillae and black triangles in many patients.

Orthodontic approaches

Orthodontic treatment is the most effective way to promote the vertical growth of the existing soft tissue to eliminate papillary defects.

When adjacent teeth separated by a space or teeth with divergent roots are moved closer together, the papillary soft tissue is squeezed and moved coronally[10,18,26] (Fig 11-11). In adjacent teeth without a space between them, this effect can also be achieved by stripping the interproximal surfaces of the affected teeth. However, the teeth should not be moved too close together because close proximity of the roots could increase the risk of periodontal disease development.[27,28]

If prosthetic treatment is to be performed in combination with soft tissue correction, orthodontic extrusion of the teeth adjacent to the papillary defect or defects is another option that can be considered.[29] Although extrusion results in coronal movement of the papillary soft tissue with the teeth, the gingival margin often remains flat be-







Fig 11-11 (a to c) A Class III papillary defect has developed between the two maxillary central incisors after completion of penodontal therapy. Orthodontic treatment is planned to align the teeth and restore parallelism of the roots with the goal of closing the open gingival embrasure.

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Fig 11-11 (d to f) There is distinct papillary tissue gain in the vertical plane after completion of orthodontic treatment. The residual black triangle will be closed with composite.





Fig 11-11 (g and h) Final result after completion of treatment. (Orthodontist: *Andi Barthelt*, Munich; composite resin reconstruction: *Bärbel Hürzeler*, Munich, Germany.)

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Fig 11-12 (a to d) A pink ceramic prosthesis is placed in the gingival embrasure space to mask a black triangle. It is crucial that the base of the papillary prosthesis be designed to allow for adequate oral hygiene practices. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

cause the buccal and lingual soft tissues are also moved along with the interproximal soft tissues. To achieve gingival scalloping at these sites, it might seem like a good idea to perform surgical crown lengthening subsequent to orthodontic extrusion, but there is a risk that orthodontic extrusion could result in retraction of the soft tissue, resulting in a relapse of surgical results.[30] Consequently, surgical crown lengthening should not be performed following orthodontic extrusion, and the use of orthodontic extrusion for treatment of papillary defects should be considered very critically.

Restorative approaches

Restorative approaches can be used to create artificial papillae or to lengthen interproximal contacts. Although restorative techniques do not reconstruct papillary defects, restorations can effectively conceal defects in many cases.[31] Crowns and veneers can be used to mask black triangles, but composite resin reconstructions are particularly well suited for this purpose because they are minimally invasive and save tooth structure. To prevent shadowing, it is important that the apical boundary of the contact point area be located directly on the papilla rather than buccally or orally (Figs 11-12 to 11-14).





Fig 11-13 (a to c) Interproximal contact points can be lengthened in the scope of crown lengthening to mask black triangles in the maxillary anterior region. Imitation of the natural root surfaces is crucial for a successful cosmetic outcome.

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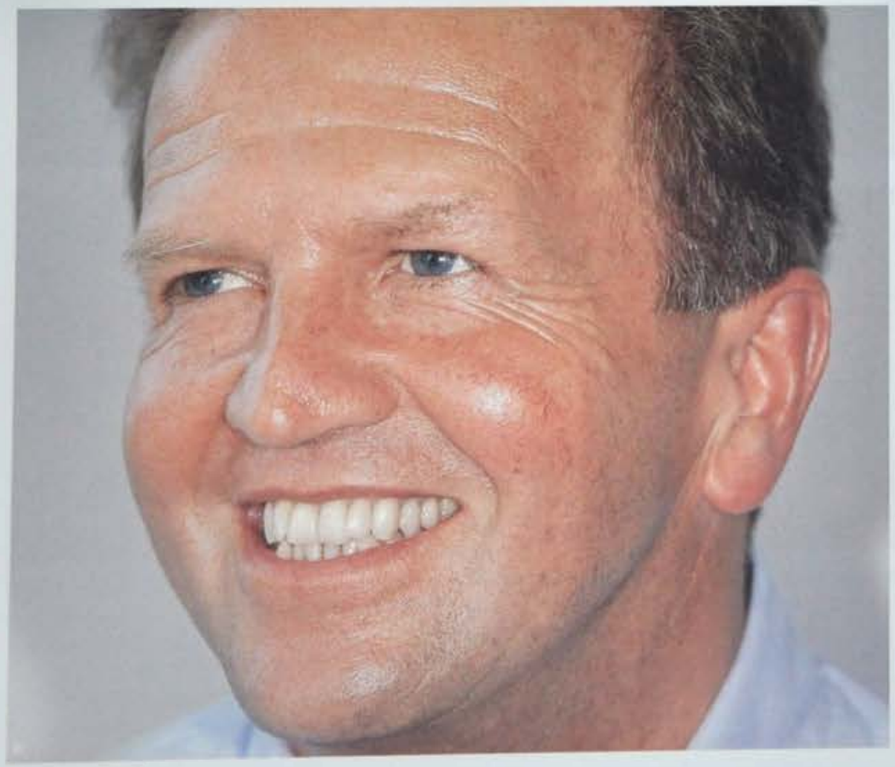


Fig 11-13 (d and e) Result after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)





Fig 11-14 (a and b) Case example of the use of composite resin for interdental closure. The establishment of conditions conducive to good oral hygiene is imperative.

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Fig 11-14 (c to f) From a technical point of view, the main challenge is to produce a composite restoration that completely fills the interdental space without impeding adequate oral hygiene. In addition to the interdental space, the incisal edge of the right central incisor was also corrected.





Fig 11-14 (g and h) Result after the completion of treatment. (Composite resin reconstruction: *Bärbel Hürzeler*, Munich, Germany.)

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Fig 11-15 (a to c) The long contact points do not end at the tip of the papilla but are extended apically by additional veneers made on a so-called Geller model.

Building up the tooth contour in the vertical plane, both to the most coronal point of the papilla and slightly subgingivally, somewhat apical to the tip of the papilla, makes it possible to achieve an additional effect. This squeezes the existing papilla, pressing the soft tissue slightly coronally, as with orthodontic tooth movement (Fig 11-15).

Although the interproximal sulcus depth is greater than the buccal or lingual sulcus depth, which would seem to imply a lower risk of violating the biologic width in this area, subgingival restoration margins always have certain biologic risks, which must be carefully weighed during individual case evaluation (see chapter 1).



Fig 11-15 (d to f) The veneers press against the papilla, displacing the existing soft tissue buccally and coronally. Intrasulcular restoration margins are essential for this procedure. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

11.1.4 Technical Aspects

Predictable surgical augmentation of the papilla is possible only in the horizontal plane. When the surgery is performed, it is important to consider the weak blood supply to the papillary region. Consequently, no vertical or horizontal releasing incisions should be made during flap elevation. Flap elevation is performed by the modified tunnel technique.

The modified tunnel technique for interdental papilla reconstruction differs slightly from the procedure used for root coverage (see chapter 9) in that the flap extends

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Fig 11-16 Unlike palatal grafts, free connective tissue grafts from the tuberosity and retromolar areas are collagen-rich and stiff and are therefore particularly well suited for augmentation of the interdental papilla.

far palatally in the area of the affected papilla. Therefore, it is necessary to make a short vertical auxiliary incision on the buccal aspect. In addition, the type of graft used must provide adequate stability to support the mobilized papilla in its coronally displaced position. Unlike palatal grafts, free connective tissue grafts from the tuberosity and retromolar areas are collagen-rich and stiff and are therefore particularly well suited for interdental papilla augmentation (see chapter 7) (Fig 11-16). If combined horizontal and vertical defects are to be corrected or masked, periodontal surgery must be performed in combination with orthodontic and/or restorative treatment.

11.1.5 Long-Term Stability

Nemcovsky[21] followed 10 patients for a period of 3 to 14 months after surgical reconstruction of interdental papillae using palatal connective tissue grafts. No clinically significant volume changes were observed at the augmentation sites after 3 months of healing. Currently, no data are available on the long-term stability of interdental papilla reconstruction procedures such as those described in the following pages.

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11.2 Procedures

11.2.1 Horizontal Papilla Augmentation Using Subepithelial Connective Tissue Graft

KEY POINTS

01. Surgical augmentation of the interdental papilla can be achieved *in the horizontal plane* but not in the vertical plane.

02. Clean the root surfaces *before the first incision* is made.

03. *Splint* the contact points with flowable composite resin as needed.

04. Elevate a partial-thickness flap/tunnel:
- Extend it *coronally and palatally* up to the base of the papilla if possible.
- Extend it *apically* beyond the mucogingival junction.
- Extend it *laterally* at least one tooth wider than the affected papilla.

05. Keep the *auxiliary vertical incision* as short as possible and apical to the affected papilla.

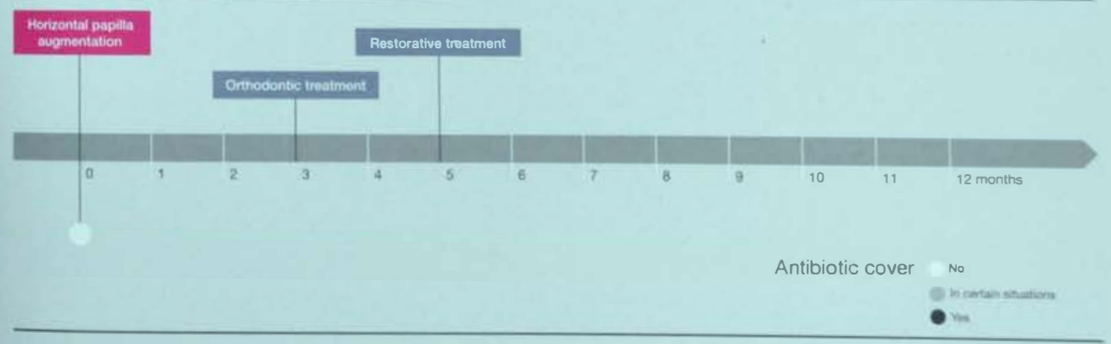
06. If possible, harvest the subepithelial connective tissue graft from the *tuberosity or retromolar area*.

07. Use vertical double-crossed sutures to *secure* the flap and the graft.

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1 Macrosurgical instrument set
2 Microsurgical instrument set
3 Tunneling Knives I and II
4 Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, and 7-0 Seralene DS-12
5 No. 15 and 12D macroblades and Keydent microblade
6 Glass slab
7 Sterile water in a metal dish
8 Blunt cannula
9 10-mL syringe
10 Local anesthetic
11 Large and small pledgets



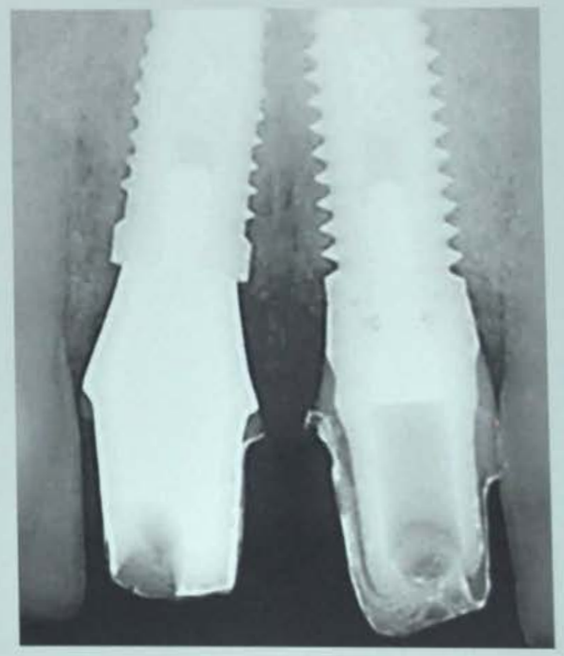
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STEP-BY-STEP PROCEDURE





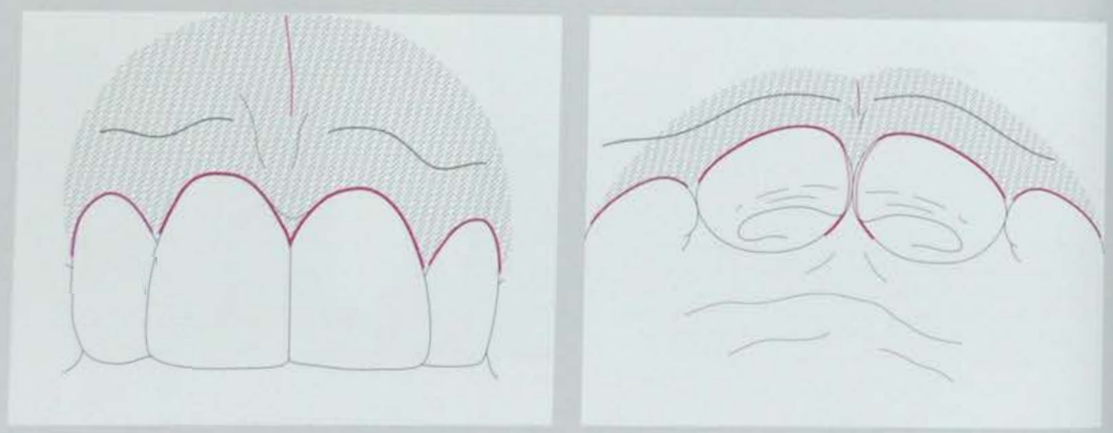




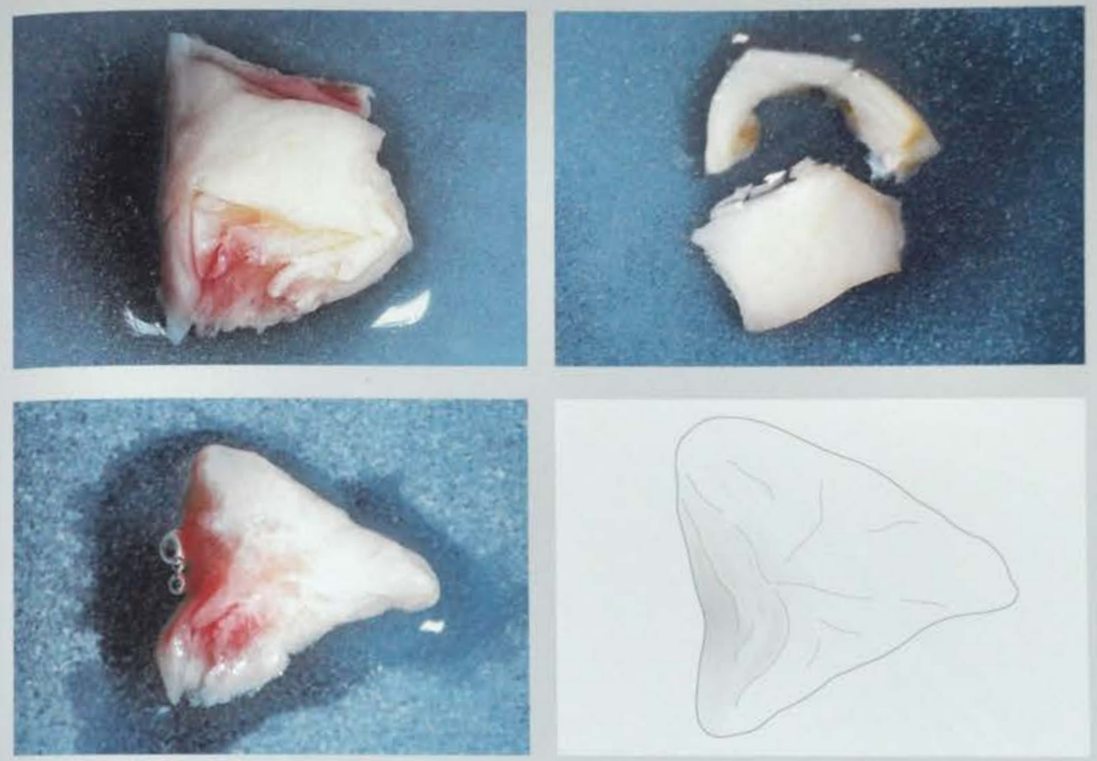
Figs 11-17 to 11-20 Two missing maxillary central incisors have been replaced with two implant-supported crowns. The inter-implant papilla has a combined vertical and horizontal tissue defect. Horizontal papilla augmentation will be performed to reduce shadowing in the interproximal area between the two implant-supported crowns.

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Figs 11-21 to 11-23 The microblade is used to make intrasulcular incisions buccal and palatal to the two implant-supported crowns; the incisions are extended interproximally between the two implants in the interimplant papilla region. Unlike the procedure on the palatal side, the incision on the facial is extended laterally, up to the distal papilla of the respective lateral incisor. To ensure controlled flap reflection and safe insertion of the connective tissue graft, a short vertical incision must be made in the alveolar mucosa apical to the affected papilla. The entire buccal area, including the affected papilla, is undermined to create a partial-thickness flap/tunnel with sufficient coronal and lateral mobility. The special Tunneling Knives are used for this purpose

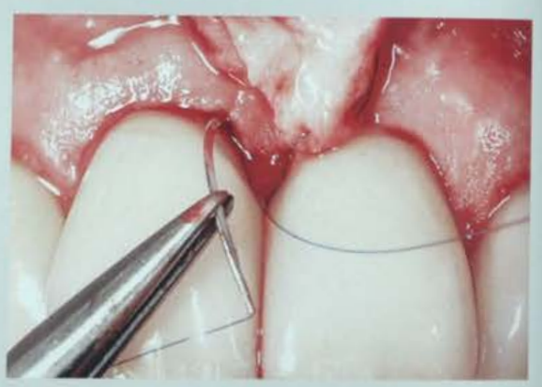


Figs 11-24 to 11-27 A subepithelial connective tissue graft is harvested from the tuberosity area, de-epithelialized, and trimmed to form an isosceles triangle.

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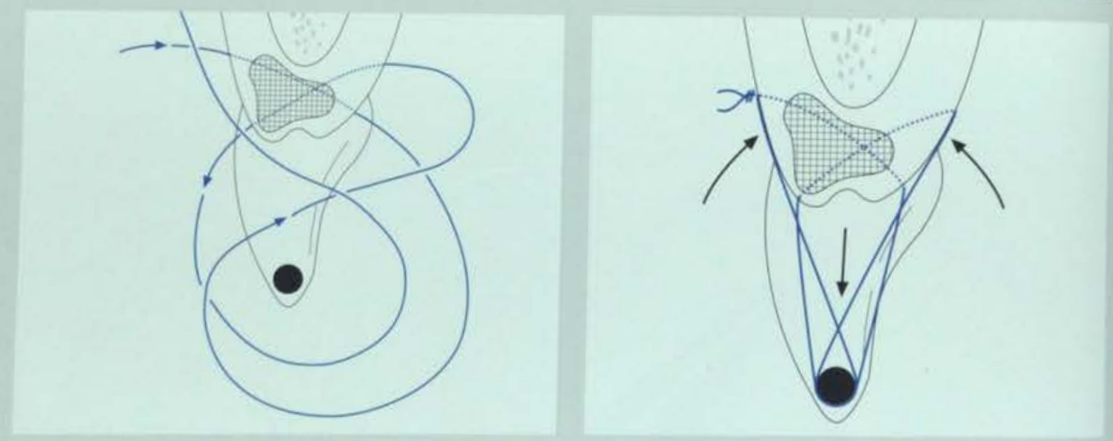




Figs 11-28 to 11-33 Positioning sutures are used to draw the graft into the prepared tunnel so that the tip of the graft is located on the palatal side. The needle (6-0 Seralene DS-15 suture) enters at the palatal base of the papilla and emerges through the sulcus on the buccal side. From the sulcus, it enters the tunnel back-first and exits through the auxiliary vertical incision. The needle then engages the tip of the graft and returns to the palatal side by the same route. Gentle pulling on the sutures on the palatal side draws the graft into the tunnel. Finally, the suture is tied.

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Figs 11-34 to 11-36 Once the contact points between the lateral incisors have been splinted with flowable composite resin (placed without etching), the site is sutured with vertical double-crossed sutures. From the buccal side, the needle (6-0 Seralene DS15 suture) enters at the base of the affected papilla, engaging the flap and the graft, and emerges slightly apical to the tip of the papilla on the palatal side. The needle then glides back-first below the splinted contact point and passes from buccal to palatal without engaging the tissue. The same steps are repeated in mirror-image order from the palatal side, and the suture is tied on the buccal side. After another vertical sling suture has been placed distal to each affected papilla, the auxiliary vertical incision is closed with a 7-0 Seralene DS-12 suture.



Fig 11-37 Result 1 week after surgery, just before suture removal.

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Fig 11-38 Result 6 months after surgery.

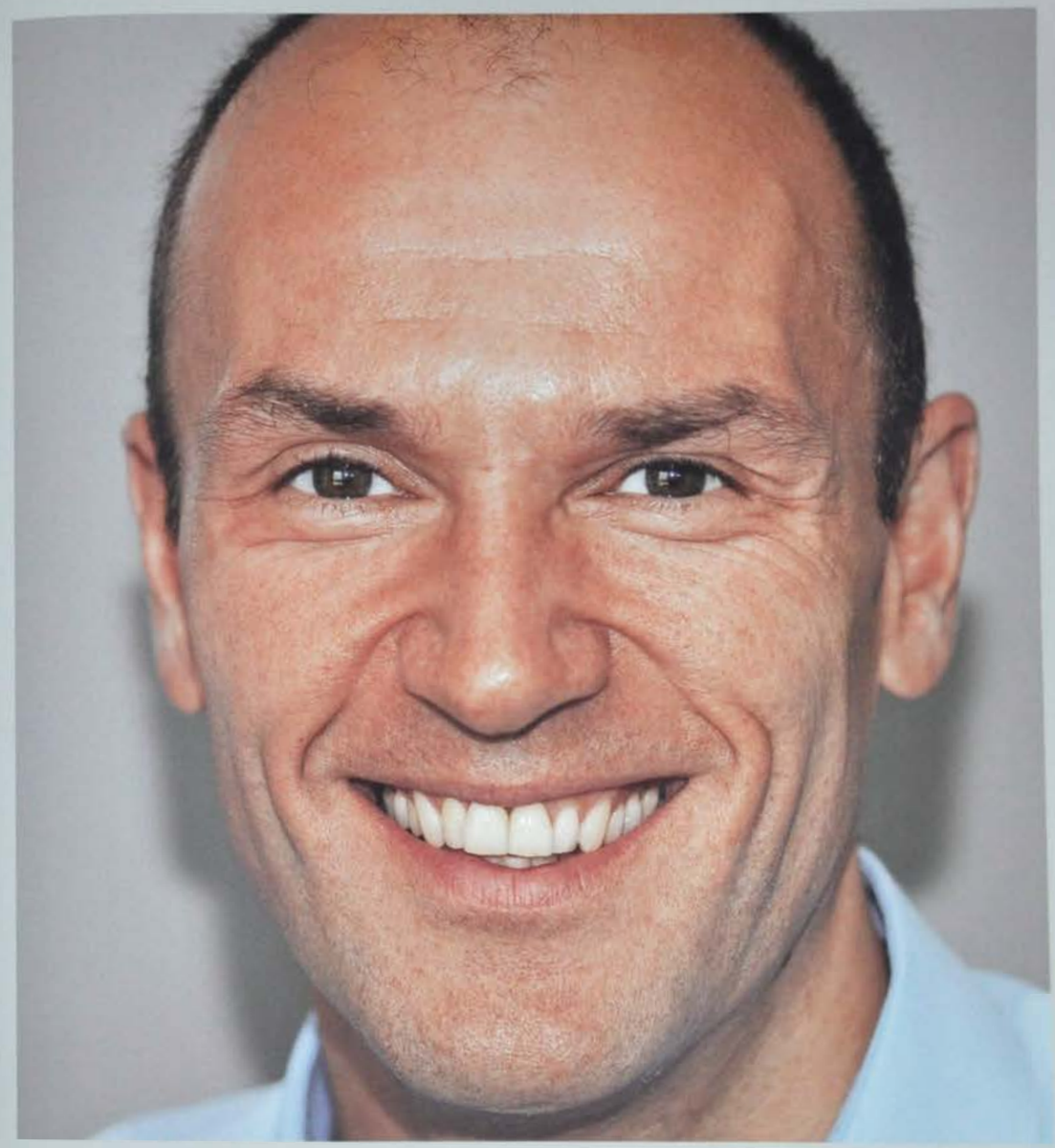


Fig 11-39 Patient after the completion of treatment.

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery. Volume 6: Horizontal Papilla Augmentation Using Subepithelial Connective Tissue Graft."

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CHAPTER 12

MANAGEMENT OF EXTRACTION SOCKETS

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Fig 12-1 Five stages of alveolar socket healing have been described by *Amler*.[2]

12.1 Theory

12.1.1 Healing After Tooth Extraction

The processes involved in the healing of extraction sockets were described nearly 60 years ago in an animal study by *Huebsch* et al[1] and 17 years later in a human biopsy study by *Amler*,[2] who described five stages of alveolar socket healing[2] (Fig 12-1). In the *first stage*, which takes about 3 days, a blood clot forms and occupies most of the extraction socket. In the *second stage* (4 to 5 days after extraction), fibroblasts begin to reorganize the blood clot. During the *third stage* (14 to 16 days after extraction), the blood clot is replaced by a provisional connective tissue matrix. The *fourth stage*, which lasts up to 6 weeks, is characterized by the start of osseous remodeling of the provisional matrix and the completion of epithelial closure of the alveolus. The *fifth stage*, in which osseous remodeling of the extraction socket is largely completed, comes to a conclusion after about 10 weeks.

Cardaropoli et al[3] more recently found in an animal study that osseous remodeling of extraction sockets takes 120 to 180 days. An outer cortical structure and a covering periosteal layer can first be identified at this time. By 180 days after extraction, only a few fractions of woven bone can be seen in the bone marrow areas, which can be taken as a sign of complete ossification.

The volumetric changes that occur after tooth extraction are particularly relevant in the esthetic zone. Detailed studies of these alterations were recently performed using study casts and direct measurements at second-stage surgery. *Schropp* et al[4] studied 46 extraction sites in the maxillary and mandibular posterior segments and observed that healing resulted in a roughly 50% reduction in buccolingual bone width in 12 months. Two-thirds

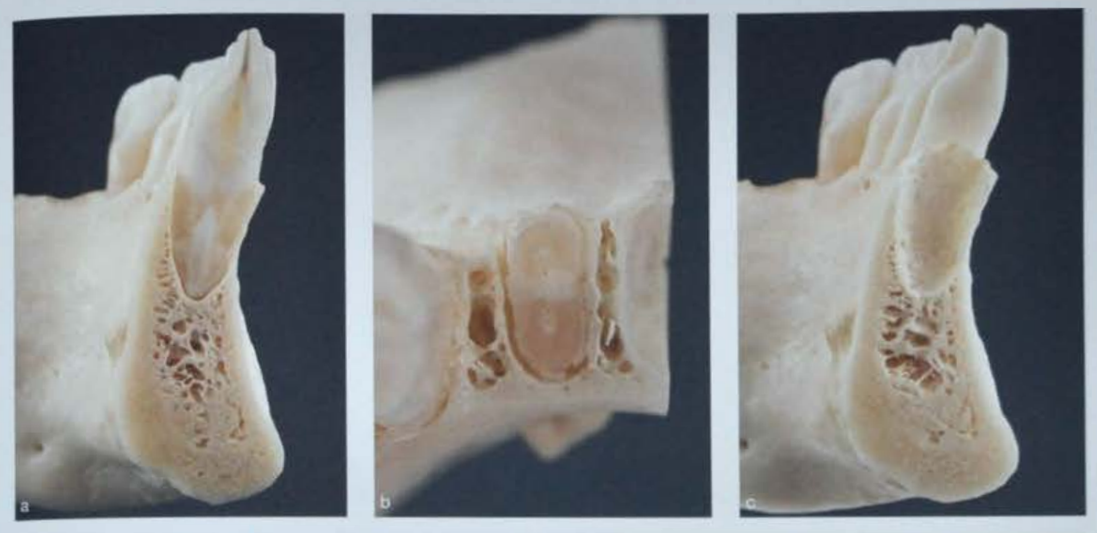


Fig 12-2 (a to c) These anatomical specimens illustrate the dimensions of the alveolar bone surrounding the teeth. The resorption of bundle bone following tooth extraction seems to occur due to the lack of functional loading. These resorptive processes could lead to a total loss of the buccal bone plate, which is often very thin.

of the bone loss occurred on the buccal aspect. The apicocoronal bone height was reduced by approximately 0.8 mm after 3 months of healing.

Several studies have investigated the reasons for these enormous morphologic alterations. Through experimental studies in animals, *Araújo* and colleagues[5–8] concluded that a loss of bundle bone may be involved in these changes, in addition to the extraction-related trauma to the surrounding hard and soft tissues. Bundle bone is the portion of the alveolar bone where fibers from the periodontal ligament insert (see chapter 1). After tooth extraction, physiologic forces can no longer act on this part of the dentoalveolar complex. Hence, complete resorption of these structures can occur. Thin gingival biotypes associated with thin buccal bone plates are presumed to be most susceptible to this type of bone loss because these structures appear to consist completely of bundle hone.[9]

When tooth extraction is performed in combination with flap surgery, the related compromise of blood supply to the buccal alveolar bone appears to result in additional bone resorption.[8,10–13] Local factors (such as the presence of inflammation and bone defects at the time of extraction), systemic factors (such as smoking), and the number of extracted teeth could also have an impact on the expected extent of bone resorption[4,14–16] (Fig 12-2).

These resorptive processes lead to the formation of tissue defects, which can be of cosmetic concern when located in the esthetic zone. The defects are associated with the *vertical and horizontal dimension of the interproximal tissue* (ie, the papillae between adjacent natural teeth, between two pontics or implants, or between a pontic and an implant) and the *vertical and horizontal dimensions of tissue* on the *midbuccal* aspect of pontics or implants (Fig 12-3).

If preventive measures are not taken at the time of tooth extraction, augmentation surgery will be needed to correct resorption-related defects in the esthetic zone. Because the possibilities for hard and soft tissue augmentation are limited and augmentation procedures are associated with greater cost and morbidity, it is both advisable and desirable to develop new evidence-based clinical strategies that ideally prevent defects and the subsequent need for augmentation surgery following tooth extraction.

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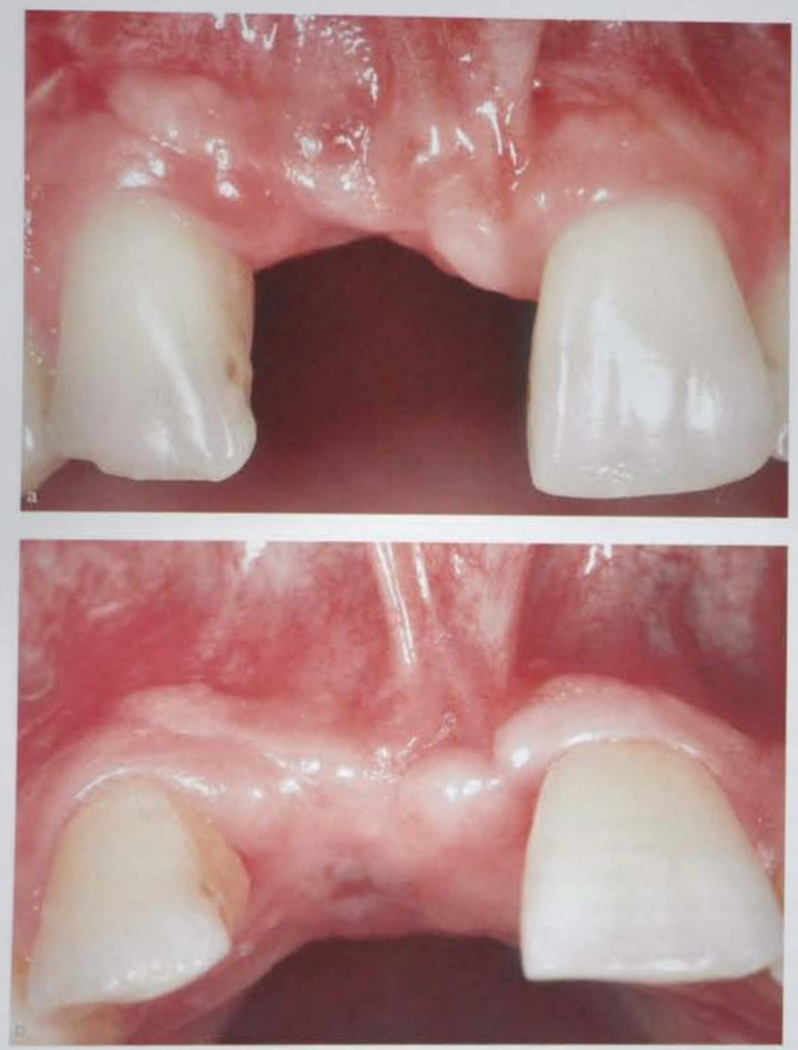


Fig 12-3 Defects associated with the vertical (a) and the horizontal (b) dimensions of the midbuccal and interproximal tissues have developed 5 months after the maxillary right central incisor was extracted without preventive measures.

10.1.2 Defect Prevention Strategies

Based on the current state of knowledge, the initial postextraction resorptive processes are physiologic processes that cannot be prevented. The only realistic goal of prevention is to *minimize the defects* and *compensate for the remodeling processes that take place*. This can be achieved by implementing a number of different preventive measures before, during, and after tooth extraction.

Procedures performed prior to extraction

Orthodontic extrusion

Both the gingiva and the alveolar bone move coronally in the direction of tooth extrusion.[17] As collagen fiber bundles are stretched during tooth movement, new bone is deposited in areas of alveolar bone along the stretched fiber bundles. Because this bone deposition occurs as a result of tension from the stretched fibers, healthy periodontal conditions are crucial.[18]

Ingber[19] proposed forced eruption as a method of treating one- and two-wall infrabony defects in otherwise nonsalvageable teeth after observing that extrusion of the teeth results in a coronal shift of the connective tissue attachment and alveolar bone, thus decreasing the depth of the osseous defect. These findings were confirmed in later animal studies.[20]

Extrusion can also be used for "orthodontic extraction" of hopeless teeth, with the goal of creating excess alveolar bone and marginal soft tissue to optimally counteract and compensate for postextraction defects. In this context, *Salama* and *Salama*[21] proposed that 4 to 6 weeks of active extrusion should be followed by 6 weeks of stabilization prior to extraction of the tooth. It is important to remember that, instead of creating new attachment, orthodontic extrusion only results in coronal repositioning of the existing attachment. Because the buccal gingiva moves about 80% of the total extruded distance[17] while the position of the mucogingival junction remains unchanged,[17,22] it is assumed that orthodontic extrusion increases the clinical crown length of the affected teeth by about 20% of the extrusion distance and widens the keratinized gingiva. Unfortunately, there is no scientific evidence of the efficacy of orthodontic extrusion prior to tooth extraction. Appropriate case selection and proper execution of orthodontic extrusion seem to be critical factors.

To achieve maximal coronal movement of the bone and gingival margin, *low traction forces* should be used for extrusion. The application of *intermittent forces* seems to have an additional positive effect on the coronal movement and maturation of marginal bone. Good results have been achieved with orthodontic wires designed for movement in 1-mm increments. The wires are active for about 2 weeks on average. After becoming inactive, the old wire is left in place for another 2 weeks before a new wire is inserted.

In contrast to the method described by *Salama* and *Salama*,[21] the application of light, intermittent forces produces only about 1 mm of movement per month. It is important to extrude the affected teeth as far as possible. The greater the *overcompensation* achieved, the better the prognosis for subsequent alveolar ridge preservation measures.

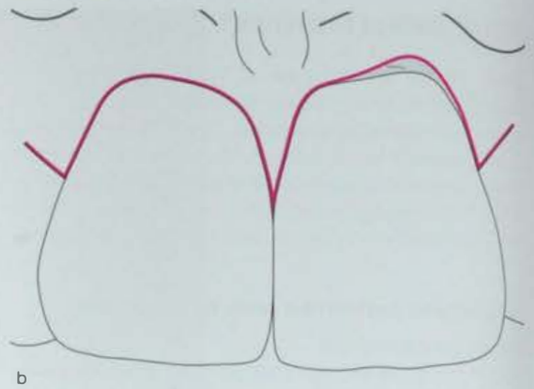
As already explained, orthodontic extrusion stretches the collagen fibers in the marginal gingiva of the affected teeth. Once orthodontic tooth movement is completed, the stretched fibers must be allowed *sufficient time for readaptation and stabilization*. Failure to do so could lead to retraction of the fibers, causing the tooth, surrounding alveolar bone, and marginal soft tissues to shift back apically to their original position.[23] This could induce the fiber apparatus to detach from the teeth, resulting in a loss of anchorage of the marginal periodontium at the postextrusion position. Currently, it is unclear exactly how long the recommended stabilization period should be, but, generally, the longer the stabilization period, the better (Fig 12-4).

Clinical experience has shown that the effect of orthodontic extrusion before tooth extraction is clinically relevant only if the procedure is performed correctly and if sufficient time is allowed for stabilization of the soft tissues before the planned extraction. In view of the high treatment cost and effort, the indication for orthodontic extraction should be carefully considered. As scientific evidence is scarce, this decision must be based on clinical experience. Orthodontic extrusion prior to extraction is mainly employed for treatment of periodontally healthy teeth. The procedure has not proved effective at sites with periodontal disease because the effect is too low and the outcome too unpredictable.

The case presented in Fig 12-5 illustrates the defect prevention potential of orthodontic extrusion performed before extraction.

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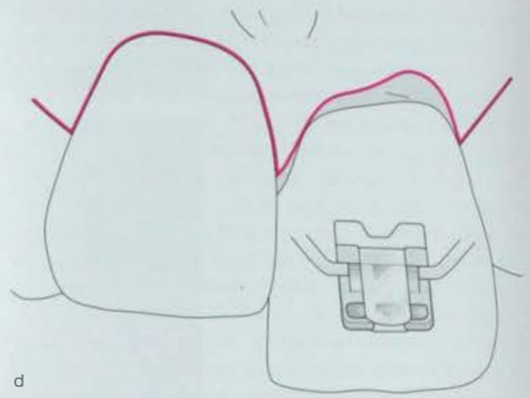


Fig 12-4 (a to d) Clinical example of orthodontic extraction. The maxillary left central incisor is shown before (a) and after orthodontic extrusion and immediately before extraction (c). Ideally, the resulting excess hard and soft tissue should counteract and compensate for the defect expected to form after extraction.





Fig 12-5 (a and b) The maxillary left central incisor is classified as hopeless because of a longitudinal fracture.





Fig 12-5 (c and d) Orthodontic extrusion was started after a new provisional restoration had been fabricated and placed. Light, intermittent forces were applied via a fixed appliance. During the period of active extrusion (approximately 6 months), incisal shortening of the provisional restoration was performed at regular intervals. Active extrusion was followed by an 8-month stabilization period. The tooth is shown after completion of orthodontic extrusion, immediately prior to tooth extraction and immediate implant placement and provisionalization.

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Fig 12-5e Result 1 week after surgery, just after suture removal.













Fig 12-5 (f to k) Clinical situation before and after placement of the definitive restoration. Preliminary orthodontic extrusion prior to tooth extraction has largely compensated for postextraction tissue shrinkage. The implant-supported restoration consists of an all-ceramic crown on a zirconia abutment. A ceramic veneer has been placed on the right central incisor.

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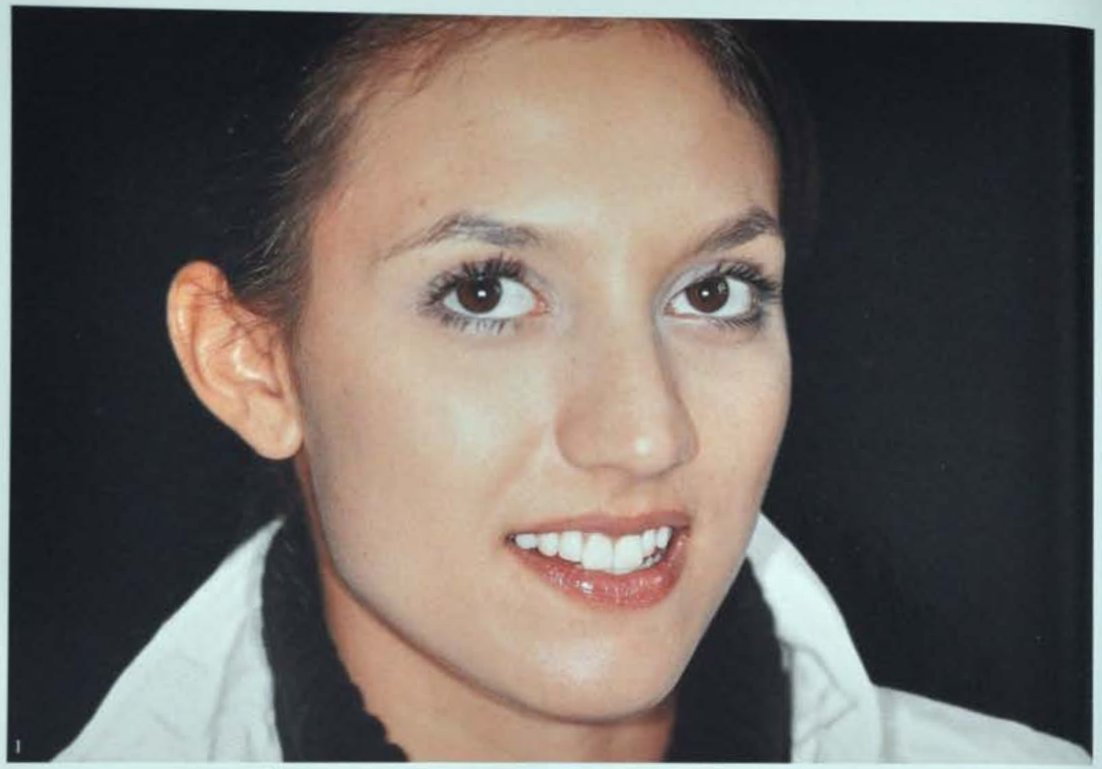


Fig 12-5l Patient after the completion of treatment. (Dental technician: *Uli Schoberer,* Seehausen, Germany.)

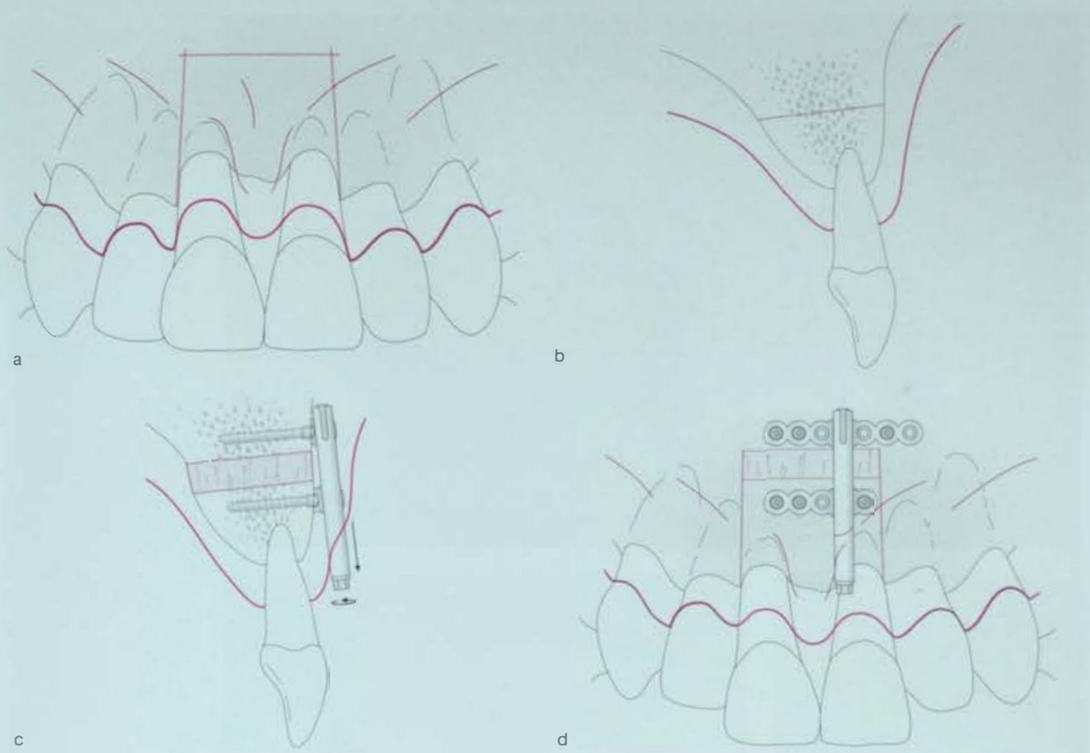


Fig 12-6 (a to d) In distraction osteogenesis for defect prevention, the surrounding bone is mobilized and the distractor is individualized and placed. Coronal movement of the teeth and surrounding tissues is achieved by turning of the distraction screw.

Distraction osteogenesis and sandwich osteotomy

Distraction osteogenesis and sandwich osteotomy involve mobilization and then coronal repositioning of teeth and their surrounding tissues, whereas orthodontic extrusion involves a gradual coronal repositioning of teeth and their surrounding tissues without mobilization of segments of bone. As in orthodontic extrusion, the goal of distraction osteogenesis and sandwich osteotomy is to create excess soft and hard tissue to compensate for defects that form after extraction.

Distraction osteogenesis, also referred to as *callus distraction*, is based on the principle of secondary wound healing. The bone is fractured, yielding a bone fragment that is gradually moved away from the base, allowing callus and, ultimately, new bone to form in the gap. To ensure adequate nutrition to the site, the periosteum is only partly elevated from the bone fragment.

Distraction osteogenesis was first proposed by *Ilizarov*[24] in 1971. It has since proved to be a safe and predictable procedure for lengthening the long bones of the body.[25–27] The first attempts to apply the principle of distraction osteogenesis for vertical callus distraction in maxillofacial surgery were started more than a decade ago,[28–30] and a number of different distraction systems for correction of mandibular alveolar ridge atrophy and for correction of localized defects of the mandibular and maxillary alveolar ridge have since been proposed.[31–33] Distraction osteogenesis does not require the harvesting of donor bone, the closure of a donor site, or a second surgery to correct the mucogingival junction. Therefore, it is associated with less postoperative morbidity and fewer complications than other augmentation procedures[34,35] (Fig 12-6). Despite the undeniably great potential of the procedure, controlled long-term studies have shown that vertical callus distraction still results in bone resorption, though admittedly less extensive than that after other augmentation procedures.[34–37] Another disadvantage is that distraction osteogenesis primarily allows only vertical augmentation. Consequently, the procedure must be performed in combination with autogenous bone grafting and guided bone regeneration for correction of combined vertical and horizontal alveolar defects.

To increase the acceptance of distraction osteogenesis by both patients and clinicians, the technical feasibility and equipment capabilities of the procedure need to be improved significantly. The main technical challenge for the clinician is to achieve correct three-dimensional orientation, adaptation, and fixation of the distractor without the need for adjustments after wound closure. Because the distracted bone fragment must remain pedicled to the tough and rather unyielding palatal mucosa during verticalization, special precautions must be taken to prevent palatal tipping of the fragment, especially in the maxillary anterior region. The extra-alveolar location of the distractor is the main drawback for the patient.

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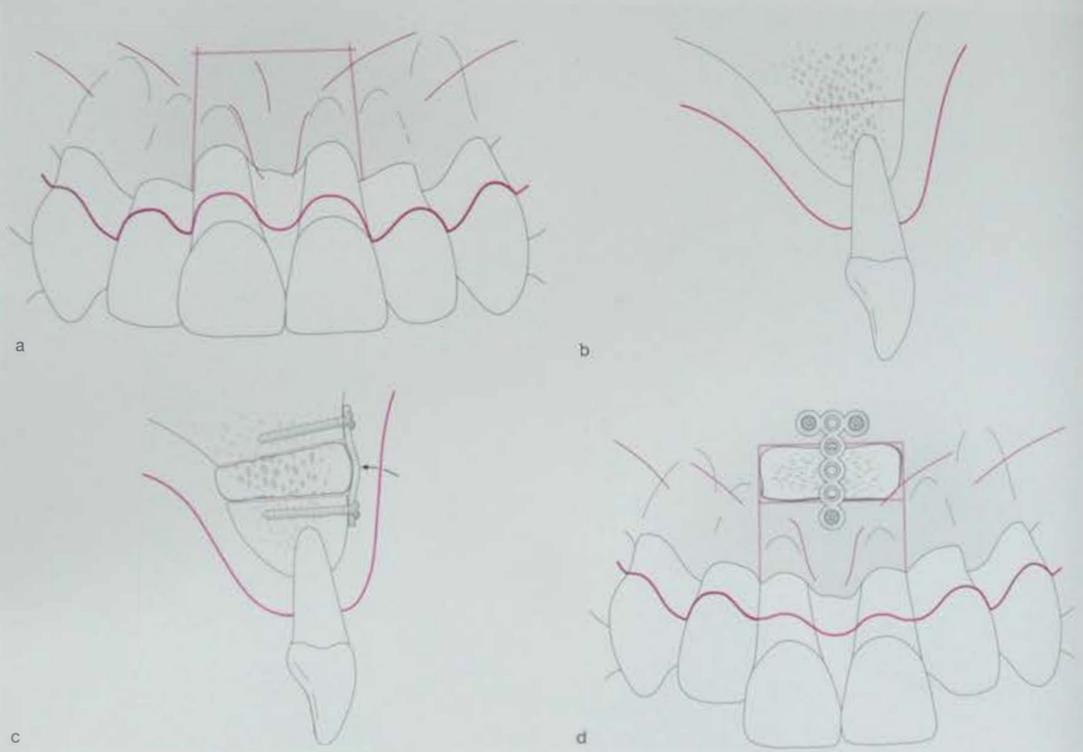


Fig 12-7 (a to d) In sandwich osteotomy for defect prevention, the mobilized bone fragment is fixed in the desired position using osteosynthesis plates, and the gaps are filled with autogenous bone.

Sandwich osteotomy has become an increasingly popular alternative to distraction osteogenesis for the aforementioned reasons.[38] In sandwich osteotomy, the mobilized bone fragment is fixed in the desired position with osteosynthesis plates, and the gaps are filled with autogenous bone. Sandwich osteotomy is easier to perform and does not require an extra-alveolar distractor. However, the relative tough and inelastic nature of palatal mucosa limits the potential of sandwich osteotomy, particularly at sites in the maxillary anterior region. It is not possible to accomplish more than 5 mm of vertical augmentation,[39] and, in most cases, only a very small amount of horizontal augmentation is possible. The long-term stability of sandwich osteotomy appears to be comparable to that of distraction osteogenesis[38,39] (Fig 12-7).

Vertical alveolar ridge distraction or sandwich osteotomy can compensate for postextraction defects to a certain degree.[40] However, as in orthodontic extrusion, adequate overcorrection is needed. Tooth extraction and alveolar ridge preservation procedures can be started 3 months after sandwich osteotomy. In the case of distraction osteogenesis, verticalization of the bone fragment cannot be started until at least 1 week after placement of the distractor. Daily rotation of the distraction screw is performed by the patient. Approximately 1 mm of distraction per day can be accomplished. Most distractors permit 8 to 10 mm of verticalization. Extraction and alveolar ridge preservation procedures can be started 3 months after the bone fragment has reached its final position.[32,41,42]



Fig 12-8 (a to c) Both maxillary central incisors are unsalvageable because of poor periodontal conditions.

Key points:

Distraction osteogenesis and sandwich osteotomy prior to tooth extraction are very effective measures to prevent postextraction defects. However, they cannot be recommended as routine procedures at present because of the limitations on horizontal augmentation and the technical complexity and cost of the procedures.

A case illustrating the potential of distraction osteogenesis for prevention of postextraction defects is presented in Fig 12-8.

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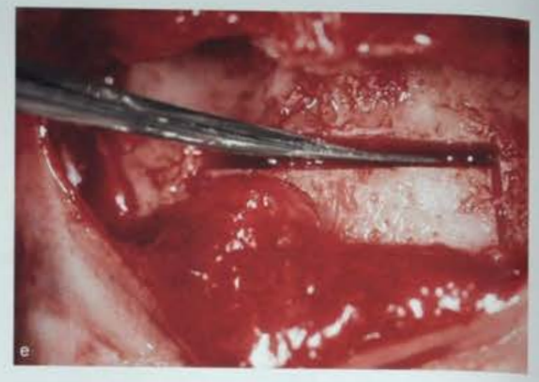






Fig 12-8 (d to g) First, the two unsalvageable teeth undergo coronal amputation (d) and endodontic treatment. Next, the bone fragment is mobilized (e) and a distractor is placed (f). The extra-alveolar distractor is shown immediately after surgery (g).





Fig 12-8 (h and i) Distraction is started 1 week after placement of the distractor. The patient is given clear instructions on how to perform distraction. A significant amount of vertical tissue has been gained 10 days later (i), after completion of distraction.









Fig 12-8 (j to m) The teeth are extracted after a 3-month stabilization period. Immediate implant surgery with immediate provisionalization is performed after alveolar ridge preservation.

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Fig 12-8 (n to p) Results after placement of the definitive restorations. The distraction osteogenesis performed at the time of extraction has successfully compensated for postextraction tissue shrinkage. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)



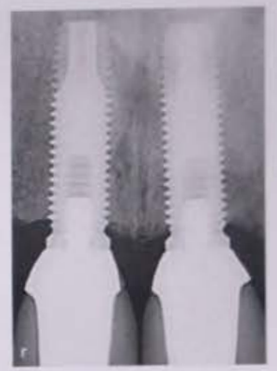


Fig 12-8 (q and r) The tissue loss is minor at the 10-year recall visit.

Atraumatic extraction

The extraction of teeth with minimal trauma to the surrounding bone and soft tissues has a positive effect on postextraction defect formation.[43] Atraumatic tooth extraction starts with the use of a microblade to cut all periodontal ligament fibers accessible via an intrasulcular incision (Fig 12-9). Depending on how tightly the tooth is anchored, it may then be possible to use extraction forceps to pull the tooth out of the socket with axial force. Care should be taken not to damage the marginal soft tissues with the forceps. As the tooth moves in the coronal direction, the space between the tooth and the socket widens. This allows deeper insertion of the tip of the microblade to sharply dissect more apical periodontal ligament fibers in the socket, thus facilitating apical tooth extraction. Luxation movements should be avoided.

If resistance to axial extraction is too great, the crown should be amputated and the root stump sectioned bucco-orally with a carbide bur. To protect the alveolar bone, it is important to preserve the surface integrity of the root, especially on the buccal aspect. A desmotome is then inserted in the groove and rotated to create a longitudinal fracture in the root without injuring the bony alveolus. Next, the desmotome is inserted in the periodontal ligament space from the palatal aspect and used to pry each half of the root stump out of the socket. The remaining periodontal ligament fibers can be cut with the microblade to facilitate atraumatic removal of the root fragments.

All marginal and apical granulation tissues are carefully debrided. However, it is not necessary to remove the periodontal ligament fibers remaining on the alveolar wall.[44]

Blood normally fills the alveolus at this point. If this does not occur because of the age of the defect, the palatal alveolar wall should be carefully perforated with a carbide bur to induce adequate bleeding.

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Fig 12-9 (a to c) In atraumatic tooth extraction, a microblade is used first to cut all supra-alveolar fibers accessible via an intrasulcular incision.



Fig 12-9d Next, an attempt can be made to use extraction forceps and axial force to pull the tooth out of the socket. Care should be taken not to damage the marginal soft tissues with the forceps. Luxation movements should be avoided.

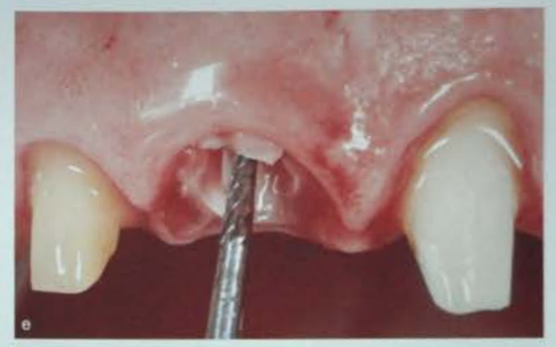


Fig 12-9e If resistance to axial extraction is too great, the crown should be amputated and the root stump sectioned in half bucco-orally. To protect the alveolar bone, especially on the buccal aspect, the external integrity of the root must be preserved in this region.









Fig 12-9 (f to i) First, a desmotome is inserted in the groove and rotated to create a longitudinal fracture in the root. Next, the desmotome is inserted in the periodontal ligament space from the palatal aspect and used to pry the two halves of the root stump out of the socket. All residual granulation tissue is carefully debrided, but it is not necessary to remove the periodontal fibers remaining on the alveolar wall.

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Fig 12-10 (a and b) The success of guided bone regeneration depends largely on whether closed healing is achieved without membrane exposure. In terms of soft tissue management, conditions for closed healing are unfavorable at the time of extraction—when guided bone regeneration is supposed to be performed for alveolar ridge preservation.

GBR → její úspěch je spojen s možností uzavřít ránu SA úplným překrytím membrány → proto není možná po extrakci zubu

Alveolar ridge preservation

Various alveolar ridge preservation procedures and combinations of different techniques have been described in the literature. The different approaches include suturing *mucosal grafts* to the soft tissue margin on the coronal aspect of the extraction socket, augmenting the buccal soft tissue around the extraction socket with *free subepithelial connective tissue grafts, filling the extraction socket with autogenous bone or bone graft replacement material*, and performing guided bone regeneration procedures. The use of *convex pontics* that project 2 to 3 mm into the extraction socket to provide soft tissue support has also been proposed. *Immediate implantation* is also said to play an important role in preserving the bone volume of the alveolar process.

This section summarizes the current methods of alveolar ridge preservation and discusses their potential to minimize the magnitude of postextraction defects and thus eliminate the need for augmentation surgery, which is particularly important in the esthetic zone.

Guided bone regeneration

Various studies have demonstrated the effectiveness d guided bone regeneration in preserving the vertical and horizontal dimensions of the alveolar ridge after tooth extraction. Both absorbable and nonabsorbable barrier membranes are used for this purpose.[45–50] In a clinical comparison study in 10 patients, *Lekovic* at al[50] demonstrated that extraction sockets covered with expanded polytetrafluoroethylene (PTFE) barrier membranes had significantly better ridge dimensions at 6 months postoperatively compared to uncovered control sockets. Their results also emphasized the importance of closed membrane healing: Although a special technique of flap mobi lization designed for tension-free primary approximation of the flap over the membrane-covered extraction socket was employed, membrane exposure occurred at 30% of the sites during the healing period. Dimensional changes in sockets with membrane exposure were similar to those of the uncovered control sockets. These findings were confirmed in later studies[47,48] (Fig 12-10).

Chen and *Dahlin*[51] proposed the use of free subepithelial connective tissue grafts obtained from the palate to cover the membrane and extraction socket in order to reduce the risk of membrane exposure after observing that this strategy prevented membrane exposure in 22 of 24 cases in their study.

The use of bone graft or bone substitute materials to fill the extraction socket before membrane placement is controversial. Some investigators have reported a positive effect.[52] while others have reported a negative effect.[53] There are also some investigators who noticed that the use of bone graft or bone substitute materials in sockets provided no effect on alveolar ridge dimensions.[46,48]

Although guided bone regeneration has a beneficial effect in the majority of cases, its use for alveolar ridge preservation is still the exception. Apart from the risk of postoperative membrane exposure, greater chairside time and costs are also important reasons for the lack of acceptance of guided bone regeneration. The need to wait for complete healing of bone before implant placement is another reason for clinicians to refrain from performing guided bone regeneration in an extraction socket. The minimum healing time between extraction and implantation is usually 6 months, which extends the overall treatment time considerably.

Socket filling procedures

Although the use of bone graft or bone substitute materials to fill extraction sockets has no advantage over guided bone regeneration in terms of the duration of treatment, it has distinct advantages in terms of the complexity and cost of treatment. Apart from case reports and animal studies, the results of which are very inconsistent, no clinical randomized controlled trials on this subject are available.[46,54–57]

In one animal study, *Fickl* and colleagues[58,59] made histologic and the first volumetric comparisons of three different postextraction socket filling procedures for alveolar ridge preservation. The investigators used deproteinized bovine bone mineral (DBBM) to fill the sockets in group 1. In group 2, a soft tissue punch harvested from the palate was used to seal the alveolus after DBBM placement using the method described by *Jung* et al[60] and adapted according to the socket seal procedure described by *Landsberg* and *Bichacho*.[61] In the control group (group 3), the untreated extraction socket was left to heal spontaneously. In group 4, the extraction socket was filled with DBBM and covered with a collagen membrane, and a convex pontic was later used to provide mechanical support to the marginal soft tissues. Volumetric measurements were obtained from cast models fabricated from impressions taken immediately before extraction and 2 and 4 months thereafter. Histologic tests were performed 4 months after extraction in all groups except group 4. It was concluded that none of the methods studied was able to prevent the resorption of buccal bone or the development of tissue defects following tooth extraction. Although groups 1 and 2 had similar tissue loss, the amount of tissue loss in these groups was significantly less than that in the control group, and the authors attributed this to the use of DBBM (Fig 12-11). Histologic studies have shown that, although the incorporation of DBBM in the extraction socket results in altered and, for the most part, delayed osseous healing, it is also able to compensate for the volumetric changes in the alveolar ridge after tooth extraction, at least to a certain extent.[44,62–65]

Key points:

Postextraction socket filling with DBBM leads to a reduction of tissue defects compared to spontaneous socket healing. However, the currently available procedures and materials do not allow for predictable, complete compensation for postextraction tissue shrinkage. The envelopment of parts of the filling material by connective tissue, especially on the coronal aspect, is a critical concern. If a fixed partial denture is subsequently used to close the edentulous space, this does not seem to have any negative consequences in cases where nonresorbable bone substitutes such as DBBM are used.

If an implant is to be used, clinical experience has shown that encapsulation of bone substitute materials by connective tissue is likely to occur, even after the bone has healed for at least 6 months. To ensure complete osseointegration of the implant, the encapsulated bone substitute material must be removed prior to implant insertion, which may make it necessary to perform additional augmentation at the time of implant placement. This prolongs treatment and results in a disproportionate increase in treatment cost and effort. Therefore, the use of bone substitutes for socket filling cannot be recommended as a means of alveolar ridge preservation prior to implant surgery at this time (Fig 12-12).

The alternative use of autologous bone particles to fill the extraction sockets failed to produce superior results in preliminary animal studies.[66] Therefore, that alternative does not seem to be justified at present because of the added stress of the additional surgical site needed for the harvesting of autologous bone.

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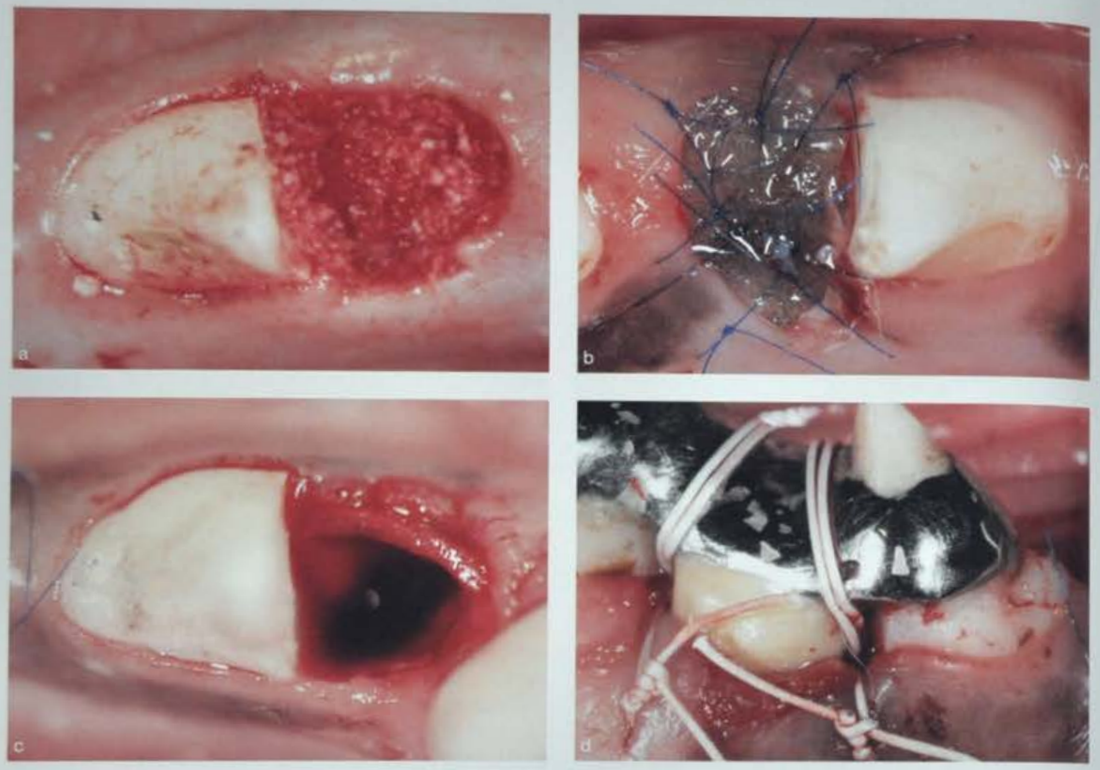
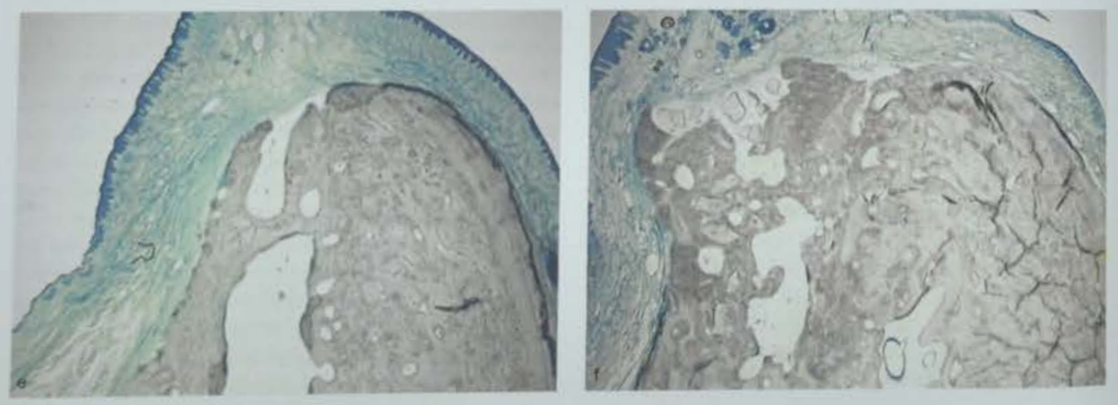


Fig 12-11 (a to d) Comparison of three alveolar ridge preservation procedures studied in animals. (a) Extraction sockets in group 1 were filled with DBBM. (b) Those in group 2 were filled with DBBM and covered with a soft tissue punch harvested from the palate. (c) In the control group (group 3), the untreated extraction sockets were left to heal spontaneously.[58] (d) In group 4, extraction sockets were filled with DBBM and covered with a collagen membrane, and a convex pontic was later used to provide mechanical support to the marginal soft tissues.



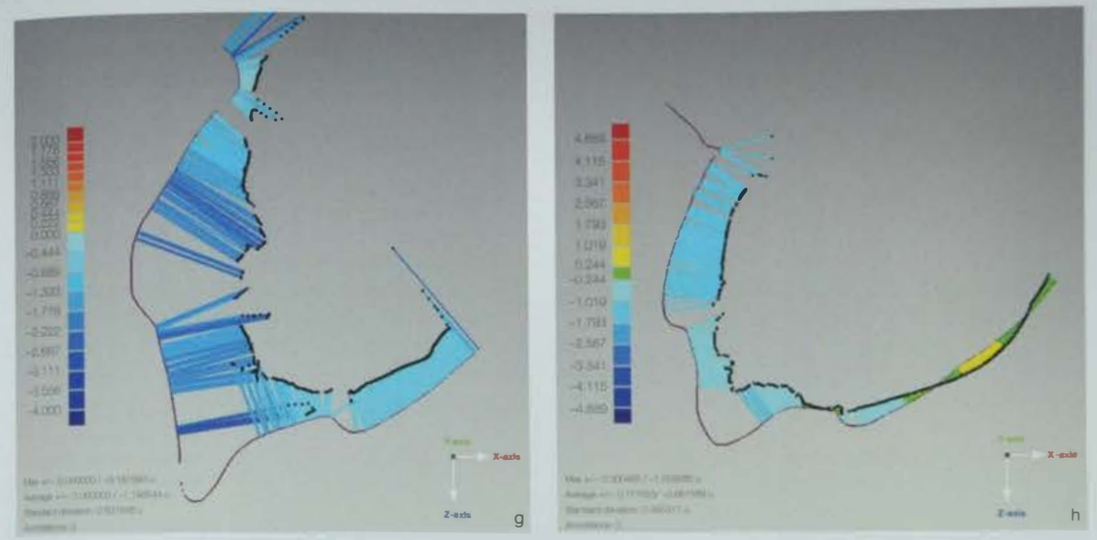


Fig 12-11 (e to h) Histologic sections from the control group (e) and group 2 (f). Bone healing as well as bone loss has occurred in the buccal bone plate (left) in both groups, but the loss of volume appears to be much lower in the test group. This difference in volume is clearly visible in examples from the control group (g) and group 2 (h). The outline of the alveolar ridge is shown before extraction (violet line) and 4 months after extraction (black line).[58,59]

Immediate implant placement

Besides shortening the duration of treatment, preserving the alveolar ridge is one of the primary goals of immediate implant placement. A number of studies have shown that immediate placement of implants in fresh extraction sockets yields a prognosis similar to that of implants placed in healed extraction sockets.[67–72] The presence of chronic periapical inflammation at the time of extraction does not appear to affect the probability of osseointegration after immediate implant placement.[73,74] However, there is evidence suggesting that the presence of periodontal disease does have a negative effect on the prognosis of immediate implants.[75,76]

Araújo et al[5] demonstrated in animals that the assumption of immediate implantation preserving the bony structures of the alveolar process was incorrect. Immediate placement of a threaded titanium implant neither prevented nor compensated for compact bone resorption at midbuccal sites. *Botticelli* et al[77] made similar observations in a clinical reentry study (Fig 12-13).

Various clinical trials have shown that soft tissue recession can also be expected after immediate implantation and loading of implants.[78–84] The magnitude of recession varied greatly in the different studies, suggesting that it is very hard to predict the behavior of the soft tissue after immediate implant placement.

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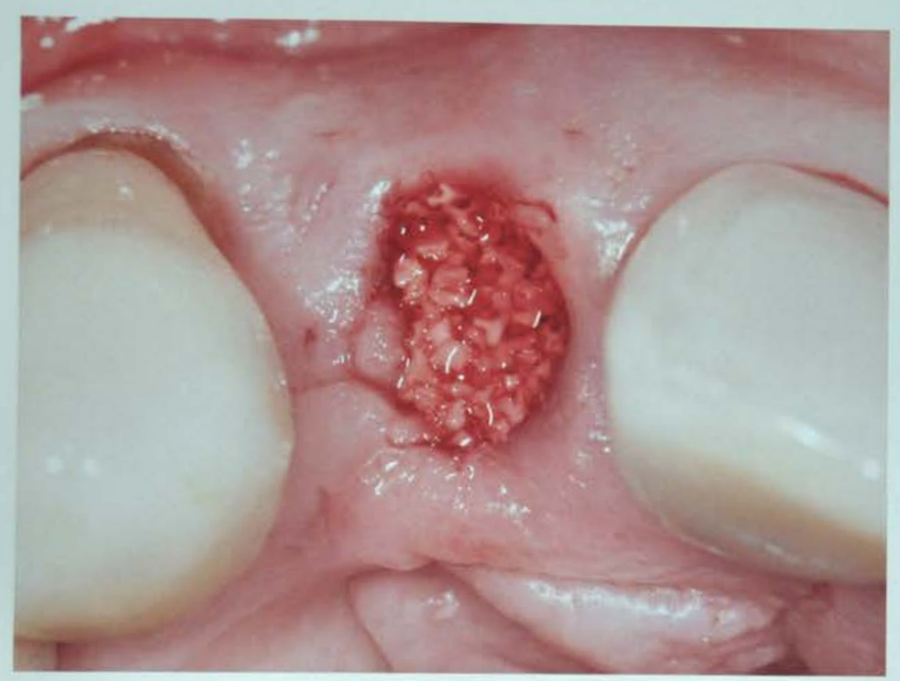


Fig 12-12 When socket filling procedures are used for alveolar ridge preservation, bone substitute materials are likely to be enveloped by connective tissue on the coronal aspect during the healing period. This is a major drawback for implant placement.

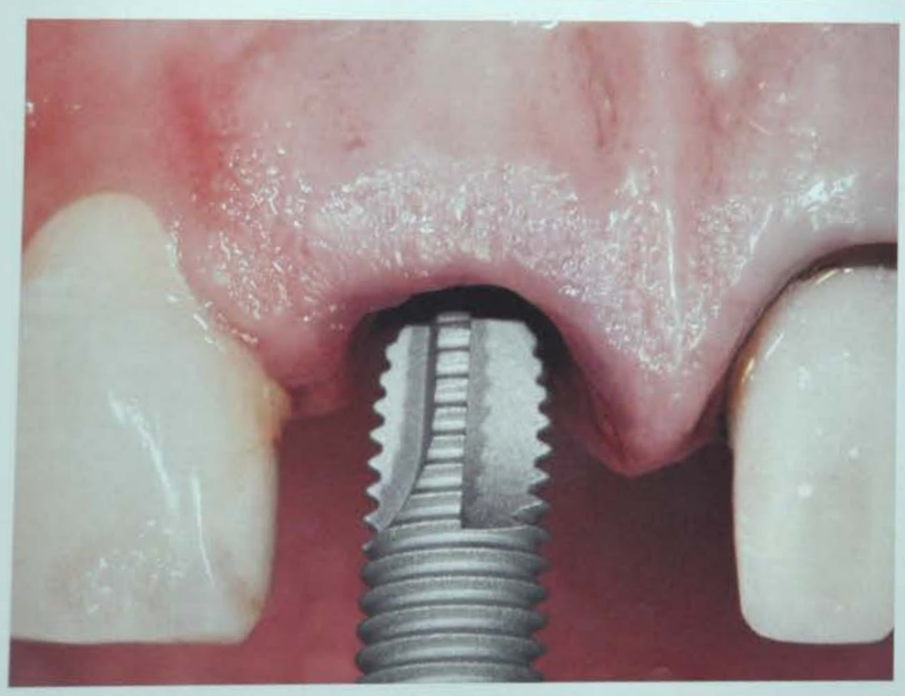


Fig 12-13 Immediate implant placement does not appear to be effective for alveolar ridge preservation. The placement of implants immediately after extraction does not preserve the alveolar bone dimensions.

Several authors raised the question of whether guided bone regeneration in combination with immediate implant placement could compensate for these resorptive processes.[67,85–89] However, the conditions for closed healing of membranes placed at the time of extraction are poor. A prospective multicenter study by *Becker* and colleagues[90] highlighted this problem. Membrane exposure occurred at 20 of 49 extraction sockets treated with guided bone regeneration in combination with immediate implant placement. All 20 exposed membranes had to be removed prematurely, whereas the 29 covered membranes remained in place until second-stage implant surgery. At that time, the horizontal gain in bone level was a mean of 4.8 mm at sites with covered membranes compared to a mean of 4.0 mm at those with exposed and prematurely removed membranes, and the mean number of exposed implant threads was 0.6 at sites with covered membranes and 2.6 at those with exposed and prematurely removed membranes.

In an animal study of immediate implantation with and without grafting of extraction sockets using DBBM, *Araújo* and coworkers[91] showed that filling the gaps between the implant and inner alveolar wall with DBBM has a positive effect on the thickness and vertical height of buccal bone 6 months after loading. However, clinical experience has shown that, in many cases, this effect is not able to achieve predictable success for immediately placed implants in the esthetic zone.

Retention of the buccal root fragment of the extracted tooth in combination with immediate implant placement could be a more promising strategy, provided that the periodontal tissues are healthy. In a proof-of-principle experiment for histologic analysis of partial root retention (socket shield technique) in combination with immediate implant placement, *Hürzeler* and colleagues[92] hemisected two mandibular premolars of a beagle dog and retained the buccal fragment of the distal root. The implant bed was prepared through the distal roots. In each case, the lateral and lingual fragments of the roots were removed and the buccal fragment of the root was retained. After enamel matrix derivative was applied to the inner surface of the retained buccal root fragment, an implant was placed lingual to the retained root fragment with direct contact to the retained root fragment in one case and with no contact in the other. The sites were left open to heal.

In the histologic evaluation performed 4 months later, newly formed acellular extrinsic fiber cementum with inserting periodontal ligament fibers was detected on the inner surface of the retained root fragment in both test groups. As described earlier, defects can normally be expected to form on the buccal aspect following tooth extraction regardless of whether extraction is performed with or without alveolar ridge preservation procedures. Therefore, the socket shield technique may be able to prevent resorption of the buccal bone plate and the associated loss of hard and soft tissues following tooth extraction (Figs 12-14 and 12-15).

Key points:

Immediate implant placement is not an alveolar ridge preservation measure per se. Furthermore, the use of immediate implants in combination with guided bone regeneration should be viewed critically because of the high risk of complications. The strategy of retaining the buccal root fragment of the extracted tooth in combination with immediate implant placement may prove to be an effective means of alveolar ridge preservation if the findings of animal studies can be confirmed in humans. The results of the first clinical study on this subject are very promising.[93] Long-term clinical studies are also needed to reliably exclude the potential for late complications of the socket shield technique.

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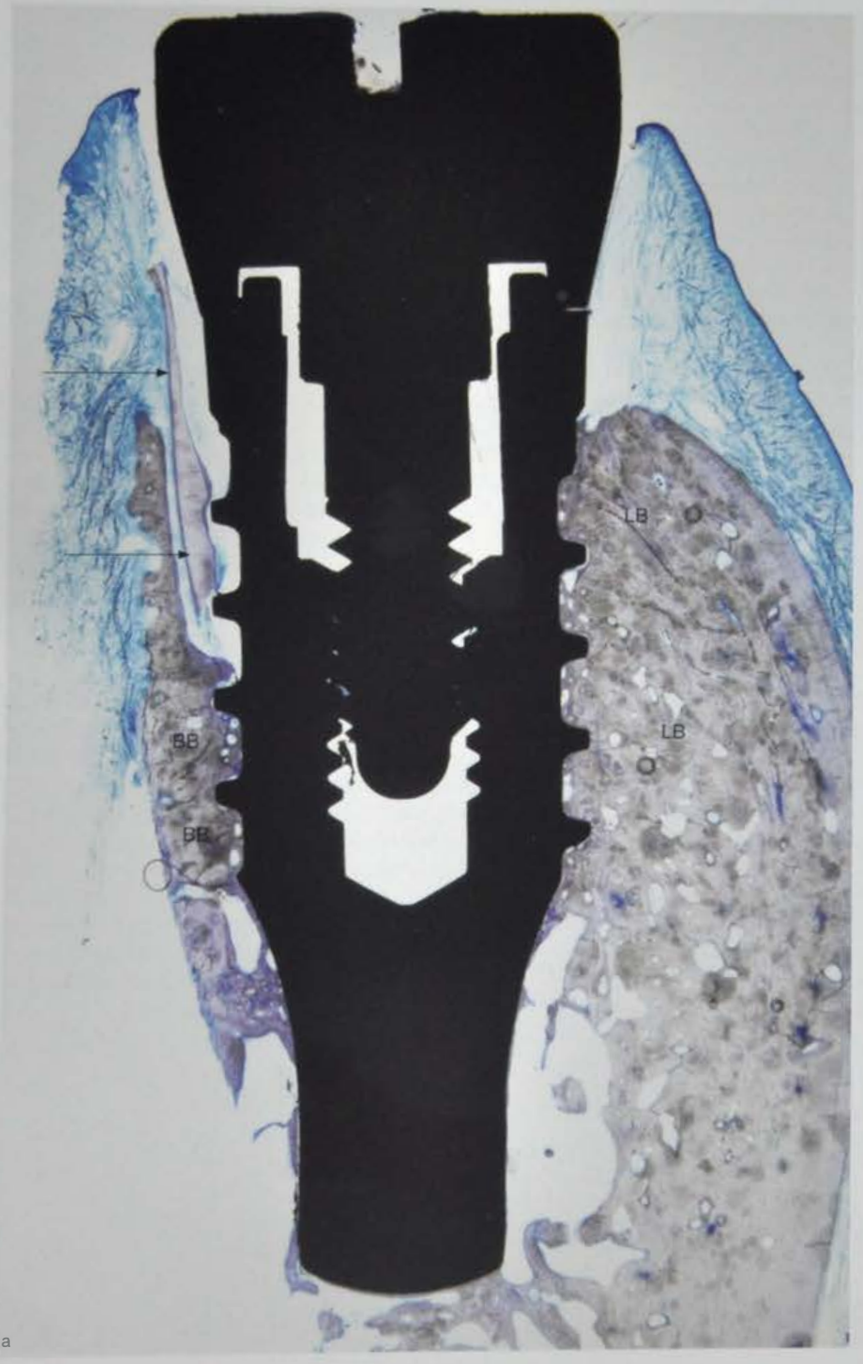
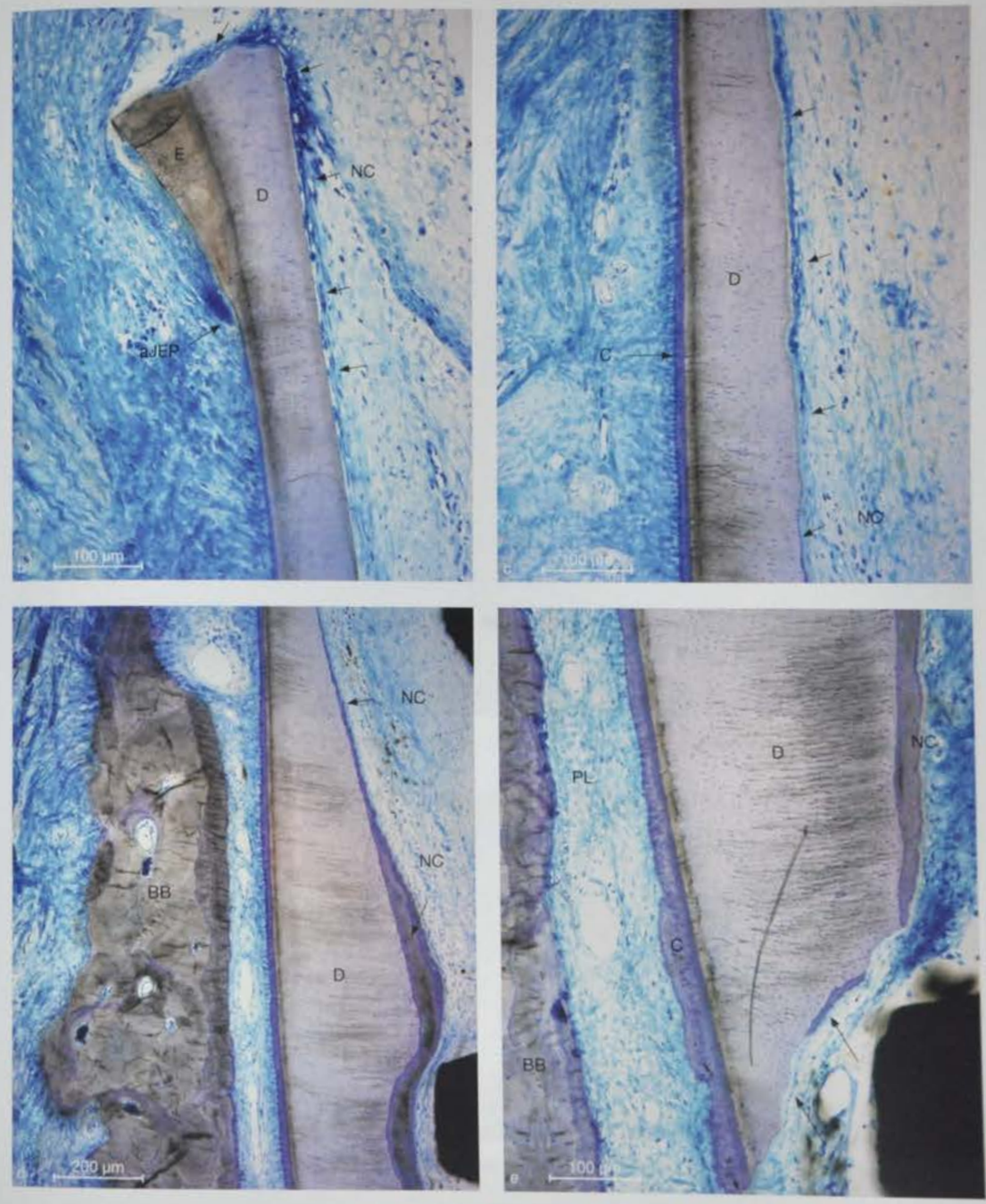


Fig 12-14 Histologic evaluation conducted 4 months after the socket shield technique (partial root retention) was performed in combination with immediate implant placement in a beagle dog. (a) View of the extraction socket where an implant was placed in direct contact with the retained buccal root fragment and left open to heal (b to e) Images of the inner surface of the retained root fragment. The buccal bone plate and overlying soft tissues appear to be fully preserved. The coronal margin is covered with junctional epithelium, and newly formed acellular extrinsic fiber cementum (arrows) with inserting periodontal ligament fibers can be seen along the entire inner wall up to the apical end of the retained root fragment. Here, the socket shield technique very effectively prevented the occurrence and late complications of bone resorption. E: enamel; D: dentin; C: cementum; BB: buccal bone plate; LB: lingual bone plate; aJEP: apical margin of junctional epithelium; NC: new cementum; PL: periodontal ligament. (Histologic testing: *Peter Schüpbach*, Zurich, Switzerland).[92]



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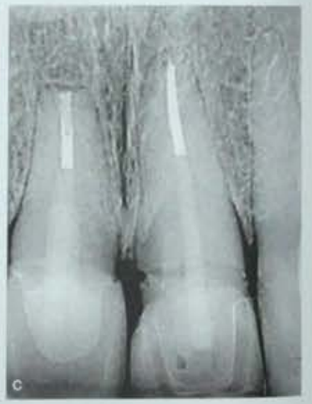


Fig 12-15 (a to c) Clinical example of the socket shield technique. The pretreatment clinical and radiographic images show a hopeless maxillary left central incisor with a vertical fracture.









Fig 12-15 (d to g) After removal of the clinical crown, the implant bed is prepared through the remaining root while the buccal root fragment is left intact.





Fig 12-15 (h and i) Enamel matrix derivative is applied to the inner aspect of the retained buccal root fragment, and the inner surface of the gingival margin is prepared with a rotating diamond.

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Fig 12-15 (j and k) Results immediately after placement of an implant-supported immediate provisional restoration.





Fig 12-15 (l and m) Results 1 week after surgery.





Fig 12-15 (n and o) Results 5 months after surgery and completion of healing.











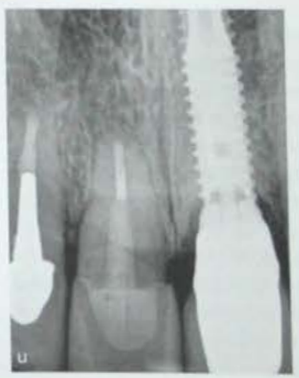


Fig 12-15 (p to u) Results after the completion of treatment. Retention of the buccal root fragment at the time of tooth extraction appears to have effectively prevented defect formation in the midbuccal region.

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Fig 12-15v Patient after the completion of treatment. (Dental technician: *Uli Werder*, Munich, Germany.)



Fig 12-16 Subepithelial connective tissue grafts from the palate or tuberosity region are often used for soft tissue augmentation in order to stabilize the soft tissue after extraction. However, the efficacy of this procedure as a method of alveolar ridge preservation cannot be definitively determined based on current scientific evidence.



Fig 12-17 Socket seal surgery is performed to create ideal soft tissue conditions in cases where delayed implant placement will be performed in combination with guided bone regeneration or where reconstruction of the alveolar ridge will be carried out in conjunction with fixed partial dentures.

Soft tissue augmentation

Many experts and clinicians support the concept of performing soft tissue augmentation on the buccal side of the extraction socket following tooth extraction in order to stabilize the soft tissues (see chapter 1) and compensate for the defects that form following tooth extraction. The *subepithelial connective tissue grafts* used for this purpose are normally harvested from the palate or the tuberosity area. Although the results of animal studies tend to question the efficacy of soft tissue augmentation as a means of alveolar ridge preservation,[94] the findings from clinical studies are promising. In a study comparing the stability of facial gingival tissue before and after placement of 20 single immediate implants in a consecutive series of patients, *Kan* et al[95] observed minimal recession defects and stable soft tissue conditions over a mean 2.15-year observation period at sites where buccal soft tissue augmentation was performed in conjunction with immediate implant placement. Nonetheless, further studies are needed to reliably determine the actual long-term efficacy and stability of soft tissue augmentation in combination with tooth extraction in the esthetic zone (Fig 12-16).

The use of thick *connective tissue grafts* from the palate or the tuberosity area to cover extraction sockets cannot completely compensate for the tissue defects that occur following tooth extraction.[58,59] Still, these alveolar ridge preservation procedures can be very beneficial if, at the time of extraction, it is already certain that delayed implant placement and/or augmentation will be performed at a later date. In this context, *Landsberg* and *Bichacho*[61] described a method of socket seal surgery (punch surgery) in which the extraction socket is filled with bone substitute material and covered with a thick free mucosal graft harvested from the palate to prevent ridge resorption and to enhance bone regeneration. They reported that, 6 to 8 weeks after surgery, soft tissue healing was complete and a closed soft tissue cover with a thick and mature mucosa had formed over the former extraction socket.

Although this method cannot completely compensate for the tissue shrinkage that occurs following tooth extraction, it optimally enhances the starting conditions for implantation in combination with soft tissue augmentation by improving the ability to achieve primary wound closure and closed healing of the implant and graft; the same applies to reconstruction of the alveolar ridge in combination with fixed partial dentures (see chapter 13). Because this is the time when postextraction defect formation is just starting, there probably will not be many large resorption defects associated with the extraction socket. Integration and color blending of the grafts into the natural surroundings appear to be acceptable from an esthetic point of view.[60] From a clinical perspective, supplementary filling of the extraction socket with bone substitute material does not appear to be necessary if it is known at the time of extraction that implantation will be delayed (Fig 12-17).

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Mechanical soft tissue support

Prestipino et al[96] proposed an alveolar ridge preservation concept in which an external gingival support splint is used to provide immediate support to the coronal soft tissue margin of the extraction socket. In the context of immediate implant placement, immediate soft tissue support can be achieved using removable provisional restorations, provisional fixed partial dentures, or immediate provisional restorations. For adequate stabilization of the soft tissues, it is important to ensure that the crown and root contours of the provisional restorations largely duplicate those of the extracted teeth.

Clinical experience has shown that recession may still occur on the buccal aspect of the affected tooth and that horizontal tissue loss can be expected to occur midbuccally and at the base of the adjacent papilla when this approach is used. However, mechanical support makes it possible to stabilize the papillae at their original vertical position in many cases because the height of the dentogingival complex in the interproximal region appears to be dependent on the support by the adjacent teeth (see chapter 1).

There is scientific evidence backing this clinical observation. Studies have shown that the maximum distance between the crest of bone and the most coronal papilla level (interproximal soft tissue height) is approximately 4 mm around single-tooth implants inserted with a multistage approach.[97,98] When a single-stage approach is used, the loss of interproximal soft tissue height is slight compared to preimplantation levels.[79] These findings suggest that immediate mechanical soft tissue support following tooth extraction could be useful, particularly in patients with triangular tooth shapes and high gingival scallop, because the maximum interproximal soft tissue height otherwise achieved (4 mm) probably will not suffice to achieve a good cosmetic outcome in these cases (see chapter 1) (Fig 12-18).

Advantages and disadvantages of the different methods of alveolar ridge preservation are summarized in Table 12-1.

12.1.3 Classification for Hopeless Teeth

The need for alveolar ridge preservation or defect reconstruction must be known at the time of tooth extraction in order to select an appropriate alveolar ridge management procedure. It is often difficult to impossible to predict whether a ridge preservation procedure designed for *single-stage surgery* can produce the desired effect. This fact often influences the decision-making process when the clinician chooses between different procedures. From the patient's perspective, it would of course be ideal if a single defect prevention measure could completely compensate for postextraction tissue shrinkage, thus eliminating the need for second surgery for defect reconstruction.[79,99] Because of the previously discussed limitations of the available alveolar ridge preservation procedures, ideal starting conditions are needed to achieve this goal.

Clinical experience has shown that it is best to use a combination of different alveolar ridge preservation procedures. If the pretreatment conditions are not ideal, a *multistage approach* to defect reconstruction is needed to achieve a predictable treatment outcome, even though this places a greater burden on the patient. Socket seal surgery should be performed in these cases, regardless of whether an implant or fixed partial denture restoration is planned. Socket seal surgery results in greater treatment time and effort and a greater treatment burden for the patient but makes it possible to attain more predictable treatment results under non-ideal conditions.[100,101]

The decision to use a single-stage or multistage approach can be based on the following classification, which is based on the condition of the extraction sockets of hopeless teeth (Table 12-2):

Type 1: A *single tooth* must be extracted and the *buccal bone plate and interproximal bone* are largely intact.
A single or multistage approach can be used in this case. The predictability and chances of achieving an acceptable esthetic outcome are good, independent of the type of procedure selected. The prognosis will be even better if the tooth to be extracted has a square tooth shape and a flat gingival scallop instead of a triangular tooth shape and high gingival scallop. If a single-stage procedure is preferred, preliminary orthodontic treatment should be considered in patients without inflammation in order to improve the starting conditions for single-stage surgery.

Type 2: A *single tooth* must be extracted and the *interproximal bone* is largely intact, but the buccal bone plate is absent or *does not have adequate dimensions.*
If implant surgery is planned, the use of a multistage procedure is imperative. If a fixed partial denture is to be placed, a single-stage approach can be used because it is easier to make secondary corrections. The predictability and chances of achieving an acceptable cosmetic out-



Fig 12-18 Immediate mechanical soft tissue support following tooth extraction could be useful for papilla preservation, particularly in patients with high gingival scallop.

Table 12-1

Advantages and disadvantages of the different methods of alveolar ridge preservation

	Advantages	Disadvantages
Guided bone regeneration	• Predictable	• Increased treatment time • Increased number of interventions needed • Technically demanding and difficult • Risk of complications (membrane exposure) • Patient morbidity
Socket filling technique	• Simple and straightforward technique	• Increased treatment time • Increased number of interventions needed (for implants) • Lack of predictability
Immediate implant surgery	• Reduced treatment time • Reduced number of interventions needed	• No bone-preserving effect • Technically demanding and difficult
Soft tissue augmentation		
Socket seal surgery	• Reduced treatment time (compared to delayed implantation) • Ideal soft tissue conditions for subsequent augmentation	• Increased treatment time (compared to immediate implantation) • Increased number of interventions needed • Patient morbidity
Soft tissue augmentation	• Compensates for subsequently formed defects	• Lack of predictability • Patient morbidity
Mechanical support measures	• Papilla preservation in patients with high gingival scallop	• Lack of predictability

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Table 12-2

Alveolar ridge preservation procedures and their prognosis based on the classification of extraction socket morphology

	Socket morphology	FPD protocols	Implant protocols	Prognosis
Type 1	▪ Single-tooth extraction ▪ Buccal and interproximal bone intact	▪ Single- or two-stage ▪ If single-stage, orthodontic treatment possible	▪ Single- or two-stage ▪ If single-stage, orthodontic treatment possible	▪ Good
Type 2	▪ Single-tooth extraction ▪ Interproximal bone intact ▪ Insufficient buccal bone volume	▪ Single- or two-stage ▪ If single-stage, orthodontic treatment possible	▪ Two-stage ▪ Single-stage if Type 2 changes to Type 1 after orthodontic treatment	▪ Good
Type 3	▪ Single-tooth extraction ▪ Insufficient interproximal bone volume	▪ Two-stage	▪ Two-stage	▪ Moderate
Type 4	▪ Multiple adjacent teeth extracted ▪ Buccal and interproximal bone intact	▪ Two-stage ▪ Orthodontic treatment or DO/SO possible	▪ Two-stage ▪ Orthodontic treatment or DO/SO possible	▪ Moderate
Type 5	▪ Multiple adjacent teeth extracted ▪ Insufficient buccal and/or interproximal bone volume	▪ Two-stage ▪ DO/SO possible	▪ Two-stage ▪ DO/SO possible	▪ Poor

FPD: fixed partial denture; DO/SO: distraction osteogenesis/sandwich osteotomy.

come are good. In some cases, prior orthodontic extrusion can transform a Type 2 environment into a Type 1 socket. The treatment plan is then modified accordingly.

Type 3: A *single tooth* must be extracted and there are extraction *defects* in the *interproximal bone* at the time of extraction.
A multistage approach must be used, regardless of whether fixed partial denture or implant restoration is planned. Depending on the magnitude of interproximal bone loss, predictable achievement of a good cosmetic outcome is not possible in Type 3 cases. Preliminary orthodontic extrusion is not advised, especially if inflammation is present. Vertical callus distraction or sandwich osteotomy for correction of single-tooth diastemas may be possible in some patients.

Type 4: Multiple teeth must be extracted and the *interproximal bone and buccal bone plate are largely intact.*
A multistage approach must be used, regardless of which type of restoration is planned. Predictable achievement of a pseudopapilla between the missing teeth is not possible, regardless of which procedure is used. Preliminary orthodontic extrusion, vertical callus distraction, or sandwich osteotomy can be considered, but this does not eliminate the need for a multistage approach.

Type 5: Multiple teeth must be extracted and there are *defects in the buccal bone plate and/or interproximal bone.*
A multistage approach is imperative. Predictable achievement of an acceptable cosmetic outcome is not possible. Preliminary orthodontic extrusion is not recommended. Vertical callus distraction or sandwich osteotomy can be considered, but this does not eliminate the need for a multistage approach.

12.1.4 Clinical Aspects of Alveolar Ridge Preservation

Alveolar ridge preservation in implant therapy

The cosmetic challenge of placing implants in the esthetic zone is no different from that of placing tooth-supported fixed partial dentures in the esthetic zone. The goal is to fabricate an implant-supported crown that is surrounded by soft tissues, mimicking the conditions in healthy natural teeth. However, the impact of the hard and soft tissues on the treatment outcome is greater for implants than for fixed partial dentures because complete osseointegration is always the primary biologic goal of implant therapy. Exposure of the implant to the oral cavity normally sets off remodeling and adaptation processes that affect the peri-implant bone (see chapter 1). To permit the formation of the biologic width while minimizing vertical bone loss around an implant, the implant must be completely covered and surrounded by an adequate thickness of peri-implant bone.[102] This goal is hardest to accomplish on the buccal aspect of implants because of the thinness of the buccal bone plate and the aforementioned remodeling processes (see chapter 13).
A controlled clinical reentry study by *Ferrus* and coworkers[103] demonstrated that the formation of buccal defects around immediate implants is influenced not only by the horizontal dimension of the gap between the implant and the internal socket wall but also by the thickness of the buccal bone plate. Animal study findings have suggested that a minimum buccal alveolar bone thickness of 2 mm is necessary to maintain a stable vertical and horizontal dimension of the vestibular bone plate after immediate implant placement.[104] Clinical and radiographic studies have shown, however, that the buccal bone plate in the maxillary anterior region rarely has a width of 2 mm or more. In a controlled clinical study of socket bone wall dimensions in the upper maxilla in relation to immediate implant placement, *Huynh-Ba* and coworkers[105] observed a mean buccal bony wall thickness greater than 1 mm at only 13% of the maxillary anterior sites and at only 41% of the maxillary premolar sites. In a radiographic study, *Braut* and coworkers[106] found that only 11.4% of sites in the maxillary anterior and premolar regions had a facial bone wall with a minimum thickness of 1 mm.

Single-stage approach

Single-stage implant surgery should ideally be performed as a flapless procedure combining hard and soft tissue augmentation with immediate implant provisionalization as needed. Many clinicians consider the single-stage approach the method of choice because it reduces treatment time, cost, and effort while enhancing patient comfort.[14,79] Single-stage implant surgery has distinct advantages over a multistage approach in terms of the previously mentioned esthetic parameters, particularly those relating to the interproximal soft tissues. As for scar formation, it also produces superior postoperative tissue quality because little surgical manipulation of the marginal gingiva and interdental soft tissues is necessary.
The main disadvantage of single-stage surgery is the frequent occurrence of horizontal and vertical defects, particularly in the midbuccal soft tissue.[107] These alterations often manifest as soft tissue recessions and appear to be more pronounced in individuals with thin gingival biotypes. If a fixed partial denture is to be placed in a single-stage approach but the ridge preservation effort has not completely achieved the desired effect, an attempt can be made to either surgically eliminate the tissue defect in a second surgery or to prosthetically mask the defect. Such corrections are more difficult to accomplish when implant placement is planned. The decision to perform single-stage implant surgery must be carefully considered in these cases because of the poor predictability of peri-implant recession coverage (see chapter 9). Furthermore, the unalterable position of the implant shoulder can complicate prosthetic treatment when unforeseen defects occur (Fig 12-19).
When implant surgery is to be performed in a single-stage approach, flapless immediate implant placement is preferred because it prevents additional bone resorption from the exterior.[8,10–13] Correct three-dimensional positioning of the implant is crucial for a successful cosmetic outcome (see chapter 13). Because flapless implant placement means that visibility is limited, total or partial computer-guided implant positioning is strongly advised, even for experienced surgeons (Fig 12-20).
When the use of a single-stage approach is considered, it is important to remember that a sufficiently high insertion torque is needed to achieve good primary stability of the implant.

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Fig 12-19 (a to j) Clinical situation before and 6 months after immediate implant placement and provisionalization. Horizontal tissue loss in the midbuccal region is pronounced. The decision to perform single-stage implant surgery must be carefully considered because secondary surgical correction of these defects is difficult and unpredictable.

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Fig 12-20 (a and b) Because flapless implant placement means that visibility is limited, total or partial computer-guided implant positioning is strongly advised.

Because of the difference in implant and socket diameter, a gap remains between the implant and the socket wall. Animal studies and human histologic studies have shown that gaps wider than approximately 2 mm must be filled with bone substitute or autogenous bone to obtain complete osseointegration.[108–114] From an esthetic perspective, it is important to consider that gaps on the buccal side close via new bone formation and marked bone resorption from the exterior.[77] Thus, it can be assumed that the extent of resorption can be reduced by using nonresorbable bone substitute material to fill these spaces.

Araújo and coworkers[91] demonstrated in animals that immediate placement of implants with and without the use of DBBM to fill the gaps between the implant and inner alveolar wall resulted in major differences in terms of bone resorption. Six months after immediate implant placement, the sites treated without DBBM had a thin buccal bone plate, the margins of which were far apical to the implant shoulder, whereas the majority of sites treated with DBBM had thick buccal bone that extended coronally up to the implant shoulder area. For this reason, it is advisable to fill the gaps with a nonresorbable bone substitute when immediate implant surgery is performed in the esthetic zone. The filling forms a stable layer of bone on the buccal side of the implant, which protects against resorption and stabilizes the soft tissues (Fig 12-21).

As explained, the development of recession defects is associated with the thickness of the buccal soft tissue around natural teeth as well as implants. In order to exhaust all options for defect prevention and compensation, it is advisable to augment the buccal soft tissue when a single-stage approach is used. The modified tunnel technique is especially well suited for this purpose because it is executed without vertical tension-releasing incisions, which ensures optimal nutrition to the grafts and prevents scarring (see chapter 8). The modified tunnel technique also permits augmentation of the papillæ of the adjacent teeth (Fig 12-22).

The extent of vertical bone loss associated with the formation of the biologic width appears to be dependent on a number of different factors, including the type of abutment material used and the frequency of change of prosthetic components (see chapter 1). For optimal alveolar ridge preservation, it would be ideal if the definitive implant abutment had a perfect emergence profile at the time of extraction and immediate implantation. This goal cannot be met with adequate precision using the currently available titanium and zirconia abutments. The utilization of composite resin provisional restorations and a certain number of component changes is unavoidable at the present time (see chapter 13).

Mechanical soft tissue support must be ensured, even when single-stage implant surgery is performed. Immediate provisionalization of implants is an ideal solution because it enhances patient comfort and reduces treatment times. *Immediate provisionalization* is defined as the insertion of a tooth replacement without static or dynamic occlusal contact up to 48 hours after implant placement.[115] Immediate provisionalization is contro-



Fig 12-21 (a and b) For optimal defect prevention, it is advisable to use a nonresorbable bone substitute to fill the gaps between the implant and the socket wall.



Fig 12-22 Soft tissue augmentation with subepithelial connective tissue grafts obtained from the palate or tuberosity has proved effective in stabilizing the marginal soft tissues on the buccal aspect of implants.

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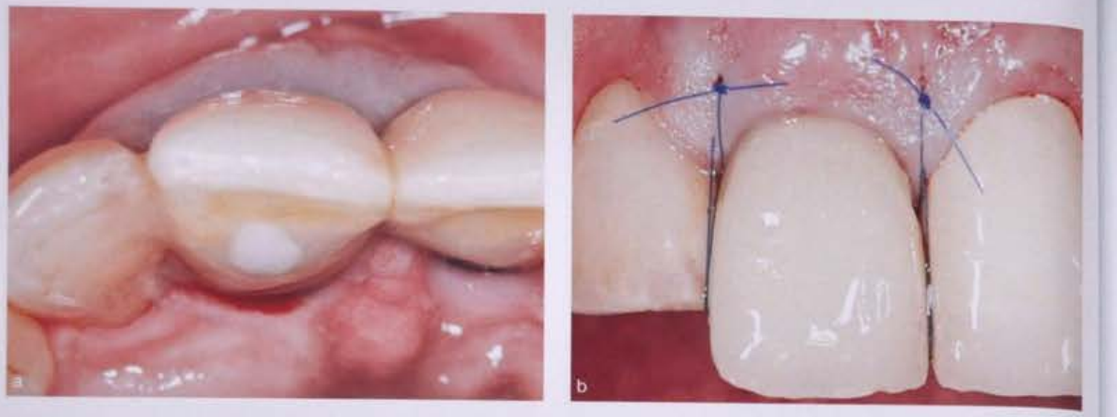


Fig 12-23 (a and b) Immediate provisionalization of implants is an ideal means of providing immediate prosthetic support for peri-implant soft tissues, even with single-stage implant placement.

versial in the literature. Some investigators achieved high success rates comparable to those of traditional protocols,[79,81,116] while others reported failure rates as high as 30%.[117]

Strict case selection, good primary stability of the implant, and the absence of direct contact in static and dynamic occlusion appear to be crucial for the success of immediate provisionalization.[79,81,116] Relief of interproximal contact point pressure is also important for the prevention of micromovement. Last, but not least, it is essential to give the patient complete and comprehensive postoperative instructions and to recommend a nightguard for patients who grind their teeth (Fig 12-23).

Where immediate provisionalization of the implants is not possible, provisional fixed partial dentures are used to support the soft tissues following alveolar ridge preservation procedures for single-stage implant placement. Conventional provisional fixed partial dentures as well as adhesive fixed partial dentures or removable prostheses can be used. This dictates a need for additional treatment steps, eg, implant uncovering and transformation of the individually formed pontic into an implant-supported provisional restoration. Fabrication of the definitive tooth replacement can be started 5 months after implantation and immediate provisionalization or 3 months after uncovering the implant. It is important to ensure that the profile of the implant-supported provisional below the soft tissue is precisely transferred to the definitive ceramic abutment (see chapter 13).

Multistage approach

Hopeless teeth may require multistage implant placement, starting with socket seal surgery, the goal of which is to optimize soft tissue conditions for implantation and augmentation (guided bone regeneration), which is generally scheduled 6 to 8 weeks later. *Tal*[118] reported an increased frequency of necrosis of soft tissue grafts at sites treated by socket seal surgery. To minimize the risk of necrosis, the grafts should be harvested with maximum thickness and inserted as deeply as possible in the extraction socket. To improve healing, a microblade or rough diamond bur should be used to de-epithelialize the inner surface of the soft tissue cuff around the extraction socket to create a bleeding bed for the graft. To shorten the diffusion path, it is necessary to harvest the graft so that it matches the shape of the extraction socket. Stable primary suture closure is essential.[60] The filling of extraction sockets with bone substitute materials does not appear to be absolutely necessary because the materials would not be osseointegrated 6 to 8 weeks later and would have to be removed during implantation. After completion of the socket seal procedure, the provisional restoration must be adapted so that its base is only lightly touching the augmented area to ensure uncomplicated healing (Fig 12-24).



Fig 12-24 (a and b) Stable primary wound closure is needed to minimize the risk of necrosis following socket seal surgery. The base of the provisional restoration should only lightly touch the augmented area.

Alveolar ridge preservation in fixed partial denture restorations

Single-stage approach

If single-stage defect prevention measures are to be performed in cases where fixed partial dentures are planned, clinical experience has shown that it is effective to use a combination of mechanical soft tissue support, socket filling, and soft tissue augmentation.

Ideally, socket filling should be accomplished with nonresorbable bone substitute materials. Any dehiscences or fenestrations present can be covered with a barrier membrane positioned to prevent contact between the bone substitute material and the soft tissues. Care should be taken to ensure that the pontic completely seals the coronal soft tissue collar of the socket ("closed pontic").[119] Augmentation and stabilization of the marginal soft tissue are achieved by the use of a free subepithelial connective tissue graft obtained from the palate or tuberosity area. The modified tunnel technique is well suited for this indication (see chapter 8). The procedure is analogous to that described for alveolar ridge preservation in single-stage implant surgery.

In view of the physiologic tissue shrinkage that occurs after tooth extraction, a tissue deficit could conceivably remain after the completion of healing, even in cases where the recommended alveolar ridge preservation procedures were performed. In many cases, this problem can be surgically corrected by placing another connective tissue graft with the modified tunnel technique (Fig 12-25). The final restoration can be placed 5 months after extraction or corrective second surgery. To avoid having to manage changes in the soft tissue margin at the time of definitive prosthetic treatment, the clinician must ensure that the cervical contour of the provisional pontic is precisely transferred to the definitive tooth replacement (see chapter 13).

Multistage approach

As in two-stage implant placement, socket seal surgery is also used for alveolar ridge preservation for two-stage placement of fixed partial dentures. The procedure is analogous to that described for alveolar ridge preservation for two-stage implants. Ideally, socket filling should be accomplished with nonresorbable bone substitute materials.

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Fig 12-25 (a to c) Tooth 11 cannot be saved because of a longitudinal root fracture. It will be replaced with an adhesive fixed partial denture. Based on the hopeless tooth classification, a Type 2 situation is diagnosed.





Fig 12-25 (d and e) It was decided to treat the recession around the two central incisors prior to extraction to improve the soft tissue conditions for subsequent procedures. Results are shown 3 months after recession coverage using the modified tunnel technique (e).









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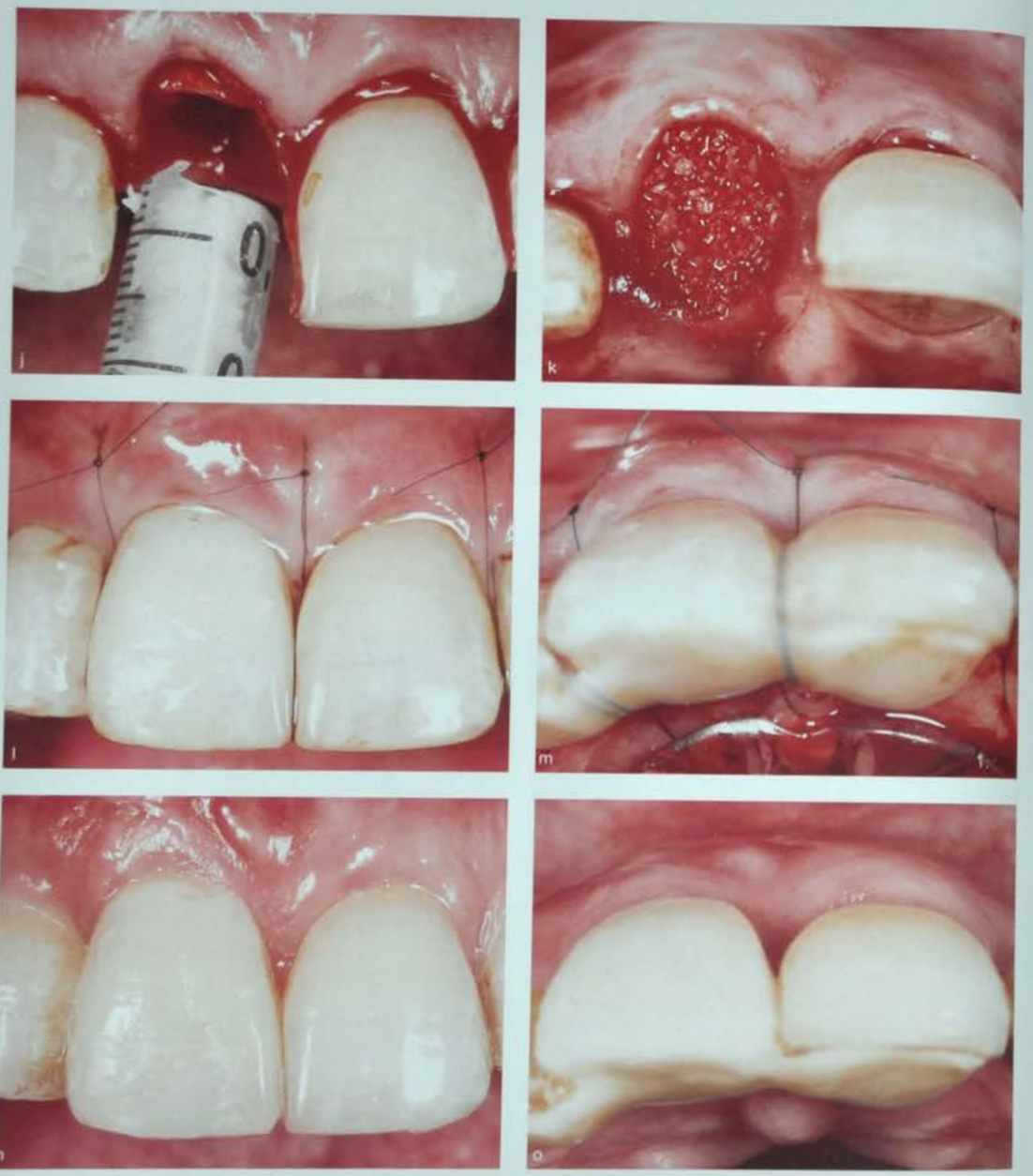


Fig 12-25 (f to o) The extraction procedure (f to i) included alveolar ridge preservation procedures—socket filling with DBBM (j and k), palatal connective tissue grafting (l and m), and the fabrication of a convex pontic to provide marginal soft tissue support—but, by 5 months after extraction, a horizontal tissue defect (n and o) has developed.

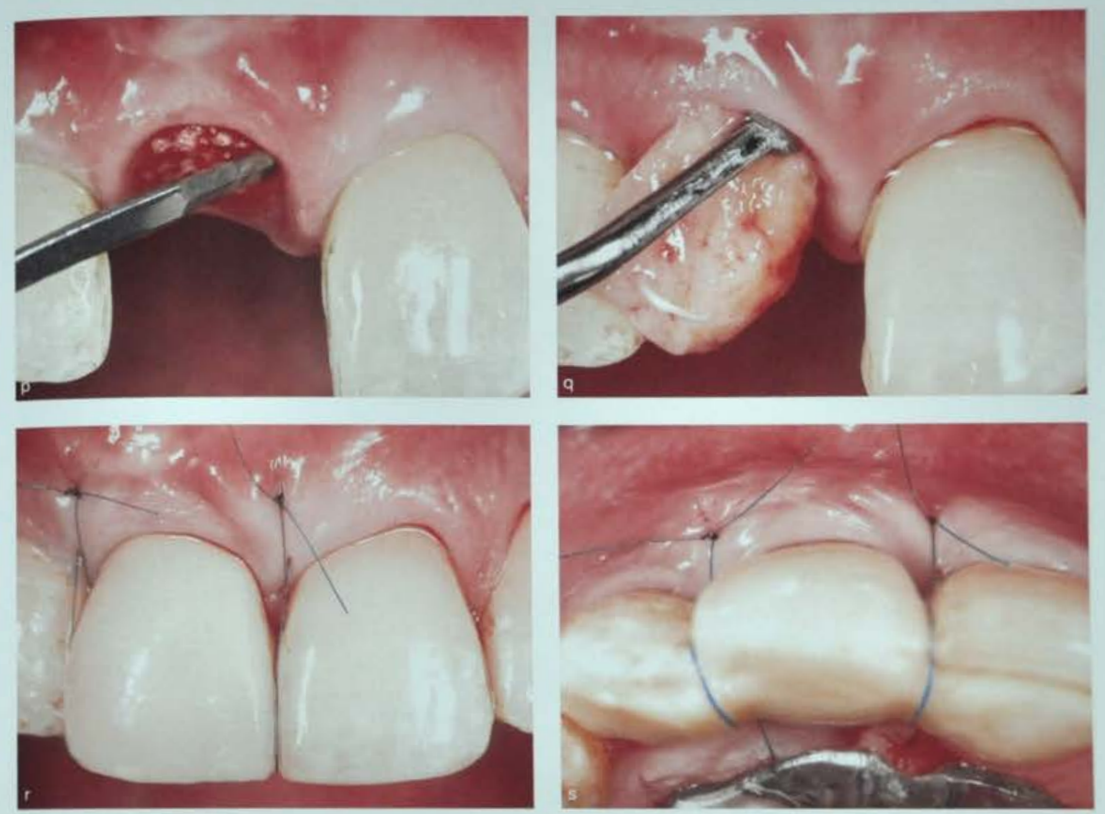


Fig 12-25 (p to s) Secondary soft tissue augmentation surgery is performed to correct the defect.

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Fig 12-25 (t to x) Final result 5 months after corrective surgery and placement of the definitive all-ceramic adhesive fixed partial denture.

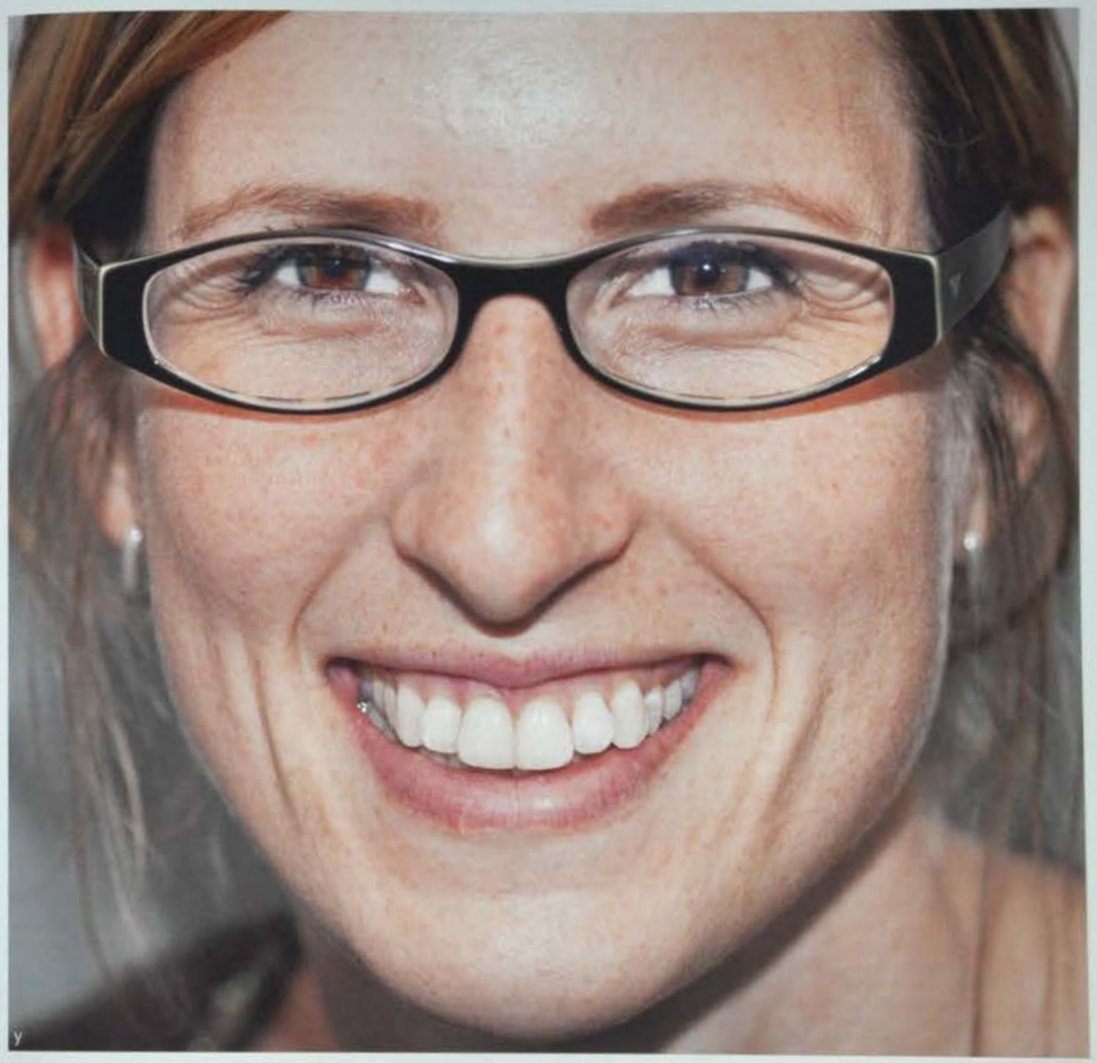


Fig 12-25y Patient after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

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12.2 Procedures

12.2.1 Ridge Preservation with Immediate Fixed Partial Denture Placement

KEY POINTS

01. Plan treatment based on the *hopeless tooth classification*.

02. Carefully assess the indications for *orthodontic extrusion* and discuss the treatment recommendations with the patient.

03. Gently *remove* the tooth and *inflamed tissues* with minimal trauma.

04. Densely *fill the extraction socket*, ideally with a nonresorbable bone substitute. Cover any fenestrations and dehiscences locally with a *resorbable barrier membrane* placed against the inner aspect of the socket wall.

05. Always perform marginal *soft tissue augmentation* with a palatal connective tissue graft. Ensure 1.0 to 1.5 mm of overcompensation in the vertical direction.

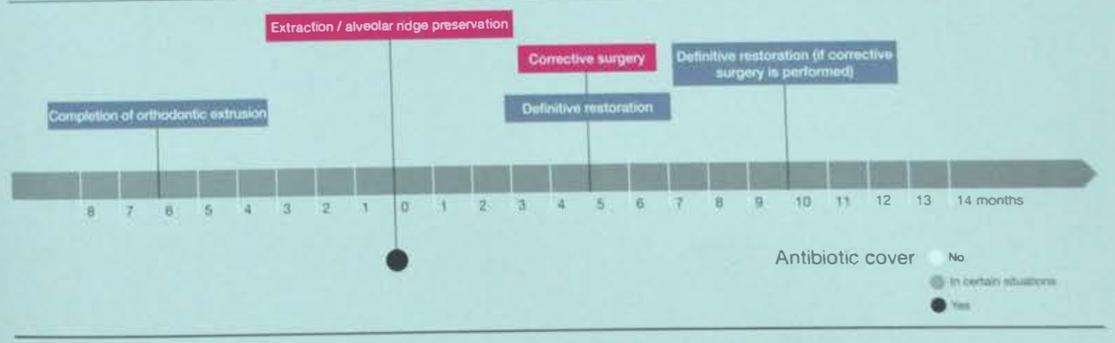
06. Check to ensure correct *pontic contours* and placement 2.0 to 3.0 mm below the soft tissue margin.

07. Use vertical double-crossed sutures to *secure* the flap and the graft.

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1 Macrosurgical instrument set
2 Microsurgical instrument set
3 Tunneling Knives I and II
4 Suture materials: Gore-Tex CV-5 and 6-0 Seralene DS-15
5 No. 15 macroblade and Keydent microblade
6 Extraction forceps
7 Desmotome
8 Red contra-angle handpiece with carbide bur
9 Sharp spoon
10 Glass slab
11 0.1% chlorhexidine solution in a metal dish
12 Sterile water in a metal dish
13 Metal dish for bone substitute material
14 Blunt cannula
15 10-mL syringe
16 Bone substitute material
17 Insulin syringe
18 Collagen membrane (within reach)
19 Local anesthetic
20 Large and small pledgets
21 Periodontal stent



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STEP-BY-STEP PROCEDURE





Figs 12-26 and 12-27 The maxillary right central incisor is unsalvageable because of endodontic problems. The tooth is to be replaced by an adhesive fixed partial denture. The site has been classified as Type 1. The conditions for a one-stage approach are ideal because there is excess tissue around the affected tooth.





Figs 12-28 and 12-29 To achieve diastema closure as the patient requested, tooth 21 is widened with composite resin at the beginning of treatment.





Figs 12-30 and 12-31 The periodontal ligament fibers in the marginal gingiva are sharply dissected to begin the atraumatic extraction.





Figs 12-32 and 12-33 Extraction forceps are used in an attempt to pull the tooth out of the socket with axial force. Care should be taken not to damage the marginal soft tissues with the forceps. Luxation movements should be avoided.

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Fig 12-34 The postextraction evaluation shows that the tooth has been successfully removed without any visible injury to the surrounding hard and soft tissues.

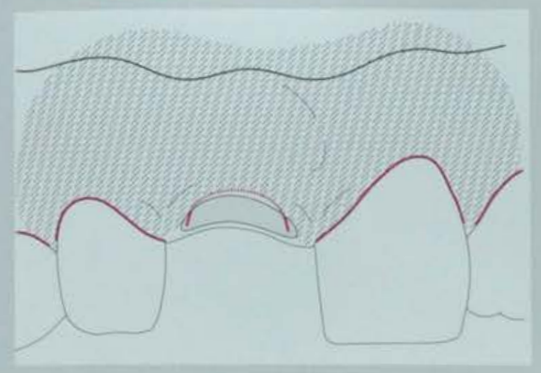


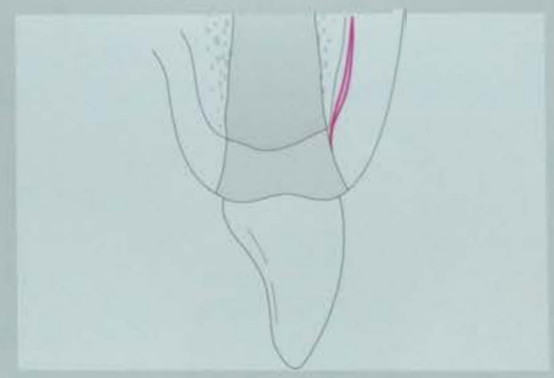


Figs 12-35 and 12-36 A buccal tunnel flap is prepared for marginal soft tissue augmentation. Flap elevation is started with a microblade, and the papillae of the adjacent teeth are included in the incision. To minimize the risk of perforation, further flap elevation should be completed with Tunneling Knives.









Figs 12-37 to 12-40 The incision is extended apically, one tooth wider than the site, until the flap has adequate mobility to enable tension-free placement in the desired coronal position.

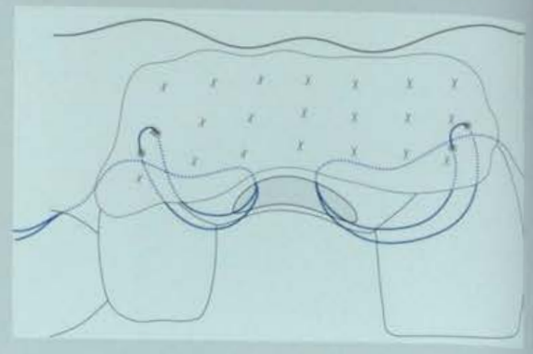




Figs 12-41 and 12-42 The connective tissue graft is harvested from the palate. Once the donor site has been closed with sutures and covered with a periodontal dressing, the graft can be inserted in the prepared tunnel.

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Figs 12-43 and 12-44 Positioning sutures made of Gore-Tex CV-5 have proved useful for graft positioning. The needle is inserted bluntly (back-first) into the tunnel one tooth lateral to the extraction socket and exits on the buccal side of the edentulous space. The needle engages the connective tissue graft laterally, from the inner to the outer aspect, and then, slightly more apically, from the outer to the inner aspect. The needle then passes back through the tunnel and returns to the starting point lateral to the edentulous space.





Figs 12-45 and 12-46 The graft is very precisely placed in the desired position by pulling on the sutures.





Figs 12-47 and 12-48 Bone substitute material (Bio-Oss) is placed in a metal cup, moistened with sterile saline solution, and loaded in an insulin syringe with the tip cut off. The material is carefully injected in the extraction socket and compacted with light pressure.



Fig 12-49 The provisional adhesive fixed partial denture is tried in. The base of the pontic must completely seal the filled extraction socket and provide a circular base of support to the overlying soft tissues. Exact placement of the provisional prosthesis in the planned position is crucial. A positioning guide is used for this purpose. When the provisional restoration is bonded, it is important to ensure that the wound is not exposed to phosphoric acid.

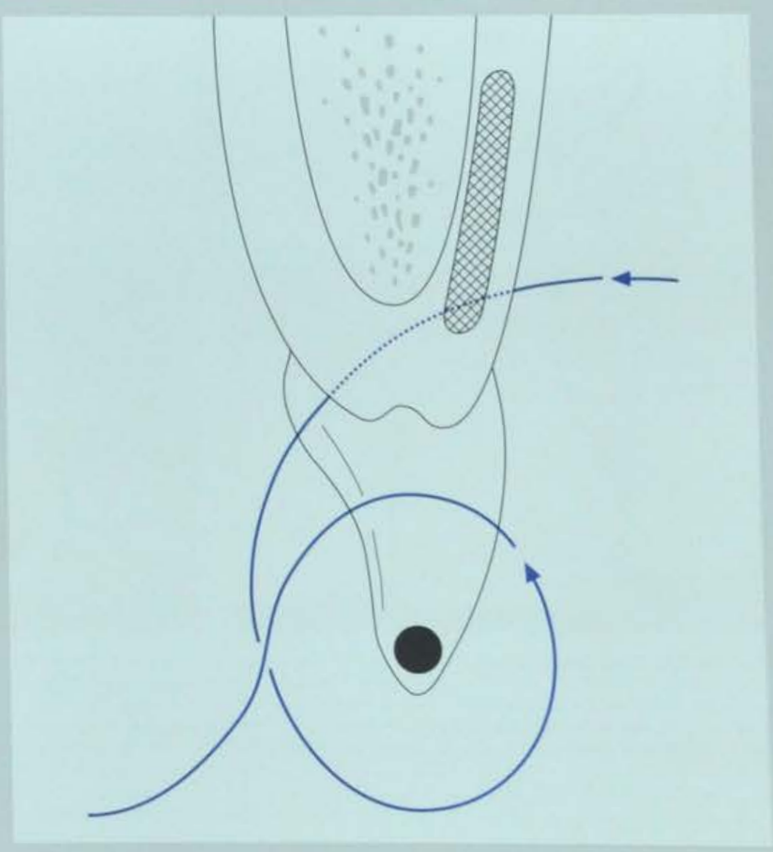
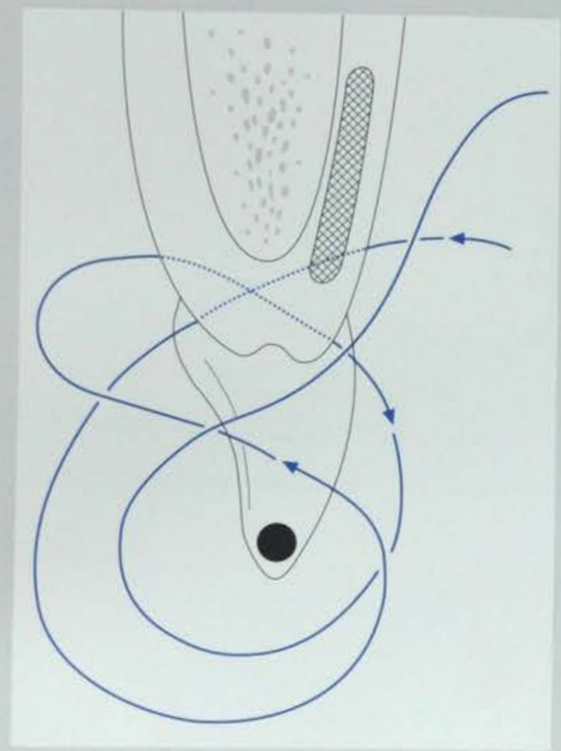
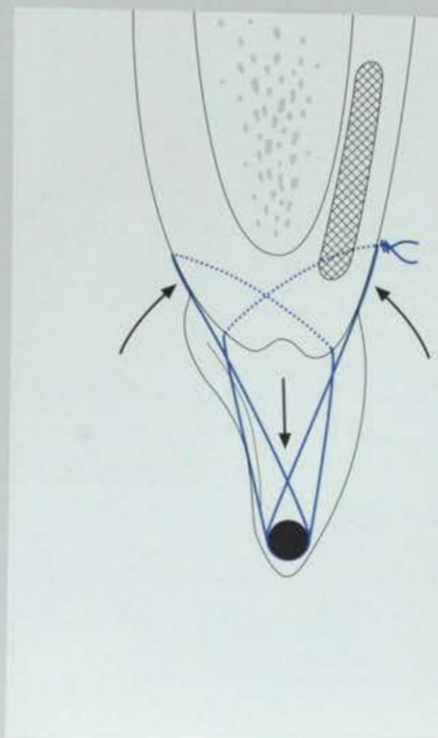


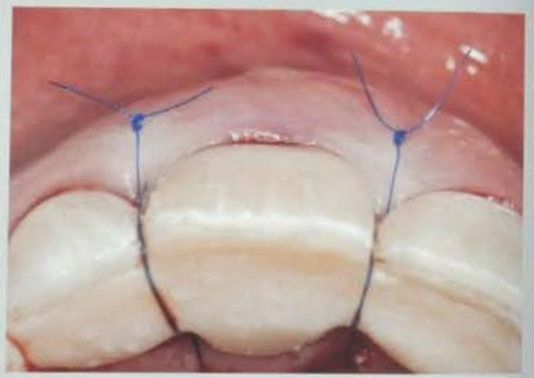
Fig 12-50 Two vertical double-crossed sutures (6-0 Seralene DS-15) are used to secure the graft. First suture: From the buccal aspect, the needle enters at the level of the mucogingival junction and engages the graft. It then passes beneath the contact point between the provisional pontic and the adjacent tooth and exits on the palatal side, slightly apical to the tip of the papilla. Next, the needle glides over the incisal edges and returns to the buccal side and then passes back-first (without engaging the tissue) under the contact point and returns to the palatal side.

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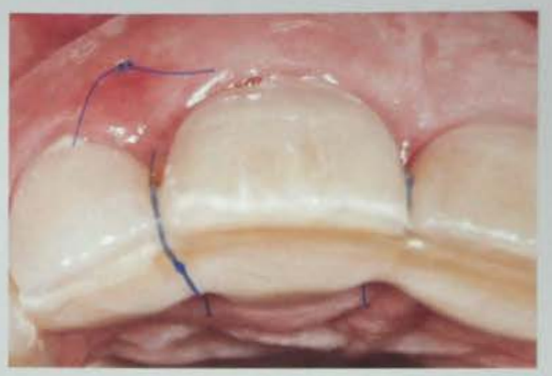






Figs 12-51 to 12-54 Second suture: From the palatal side, the needle enters at the base of the papilla and exits slightly apical to the tip of the papilla on the buccal side. It is not necessary to engage the connective tissue graft; however, the needle must exit the buccal tissue in the region of the mobilized flap to prevent folds from forming at the base of the papilla. As before, the needle returns to the palatal side and then passes beneath the contact point back-first (without engaging the tissue) and returns to the buccal aspect, where the suture is tied. After the positioning sutures have been removed, gentle pressure is applied to the surgical site for a few minutes.





Figs 12-55 and 12-56 The 1-week postoperative examination reveals healing without complications.





Figs 12-57 and 12-58 Result 5 months after surgery, immediately before the definitive impressions were taken. Clearly, the ridge maintenance measures have adequately compensated for postextraction shrinkage.

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Figs 12-59 to 12-64 Final result after placement of the definitive restoration, an all-ceramic adhesive fixed partial denture. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 7: Management of Extraction Sockets. Chapter 1: Ridge Preservation with Immediate Fixed Partial Denture Placement."

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12.2.2 Ridge Preservation with Single-Stage Implants

KEY POINTS

01. Plan treatment based on the *hopeless tooth classification*.

02. Carefully assess the indications for *orthodontic extrusion* and discuss the treatment recommendations with the patient.

03. Gently *remove* the tooth and *inflamed tissues* with minimal trauma.

04. Perform *flapless immediate implant placement* using computer guidance (mandatory) while ensuring that the implant is in a slightly *palatally displaced* position.

05. *Densely fill the gap* between the implant and the extraction socket, ideally with a nonresorbable bone substitute. Cover any fenestrations and dehiscences locally with a *resorbable barrier membrane* placed against the inner aspect of the socket wall.

06. Always perform marginal *soft tissue augmentation* with a palatal connective tissue graft. Ensure 1.0 to 1.5 mm of overcompensation in the vertical direction.

07. *Immediate implant placement* should not be performed unless good primary stability of the implant is ensured, that is, unless all potential causes of implant *micromovement* have been eliminated.

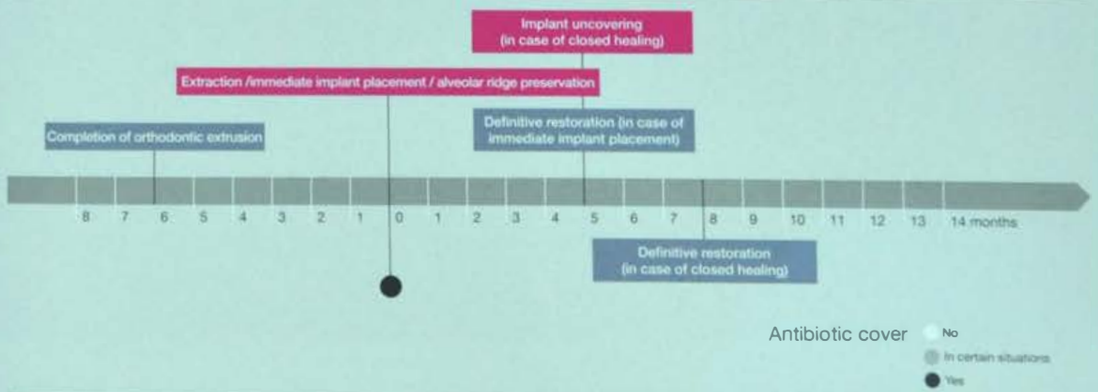
08. Check to ensure that the *contours* of the *implant-supported provisional restoration* or *provisional pontic* are correct.

09. Use vertical double-crossed sutures to *secure* the flap and the graft.

10. Apply *gentle pressure* to the wound for several minutes.

11. Give the *patient* complete and comprehensive *postoperative instructions*.

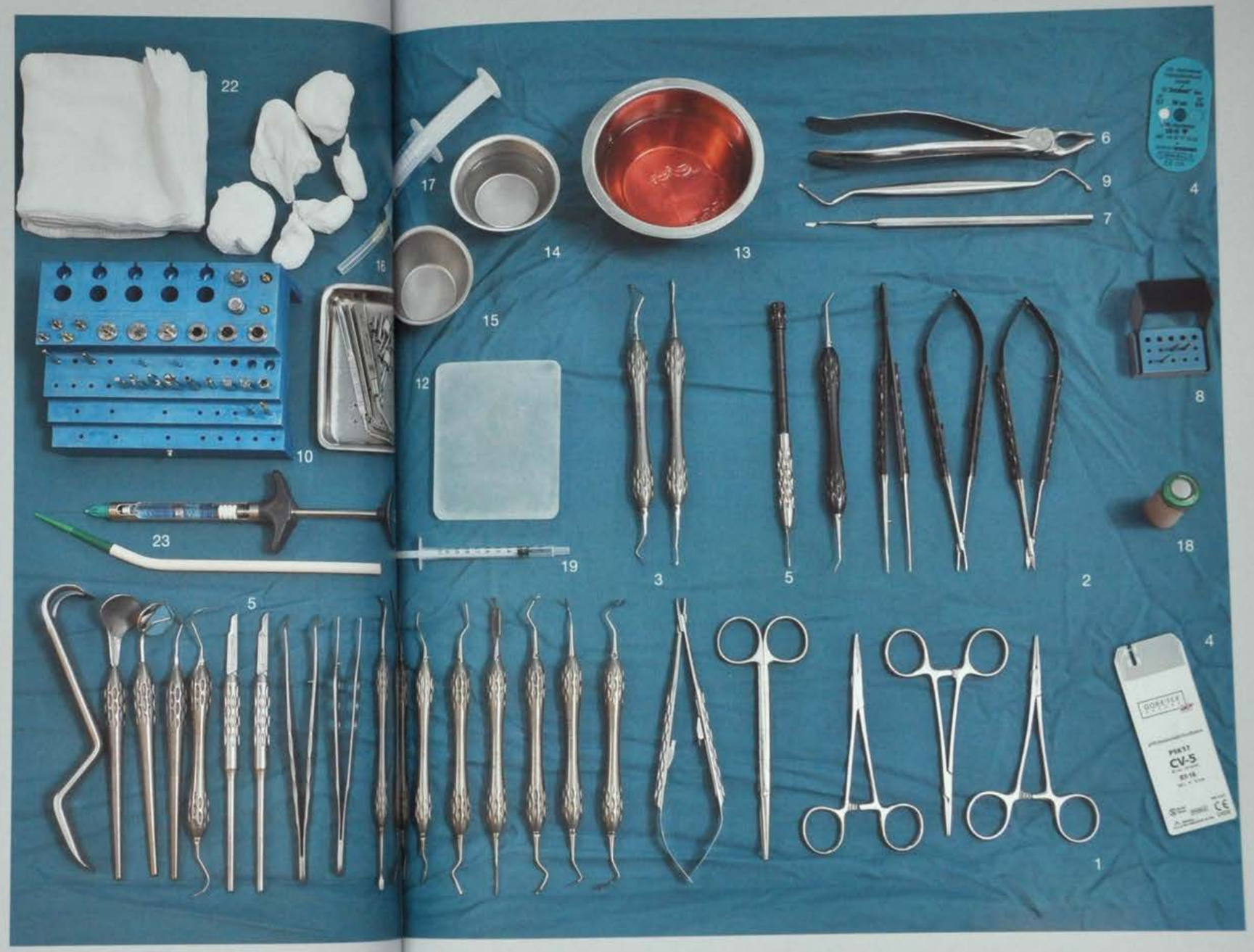
TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1 Macrosurgical instrument set
2 Microsurgical instrument set
3 Tunneling Knives I and II
4 Suture materials: Gore-Tex CV-5 and 6-0 Seralene DS-15
5 No. 15 macroblade and Keydent microblade
6 Extraction forceps
7 Desmotome
8 Red contra-angle handpiece with carbide bur
9 Sharp spoon
10 Implant motor with contra-angle handpiece and implantation set
11 Selection of implants (within reach)
12 Glass slab
13 0.1% chlorhexidine solution in a metal dish
14 Sterile water in a metal dish
15 Metal dish for bone substitute material
16 Blunt cannula
17 10-mL syringe
18 Bone substitute material
19 Insulin syringe
20 Collagen membrane (within reach)
21 Local anesthetic
22 Large and small pledgets
23 Periodontal stent
24 Temporary abutment for immediate implant placement, if applicable (within reach)



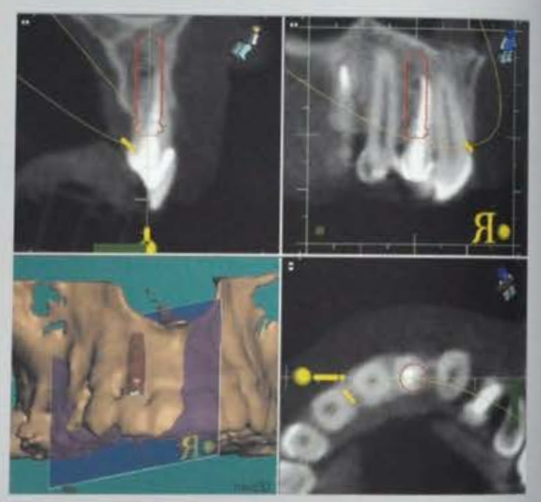
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STEP-BY-STEP PROCEDURE





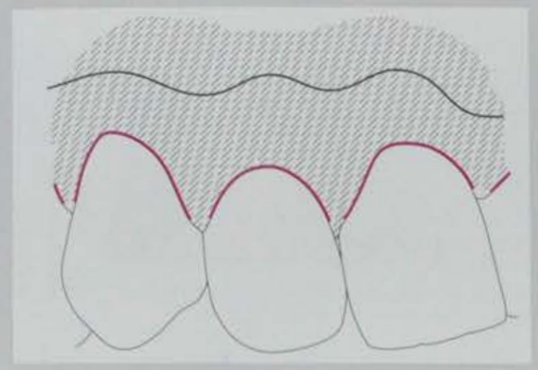




Figs 12-65 to 12-68 The maxillary right lateral incisor is unsalvageable because of endodontic problems. A Type 1 environment was diagnosed based on the hopeless tooth classification. Volumetric tomography will be used for planning of the implant surgery in order to enable computer-guided flapless implant placement.









Figs 12-69 to 12-72 Before the tooth is extracted, the microblade and Tunneling Knives are used to prepare a buccal partial-thickness tunnel according to the modified tunnel technique. The incision should be extended to the teeth adjacent to the tooth to be extracted.

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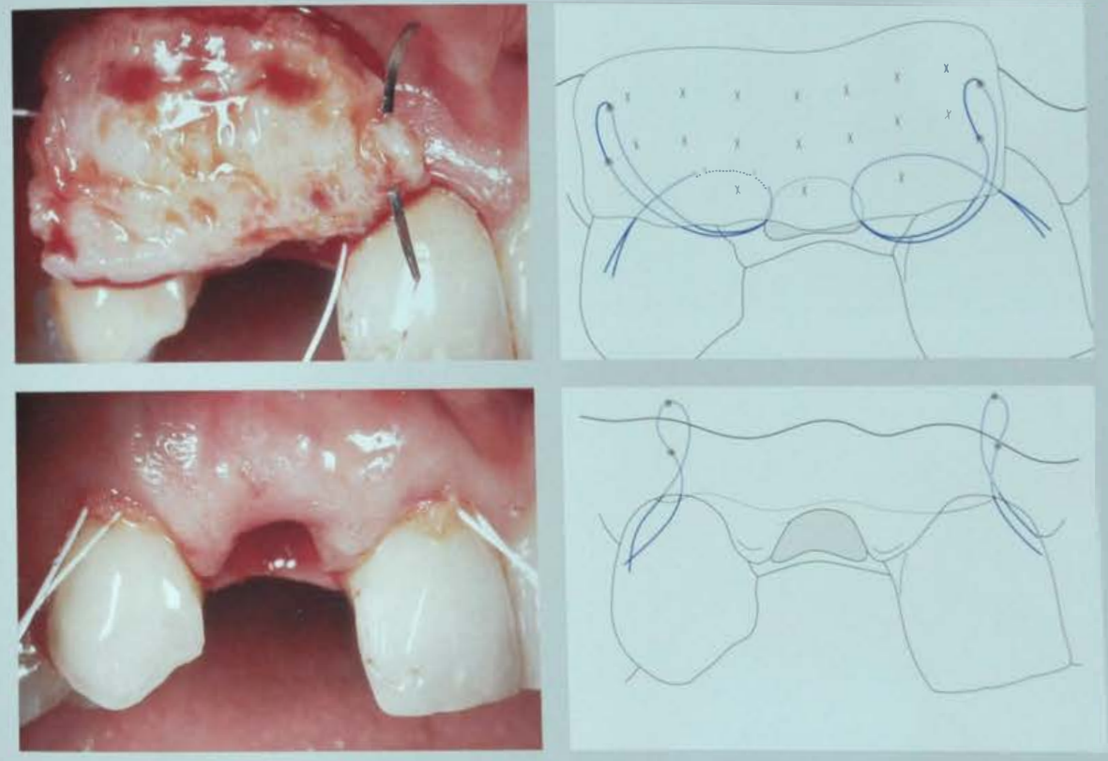


Figs 12-73 to 12-76 Because the attempt to pull the tooth out of the socket axially with extraction forceps was unsuccessful, the tooth is sectioned in the bucco-oral direction and the two halves of the root are removed separately.



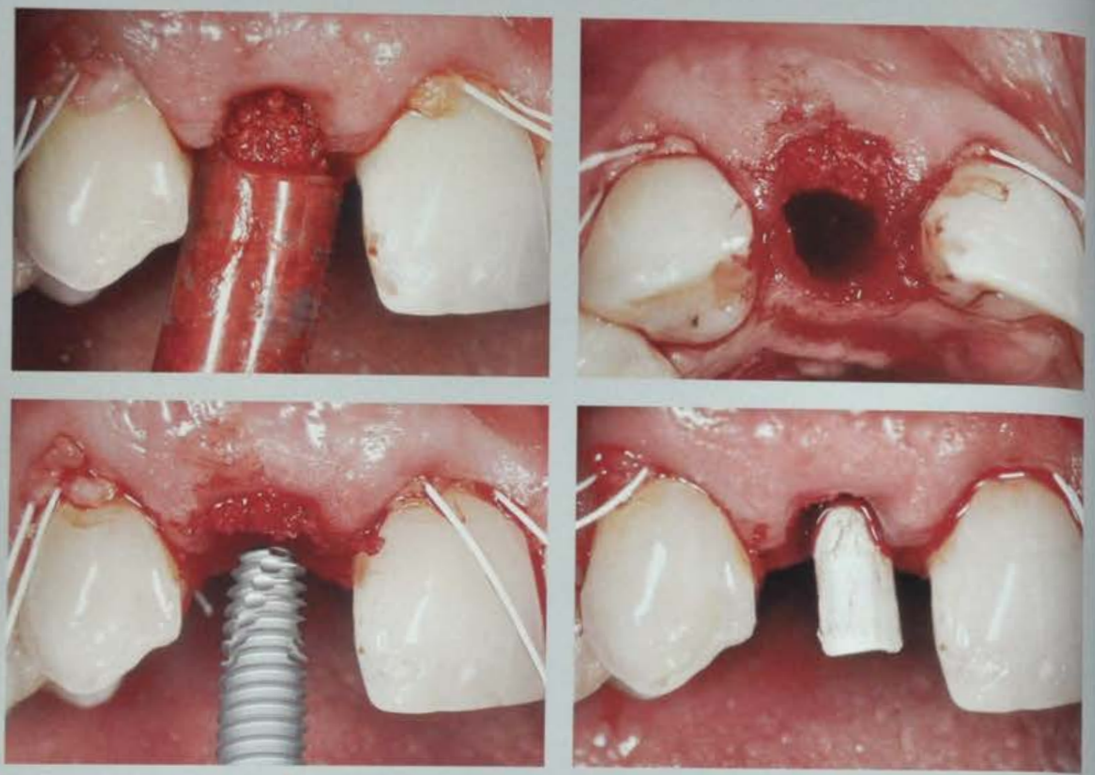


Figs 12-77 to 12-80 The dimensions of the buccal bone plate are checked for adequacy before implant bed preparation.



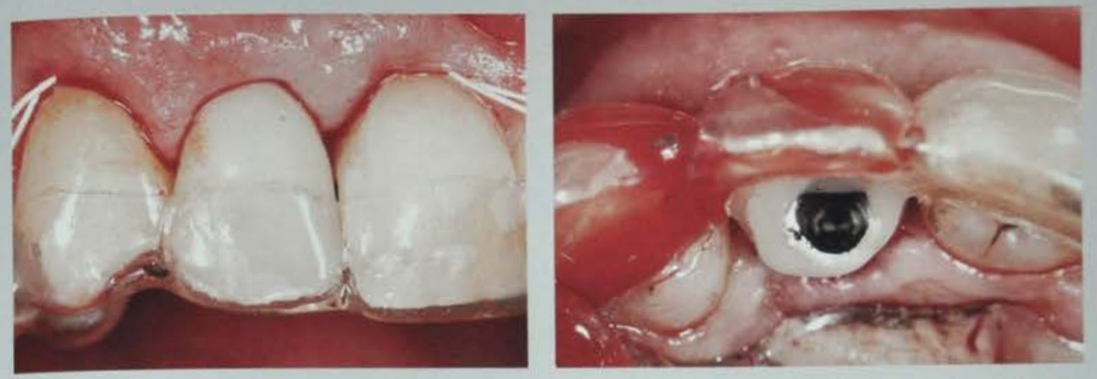
Figs 12-81 to 12-84 A connective tissue graft harvested from the palate is used to augment the buccal soft tissue. The graft is inserted in the prepared tunnel with the aid of positioning sutures.

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Figs 12-85 to 12-88 The buccal aspect of the extraction socket is filled with DBBM (Bio-Oss), and the implant is inserted. Good primary stability has been achieved, permitting immediate provisionalization of the implant. Therefore, a temporary abutment is connected to the implant abutment and secured with a retaining screw.





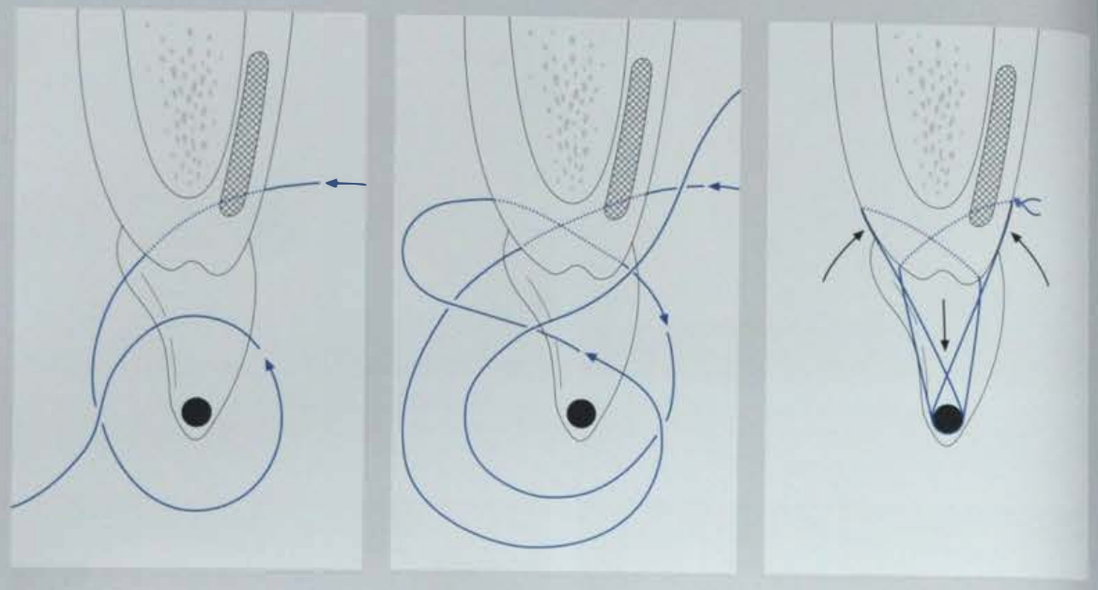
Figs 12-89 to 12-92 A positioning guide is used to ensure exact positioning of the laboratory-prepared provisional shell in the patient's mouth. The palatal surface is connected to the temporary abutment with flowable composite resin.





Figs 12-93 to 12-96 The provisional shell is precisely finished with composite resin on the temporary abutment and polished outside the patient's mouth. The finished immediate provisional restoration is tightly screwed onto the implant by hand. The access hole is covered with a foam pellet before it is closed with light-cured composite. Contacts are then evaluated in centric and dynamic occlusion. Any undesirable contacts should be eliminated and interproximal contacts loosely shaped.

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Figs 12-97 and 12-101 Suturing is performed using vertical double-crossed sutures (6-0 Seralene DS-15). First suture: From the buccal side, the needle enters at the level of the mucogingival junction and engages the connective tissue graft before passing beneath the splinted contact point and through the tissue until it emerges on the palatal side, slightly apical to the tip of the papilla. The needle then passes over the incisal edges of the teeth and is returned to the buccal side. It then passes under the splinted contact point back-first (without engaging the tissue) and returns to the palatal side. Second suture: From the palatal side, the needle enters at the base of the papilla and emerges on the buccal side, slightly apical to the tip of the papilla. It is not necessary to engage the connective tissue graft; however, the needle must exit the buccal tissue in the region of the mobilized flap to prevent folds from forming at the base of the papilla. Next, the needle passes back to the palatal side, then glides beneath the contact point back-first (without engaging the tissue) and returns to the buccal side, where the suture is tied. The positioning sutures can be removed once the second suture is completed.



Fig 12-102 A night-guard is fabricated to prevent grinding and thus to prevent overloading of the implant at night.





Figs 12-103 and 12-104 Result 1 week after surgery, just before suture removal.

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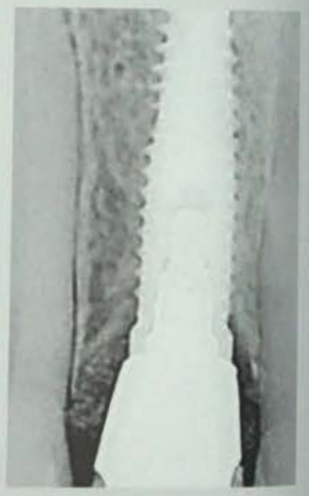


Figs 12-105 and 12-106 The definitive impression is taken 5 months after surgery. Additionally, the patient requested a new crown on the left lateral incisor.











Figs 12-107 to 12-111 Clinical and radiographic situation after the completion of treatment. The definitive restoration consists of a zirconia abutment and an all-ceramic crown.

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Fig 12-112 Patient after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 7: Management of Extraction Sockets, Chapter 2: Ridge Preservation with Single-Stage Implants."

12.2.3 Socket Seal Surgery for Alveolar Ridge Preservation in Combination with Two-Stage Fixed Partial Denture or Implant Placement

KEY POINTS

01. Plan treatment based on the *hopeless tooth classification*.

02. Carefully assess the indications for *orthodontic extrusion, distraction osteogenesis, and/or sandwich osteotomy* and discuss the treatment recommendations with the patient.

03. Gently *remove* the tooth and *inflamed tissues with minimal trauma*.

04. *Excise the epithelium* and induce bleeding in the marginal gingiva facing the extraction socket.

05. If a *fixed partial denture restoration* is planned, fill the extraction socket with *nonresorbable bone substitute material*.

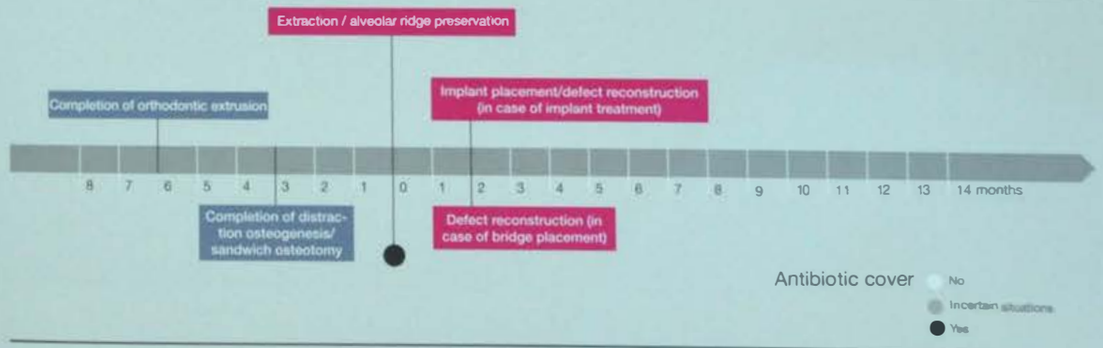
06. Harvest a free mucosal graft of *sufficient thickness* from the palate.

07. Suture the graft to *tightly seal* the socket.

08. Only permit light contact between the *provisional* and surgical site.

09. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Microsurgical instrument set
2. Suture materials: 7-0 Seralene DS-12
3. No. 15 macroblade and Keydent microblade
4. Extraction forceps
5. Desmotome
6. Red contra-angle handpiece with carbide bur and rough diamond
7. Sharp spoon
8. Tissue adhesive for palatal donor site (within reach)
9. Glass slab
10. 0.1% chlorhexidine solution in a metal dish
11. Sterile water in a metal dish
12. Metal dish for bone substitute material (for fixed partial dentures)
13. Blunt cannula
14. 10-mL syringe
15. Bone substitute material (for fixed partial dentures)
16. Insulin syringe (for fixed partial dentures)
17. Local anesthetic
18. Large and small pledgets
19. Periodontal stent



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STEP-BY-STEP PROCEDURE







Figs 12-113 to 12-115 The maxillary left central incisor is classified as hopeless because of a vertical root fracture. A Type 1 situation was diagnosed based on the hopeless tooth classification. In this multistage approach, socket seal surgery is first performed for alveolar ridge preservation.





Figs 12-116 and 12-117 To allow for extraction of the tooth with minimal trauma, the microblade is used first to make an intrasulcular incision and to sharply dissect the marginal periodontal fibers. The subsequent attempt to axially extract the tooth with forceps failed, so the crown was amputated.

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Figs 12-118 to 12-122 A carbide bur is used to section the residual roots in the bucco-oral direction; care is taken to preserve the surface integrity of the tooth on the buccal side. A desmotome is placed in the groove and rotated to create root fracture. The desmotome is then inserted in the periodontal ligament space on the palatal side to extract each half of the root individually.





Figs 12-123 and **12-124** The absence of buccal bone plate is clinically confirmed after extraction.

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Fig 12-125 To ensure good integration of the soft tissue graft, the microblade is used to de-epithelialize the marginal gingiva on the side facing the extraction socket while simultaneously creating a bleeding wound surface.

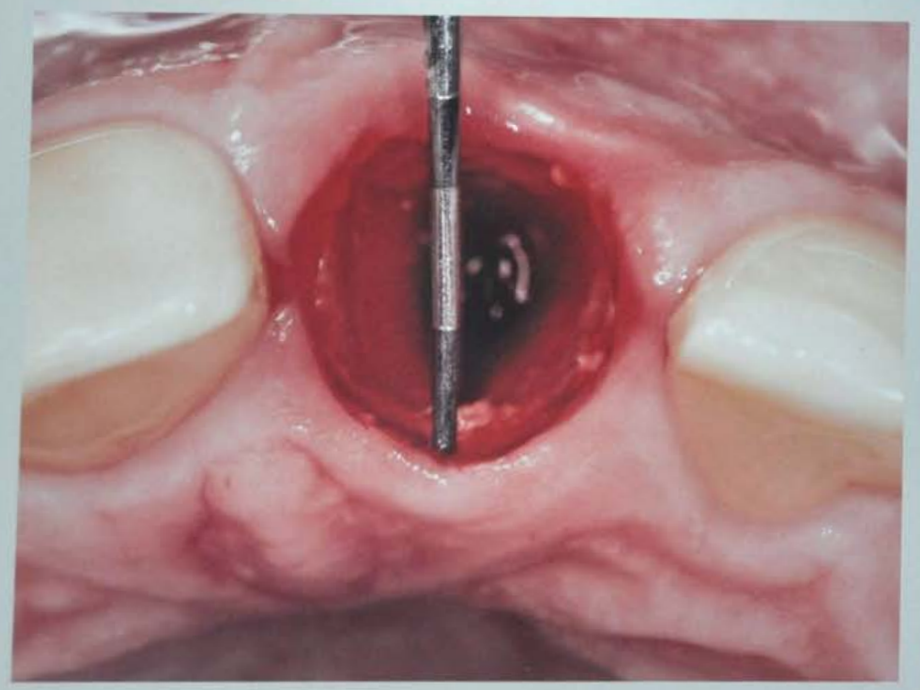


Fig 12-126 The soft tissue opening over the extraction socket must be precisely measured before the graft is harvested.





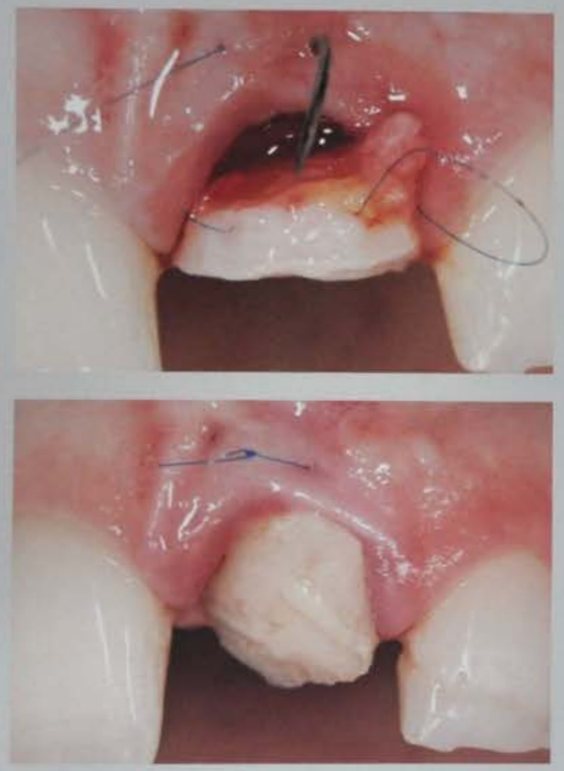




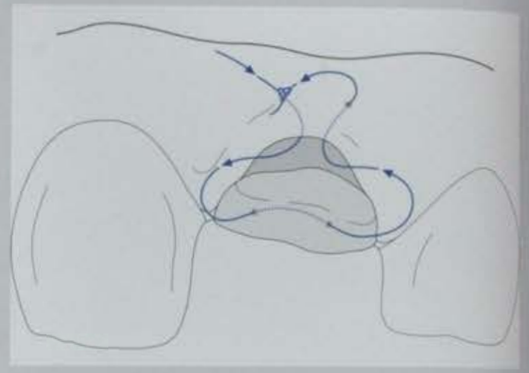


Figs 12-127 to 12-131 A free mucosal graft is harvested from the palate based on these measurements. The incision must be made perpendicular to the tissue surface. Furthermore, the graft should be harvested with maximum thickness while leaving the periosteum on the bone. Histoacryl can be applied and a periodontal dressing placed to achieve hemostasis.

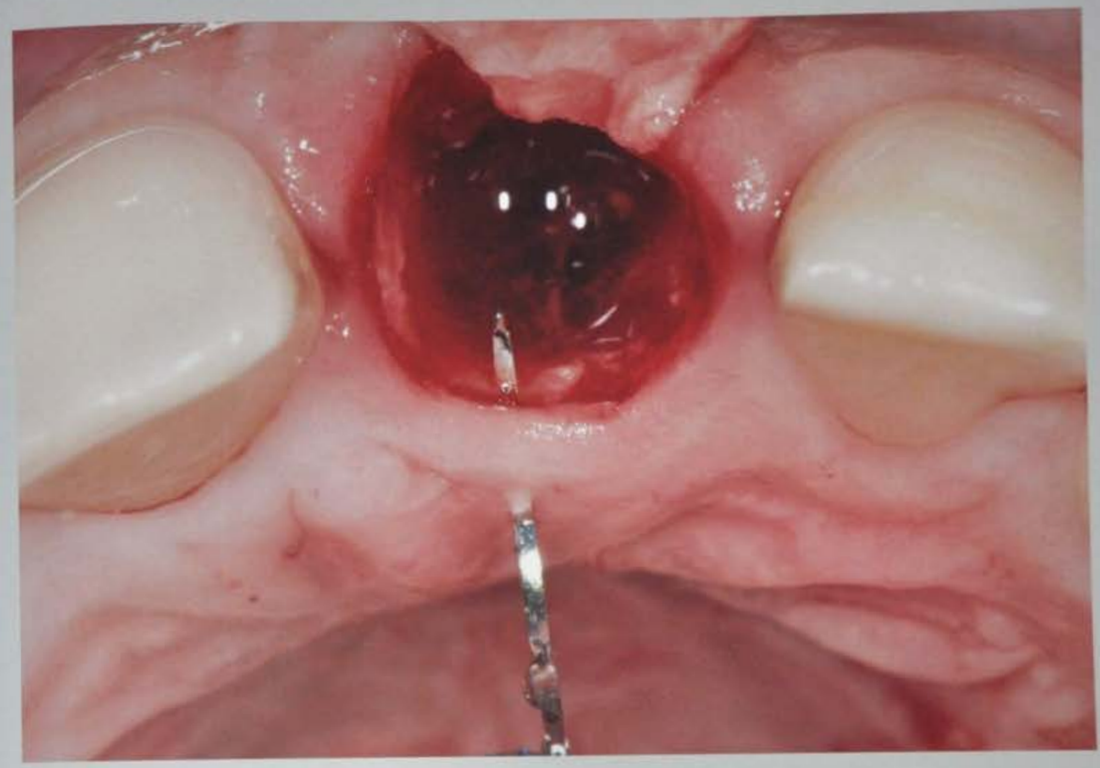
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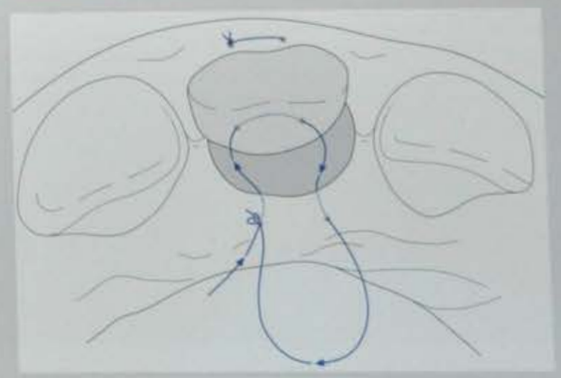




Figs 12-132 to 12-135 A horizontal mattress suture (7-0 Seralene DS-12) is placed on the buccal side to stabilize the graft in the recipient bed. Starting on the buccal side, the needle enters the soft tissue slightly coronal to the mucogingival junction. Next, it passes horizontally through the subepithelial connective tissue graft, through the marginal soft tissue from the interior to the exterior aspect, and returns to the buccal side. Controlled tension should be used to tie the suture to ensure that the graft is aligned flush with the marginal soft tissue around the extraction socket.

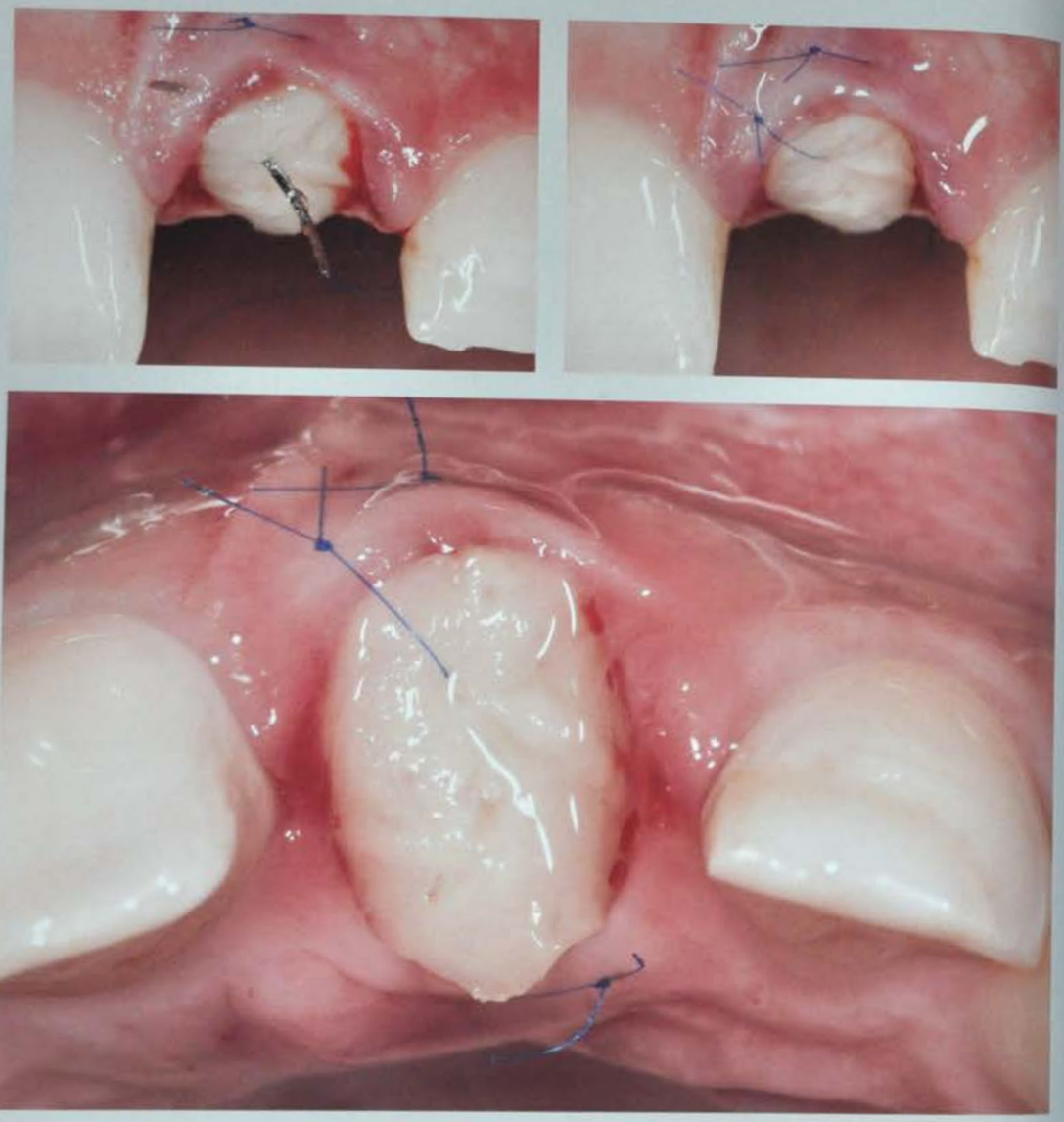


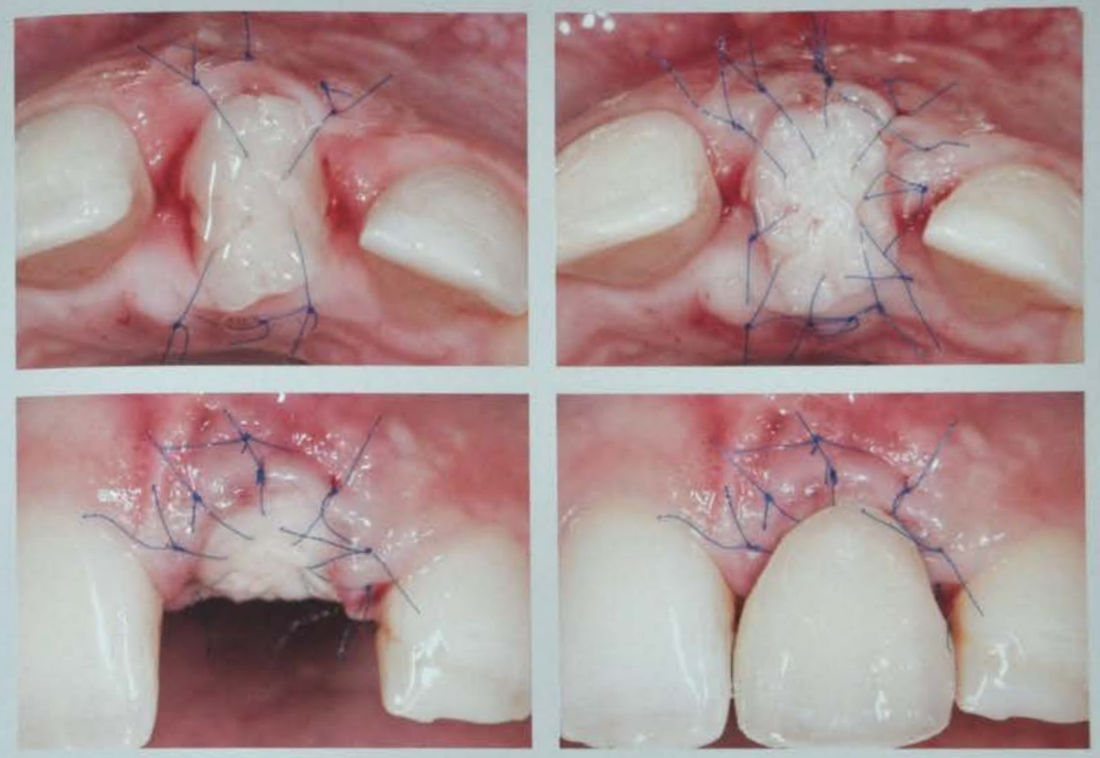




Figs 12-136 to 12-138 Starting from the palatal side, a second horizontal mattress suture is made as already described.

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Figs 12-139 to 12-145 Closure is completed with interrupted sutures. This suturing technique is designed to achieve exact approximation of the wound margins in order to minimize the diffusion distance to the graft during the first postoperative days. The socket does not have to be filled with bone substitute material before suture closure because implantation and augmentation will be performed later. After the procedure, the provisional restoration must be contoured to ensure minimal contact with the surgical site.

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Figs 12-146 and 12-147 Result 1 week after surgery, just before suture removal.





Figs 12-148 and 12-149 Result 7 weeks later, immediately prior to implantation. Soft tissue conditions are ideal for implantation and augmentation with predictable primary wound closure.

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery. Volume 7: Management of Extraction Sockets. Chapter 3: Socket Seal Surgery for Alveolar Ridge Preservation in Combination with Two-Stage Fixed Partial Denture or Implant Placement."

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CHAPTER 13

REPLACEMENT OF MISSING TEETH

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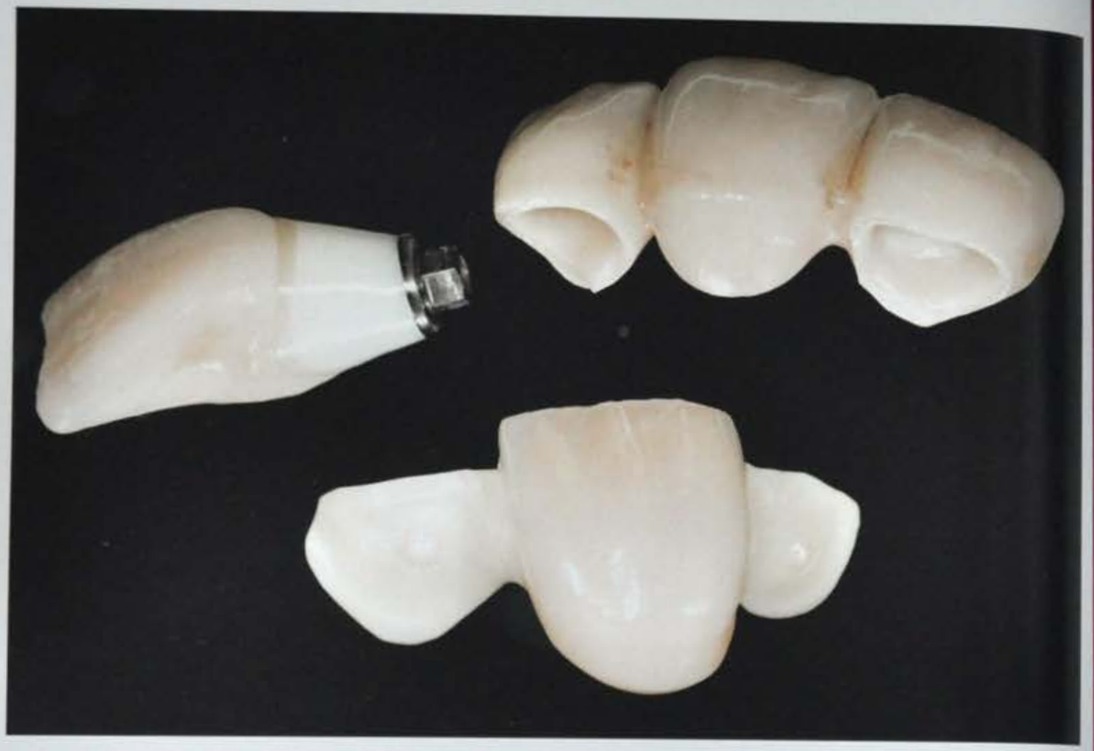


Fig 13-1 Missing teeth can be replaced with a conventional fixed partial denture, an adhesive fixed partial denture, or an implant-supported prosthesis.

13.1 Theory

13.1.1 Fixed Partial Denture Versus Implant

Several prosthetic options are available for the replacement of one or more missing teeth. Both removable and fixed replacements such as conventional fixed partial dentures, adhesive fixed partial dentures (Maryland bridges), and implant-supported prostheses can be used to replace missing teeth. Orthodontic treatment may also be considered for the elimination of gaps between teeth in certain cases. With different treatment options to choose from, a detailed baseline clinical assessment is crucial to the clinical decision-making process. The potentials and limitations of each modality must be carefully analyzed and weighed against the other alternatives in terms of their ability to solve the existing problems in a given case (Fig 13-1).

Patients expect the clinician to use tooth replacement protocols that will provide predictable functional and esthetic outcomes and long-term stability, especially in the esthetic zone. Minimal invasiveness, low morbidity, maximum patient comfort, optimal cost efficiency, and the avoidance of the need for removable tooth replacements are factors of great importance.[1]

As discussed in chapter 12, tooth extraction results in massive bone resorption and defects that can later impair the *cosmetic and functional outcomes of treatment*. This can ultimately lead to food retention problems, oral hygiene problems, impaired phonetics, and poor





Fig 13-2 (a and b) Conventional fixed partial denture in the mandibular anterior region. The fixed partial denture blends in so well that it is virtually indistinguishable from the surrounding teeth and soft tissues. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

esthetic outcomes.[2,3] Especially in the esthetic zone, the bone resorption and defects that occur following tooth extraction result in the need for surgical reconstruction, regardless of whether the gap is to be closed by a conventional fixed partial denture, an adhesive fixed partial denture, or one or more implants. From an esthetic point of view, the goal of treatment is to produce a fixed partial denture or implant reconstruction that blends in so well that it is virtually indistinguishable from the surrounding teeth and soft tissues (Fig 13-2).

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Implant-supported prostheses

From a medical perspective, the replacement of missing teeth with implant-supported restorations is the optimal treatment option. The survival and success rates for implant-supported restorations placed in the anterior region are similar to those placed in other regions[4–7] and are comparable to those of conventional tooth-supported partial dentures.[8] The advantage of implants is that no preparation of the adjacent teeth is required, and there is potential for expansion or repair of the restoration in the event of future dental complications or problems.

Nonetheless, it is a challenge to achieve a good esthetic outcome with implants, although great advances have been made in recent years. In particular, the need to replace more than one tooth and the presence of vertical tissue defects are fundamental problems that cannot be solved with predictable esthetic results using the implant systems available today. Another drawback stems from the fact that the successful placement of dental implants in the esthetic zone is a technically demanding procedure that requires perfect implant positioning in all three spatial dimensions.

Implant therapy is also usually rather costly. Soft tissue augmentation alone often provides acceptable function and esthetics for fixed partial dentures, whereas both soft tissue augmentation and hard tissue augmentation are generally required for adequate osseointegration of implants.

Furthermore, the exposure of implants to the microbial environment of the oral cavity gives rise to remodeling processes associated with formation of the biologic width and could have deleterious effects on the gingival contour around the implants (see chapter 1). A mean of 0.6 to 1.6 mm of soft tissue recession can be expected 3 to 12 months after transmucosal and submucosal implant placement.[9–11] Given healthy peri-implant conditions, the tissues appear to be largely stable by the end of this stabilization period.[12–14]

Conventional fixed partial dentures

Conventional fixed partial dentures in combination with surgical alveolar ridge reconstruction can produce excellent esthetic results at relatively low cost and effort. Conventional fixed partial dentures are predictable and provide a good functional outcome and an excellent long-term prognosis.[8,15]

However, it is generally not necessary to consider using a conventional fixed partial denture in preference to an implant unless the teeth adjacent to the edentulous space have already been prepared and prosthetically treated. In these cases, the placement of implants in the edentulous area could have the advantage that all restorations are individualized, which would allow for repair or expansion of the prosthesis with relatively little cost and effort in the event of future complications to the abutment teeth. Therefore, the long-term prognosis of the abutment teeth must be considered when deciding for or against the placement of a fixed partial denture. A risk assessment must be conducted for each individual tooth. Local factors, such as the extent of tooth structure loss, endodontic treatment, mobility, attachment loss, probing depth, and bleeding on probing, as well as patient-related factors, such as compliance, oral hygiene, state of the remaining dentition, general health, smoking habits, and dental history, must be considered in the analysis. Furthermore, the therapeutic consequences of the potential failure of the planned fixed partial denture must be taken into account. The more questionable the long-term prognosis of the abutment teeth and the more wide-ranging the potential consequences of fixed partial denture failure, the more sense it would make to place implants in the edentulous area. In the end, the advantages and disadvantages of a fixed partial prosthesis in a given clinical case must be weighed against each other, and the decision for or against the fixed partial denture must be made in collaboration with the patient.

Because pontics do not penetrate the epithelial lining of the oral cavity, they do not result in the aforementioned remodeling processes associated with the formation of biologic width. Consequently, fixed partial dentures have certain advantages over implant-supported prostheses in terms of the expected cosmetic outcome. Most importantly, the vertical dimension of interproximal tissue that can be achieved between a pontic and a tooth or between two pontics appears to be much greater than that between an implant and a tooth or between two implants.[16] However, fixed partial dentures are also unable to predictably solve the previously mentioned problems associated with the presence of vertical tissue defects.

A disadvantage of fixed partial dentures is that they require soft tissue sculpting, which is very time-consuming. During the first weeks after augmentation surgery, the provisional pontic is selectively built up and contoured to gradually sculpt the augmented soft tissue in a way that will ensure that the gingival margin around the pontic ideally mimics that of the adjacent teeth. Because this sculpting is accomplished through the application of pressure, there is a risk of apical displacement of tissue. Therefore, contouring must be performed in small increments over multiple visits. When implants are used, soft tissue sculpting can be performed from a deep position, from apical to coronal, after the implant is uncovered. This simplifies and shortens the procedure considerably. Unfortunately, there is a lack of scientific data on the long-term stability of soft tissue augmentation in combination with fixed partial dentures.

Adhesive fixed partial dentures

Adhesive fixed partial dentures provide a minimally invasive option for the replacement of missing teeth at sites where the adjacent teeth are intact and caries free.[17] The long-term results of different studies vary widely, suggesting that adhesive fixed partial denture fabrication is a technique-sensitive procedure.[18–20] Decementation of one of the two retainers of an adhesive prosthesis leads to plaque accumulation and the risk of secondary caries.[20] Because of the compromised optical design of adhesive metal-ceramic restorations, the current trend is to use ceramic materials in the esthetic zone. *Kern*[21] studied the clinical long-term survival of 37 one- and two-retainer all-ceramic adhesive prostheses made of glass-infiltrated alumina ceramic used for single-tooth replacements. The survival rate was only 67.3% for two-retainer prostheses after about 6 years compared to 92.3% for single-retainer prostheses after approximately 4.5 years. Based on these results and in view of the currently available restorative materials and procedures, it can be concluded that although the use of a one-retainer fixed partial denture design and modern high-strength ceramics significantly improves the stability of all-ceramic adhesive fixed partial dentures, implant-supported fixed partial dentures have a better long-term prognosis.

However, all-ceramic adhesive fixed partial dentures are still a useful alternative for single-tooth replacements in cases where the adjacent teeth are intact and the use of implants is not feasible or not currently possible. A possible reason for this, apart from physical immaturity of the patient, could be, for example, a lack of mesiodistal space for implantation at a site that cannot be enlarged by orthodontic treatment. Various medical conditions in certain at-risk populations may also contraindicate the use of implants. Last but not least, the patient may decide against implant therapy because of lack of time or for physical, financial, or other reasons.

The fabrication of adhesive fixed partial dentures is technically demanding. Correct and painstaking patient selection, preparation, laboratory work, and adhesive bonding are crucial to achieving a good long-term prognosis. Like conventional fixed partial dentures, adhesive prostheses can provide excellent esthetic results at a relatively low cost when combined with surgical alveolar ridge reconstruction.

13.1.2 Defect Morphology and Classification

Edentulous spaces are often associated with variably extensive alveolar ridge defects involving the hard and soft tissues. Using a simplified approach based on the feasibility of achieving predictable and complete defect reconstruction, defects of the edentulous alveolar ridge can be broken down into *horizontal* and *vertical* components, which may occur alone or, not infrequently, in combination. Successful reconstruction of horizontal ridge defects can be expected, whereas the prognosis for reconstruction of vertical ridge defects is rather unfavorable.

The occurrence of horizontal and/or vertical ridge defects is not limited to edentulous parts of the alveolar ridge. Ridge defects involving the hard and soft tissues surrounding a tooth may also be present prior to tooth extraction, and they affect the prognosis and treatment of these sites accordingly.

These aspects have been discussed in detail in chapter 12. Therefore, the following sections focus solely on the treatment of edentulous ridge areas, ie, sites where the tooth or teeth to be replaced are missing or have already been extracted.

In principle, both horizontal and vertical defects in the edentulous alveolar ridge can be treated by hard and/or soft tissue augmentation. In a prospective clinical study of horizontal ridge augmentation using autogenous bone blocks and guided bone regeneration (GBR) with a bioabsorbable collagen membrane, *von Arx* and *Buser*[22] observed a mean gain of 4.6 mm in horizontal bone thickness after an average of 5.8 months in 42 patients with severe horizontal bone atrophy. In a controlled clinical trial designed to compare the potentials of distraction osteogenesis and GBR for vertical ridge augmentation, *Chiapasco* et al[23] treated 11 patients by means of vertical GBR with autogenous bone and expanded polytetrafluoroethylene (e-PTFE) membranes (Gore-Tex) and 10 patients by means of distraction osteogenesis.

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Fig 13-3 (a and b) Soft and hard tissue augmentation procedures were performed for correction of this Class III defect. The long-term stability of vertical tissue gain proved to be poor. Therefore, volume changes must be expected years after augmentation.

The trial concluded that both procedures effectively resulted in vertical bone gain. In a prospective clinical study of volumetric changes after soft tissue correction of single-tooth pontic spaces, *Studer* et al[24] observed a significant gain in volume 3.5 months after placement of partial- or full-thickness palatal soft tissue grafts to treat combined horizontal and vertical alveolar ridge defects in 24 patients.

Nonetheless, the question of whether *complete reconstruction of different defect morphologies* can be achieved using the hard and soft tissue augmentation procedures investigated in these studies remains unanswered. Furthermore, the findings of the available studies on the long-term stability of the augmented tissues are sobering. Scientific studies on the *long-term stability* of soft tissue augmentation are completely lacking, and the results of the available trials on the long-term stability of hard tissue augmentation are not very promising. The evidence suggests that volume changes must still be expected years after augmentation[23,25–30] (Fig 13-3).

Efforts to use implants in hopes of improving long-term stability have not been a clear success. Although *Buser* et al[31] demonstrated that the clinical results of implants placed in augmented bone are comparable to those of implants placed in nonaugmented bone at 5 years, they did not perform a volumetric assessment of the outcome, which is crucial to the analysis of long-term stability from an esthetic perspective.

Both *qualitative*[32] and *semiquantitative*[33] *systems for classification* of defects in edentulous ridges have been proposed. *Seibert*'s qualitative classification distinguishes three classes of alveolar ridge defects based on the three-dimensional form of the defect: *horizontal defects* (Class I), *vertical defects* (Class II), and *combined horizontal and vertical defects* (Class III).[32] The semiquantitative classification by *Studer* et al[33] differentiates alveolar ridge defects according to the extent of the defect and the number of missing teeth. They recommend this semiquantitative method of defect analysis because it allows a reliable determination of the volume of graft tissue needed to correct the defect and makes it possible to predict the prognosis of augmentation.

In recent years, the clinical significance of these qualitative and semiquantitative classifications has decreased significantly because the current understanding of the physiodynamics of postextraction tissue changes and defect development indicates that a horizontal loss of midbuccal tissue fractions always occurs after extraction and that this tissue loss may occur in combination with a local vertical defect that varies in severity depending on the anatomical dimensions of the defect in the individual case (see chapter 12). Furthermore, the underlying bone mainly determines which results can be achieved because the vertical dimensions of the peri-implant soft tissue remain largely constant (see chapter 1). Clinical experience suggests that the same holds true for the soft tissue around pontics. The *vertical bone height at interproximal sites* adjacent to the edentulous space and the *number of missing teeth* appear to be the most important prognostic factors. Therefore, simple classification of edentulous spaces into three alveolar ridge defect classes is sufficient for prognostic assessment and treatment planning in contemporary prosthodontics (Fig 13-4):

Class I: A single tooth is missing and the vertical height of the interproximal alveolar bone of the teeth adjacent to the edentulous space is largely intact. Radiographically, the distance between the interproximal alveolar bone crest and the cementoenamel junction of the adjacent teeth is approximately 1 mm. There is a predominantly horizontal type of defect at the midbuccal tissue fractions, and the prognosis is relatively good. Interproximal soft tissue conditions are conducive to a good outcome of treatment, so the prognosis for the cosmetic outcome is also good. It is easiest to achieve a satisfactory cosmetic outcome when the teeth adjacent to the gap have a square shape, a moderate to flat gingival scallop, and a thick to moderately thick gingival biotype. When the teeth adjacent to the gap have a triangular shape, a high gingival scallop, and a thin gingival biotype, the prognosis is questionable. The same is true of Class I situations in which the horizontal tissue defect is not restricted to the midbuccal area but also extends to the palatal or lingual tissue zones. If such a defect configuration is present, extensive horizontal defect reconstruction will be required, but the prognosis will still be much better than that for Class I defects.

Class II: A single tooth is missing and the vertical height of interproximal alveolar bone of the teeth adjacent to the edentulous space is reduced. Radiographically, the distance between the cementoenamel junction and the interproximal alveolar bone crest of the teeth adjacent to the gap is greater than 1 mm. Consequently, these are combined horizontal and vertical defects, so both horizontal and vertical augmentation procedures are needed for complete defect reconstruction. Complete defect reconstruction cannot be achieved in the interproximal region using the currently available procedures and is subject to the aforementioned limitations in the alveolar ridge region. Therefore, the prognosis for a good cosmetic outcome cannot be classified as good.

Class III: Multiple teeth are missing and extensive combined vertical and horizontal defects are present. The prognosis for a good cosmetic outcome is poor.

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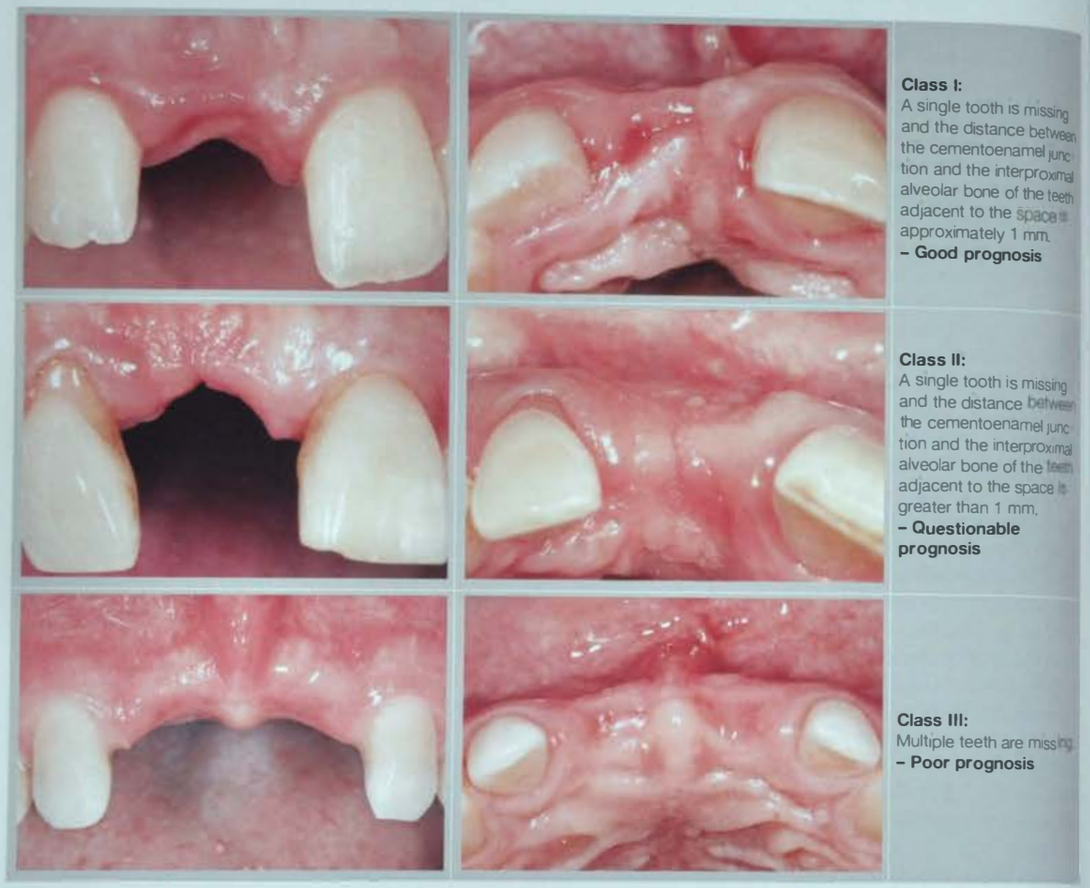


Fig 13-4 Classification of edentulous spaces based on the number of missing teeth and the vertical height of the interproximal alveolar bone of the teeth adjacent to the edentulous area.

13.1.3 Clinical Aspects of Defect Reconstruction

The treatment options arising from the classification of edentulous spaces vary, depending on whether an implant or a fixed partial denture is planned.

Horizontal *hard tissue augmentation* is always required in the scope of defect reconstruction in order to achieve complete osseointegration of *implants*, whereas soft tissue augmentation alone may suffice for successful *fixed partial denture restoration*. *Soft tissue augmentation alone* is very well suited for reconstruction of horizontal defects in a Class I environment but has little or limited ability to eliminate vertical tissue defects in Class II or Class III situations. Still, there are good arguments in favor of performing soft tissue augmentation alone, even in cases where vertical tissue defects are also present, as will be explained.

During the first 3 to 4 months after soft tissue augmentation, a substantial loss (up to 30%) of the gain in tissue volume occurs. The loss associated with onlay grafts (full-thickness grafts) is significantly greater than the volume loss associated with inlay grafts (interpositional connective tissue grafts).[24] Although scientific studies on the long-term stability of alveolar ridges augmented with connective tissue grafts are lacking, clinical experience has shown that minimal further volume changes occur after a 4- to 5-month period. Conversely, long-term hard tissue remodeling processes can be expected after combined hard and soft tissue augmentation.[23,25,29,30] Therefore, a great advantage of soft tissue augmentation alone over combined hard and soft tissue augmentation appears to be a shorter tissue remodeling process, ie, greater long-term stability. The decision to perform soft tissue augmentation alone or in combination with hard tissue augmentation for the reconstruction of edentulous spaces should be critically considered and made on a case-by-case basis, taking the specific conditions of the individual case into account (Figs 13-5 and 13-6).



Fig 13-5 Soft tissue augmentation alone for fixed partial denture restoration: (a) Clinical findings immediately after placement of the final fixed partial denture. (b) Soft tissue conditions are still stable 13 years after the completion of treatment. (Dental technician: *Rainer Janousch*, Munich, Germany.)



Fig 13-6 Combined hard and soft tissue restoration for fixed partial denture restoration. (a) Clinical findings immediately after placement of the final fixed partial denture. (b) Nine years after the completion of treatment, the pontic is exposed and tissue recession is present around the abutment teeth, reflecting the instability of the augmented tissue. (Dental technician: *Rainer Janousch*, Munich, Germany.)

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Class I defects

Fixed partial dentures

Surgical procedures for soft tissue augmentation are dictated by the knowledge that shrinkage processes occur during the postoperative period, resulting in the need for substantial overcompensation when alveolar ridge defects are reconstructed.[24] The lack of tissue availability in this region rules out the use of roll flaps,[34] and full-thickness onlay grafts[32] are no longer employed because it is now known that they have a high complication rate and lead to extensive postoperative shrinkage and unsatisfactory cosmetic results. Good results for soft tissue augmentation have been achieved with the inlay grafting technique and the pouch procedure.

Inlay grafting technique

Originally, inlay grafts were inserted in the recipient bed and covered by the flap, leaving a small portion of the graft uncovered. This made it possible to harvest the graft with epithelium, resulting in horizontal and vertical tissue gain without major displacement of the mucogingival junction.[35,36] Contemporary strategies focus on minimizing the uncovered portion of the connective tissue graft to prevent graft necrosis, harvesting grafts without epithelium to prevent differences in the color and surface texture of the transplanted graft and local tissues, and achieving flap mobility by using tunnel incisions instead of vertical releasing incisions to prevent scarring on the buccal surface. Tunneling instruments are used to extend the incision to the adjacent teeth in order to achieve sufficient flap mobility in the coronal direction.

A distinct advantage of this procedure is that it can be used for both horizontal augmentation of the alveolar ridge and augmentation of the papillae of the adjacent teeth. The inlay grafting technique should be performed in combination with a palatal island flap to ensure that graft coverage is as complete as possible. The use of a two-layer partial-thickness technique for elevation of the palatal island flap (first in the coronal-to-apical and then in the opposite direction) makes it possible to unfold the flap like an accordion in the coronal direction[37] (Fig 13-7).

Pouch procedures

Good results have been obtained using pouch procedures in which a connective tissue graft harvested from the palate is inserted in a prepared pouch and secured with sutures.[38–41] Nutritional conditions for these grafts are optimal, regardless of the location of the access incision. The modified pouch technique makes it possible to perform tissue sculpting around the provisional pontic and surgical reconstruction of the alveolar ridge in a single session. The clinical procedure can be substantially simplified and shortened if the access incision for the pouch is placed so as to allow for definitive shaping and positioning of the provisional pontic immediately after surgery.

The first step of the procedure is to de-epithelialize an area of the affected alveolar ridge; the position and size of the area should correspond to the root cross section of the pontic or missing tooth. Next, the interproximal and buccal soft tissues of the defect region are undermined to prepare a partial-thickness pouch. The pouch must be extended laterally to the adjacent teeth and apically to distinctly beyond the mucogingival junction to ensure sufficient flap mobility. It is also advisable to prepare an island flap on the palatal side.

A large connective tissue graft may be needed, depending on the anatomy of the defect. If this is the case, it may be necessary to make a vertical releasing incision in the region of the alveolar mucosa apical to the defect. The graft can be easily drawn into the pouch with the aid of positioning sutures and sutured in place.

The provisional pontic is inserted in the soft tissue opening, and the provisional fixed partial denture is temporarily cemented before final suture closure. Because the graft is located entirely buccal to the pontic, there is no risk that pressure necrosis will result from postoperative swelling (Fig 13-8).

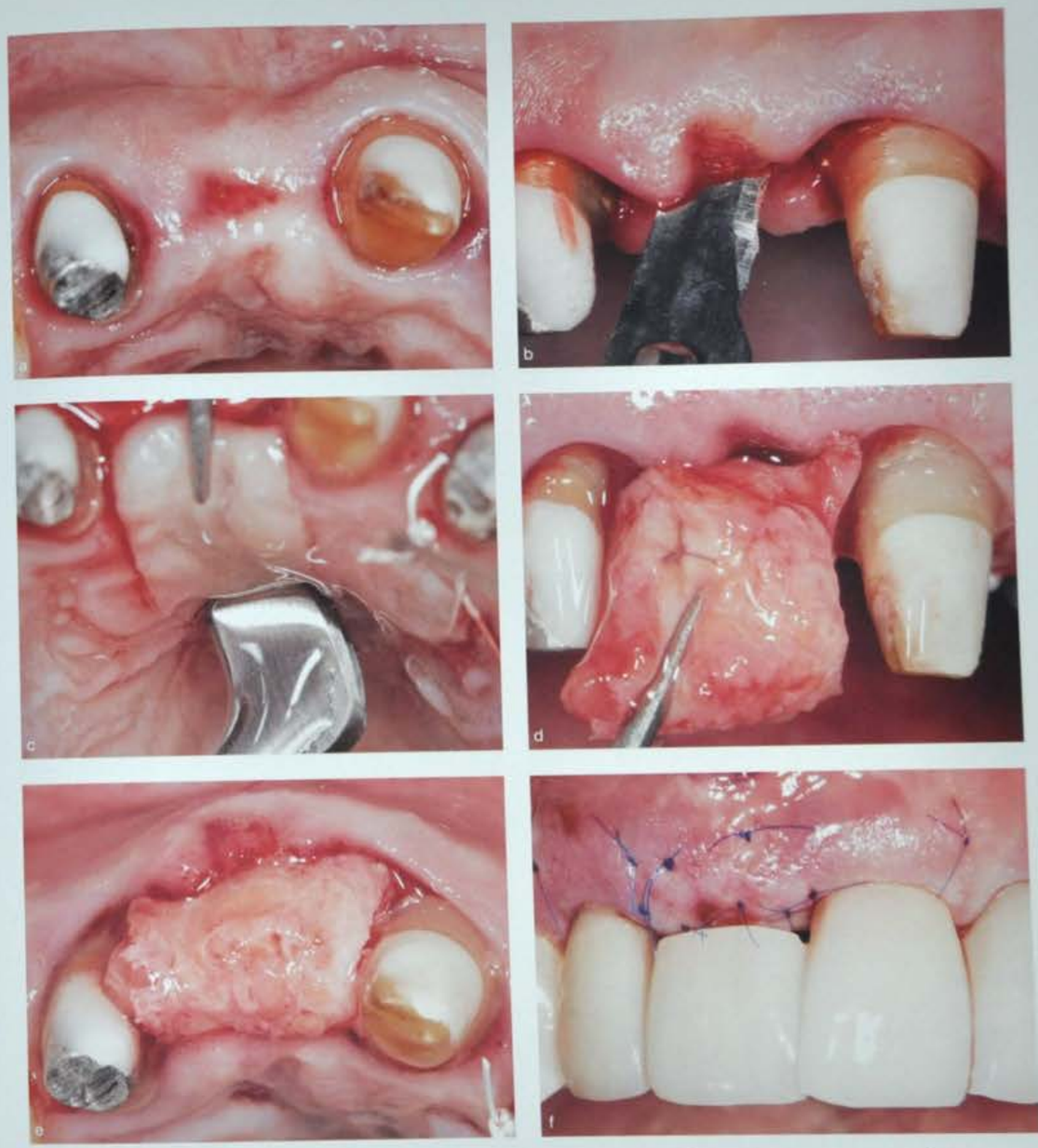


Fig 13-7 (a to f) To obtain adequate flap mobility for the inlay grafting technique, a palatal island flap should be elevated without buccal vertical releasing incisions. After surgery, the provisional pontic must be ground back to ensure that it is not exerting pressure on the augmented tissue. Consequently, the reconstructed soft tissue must be contoured a few weeks later in a secondary procedure.

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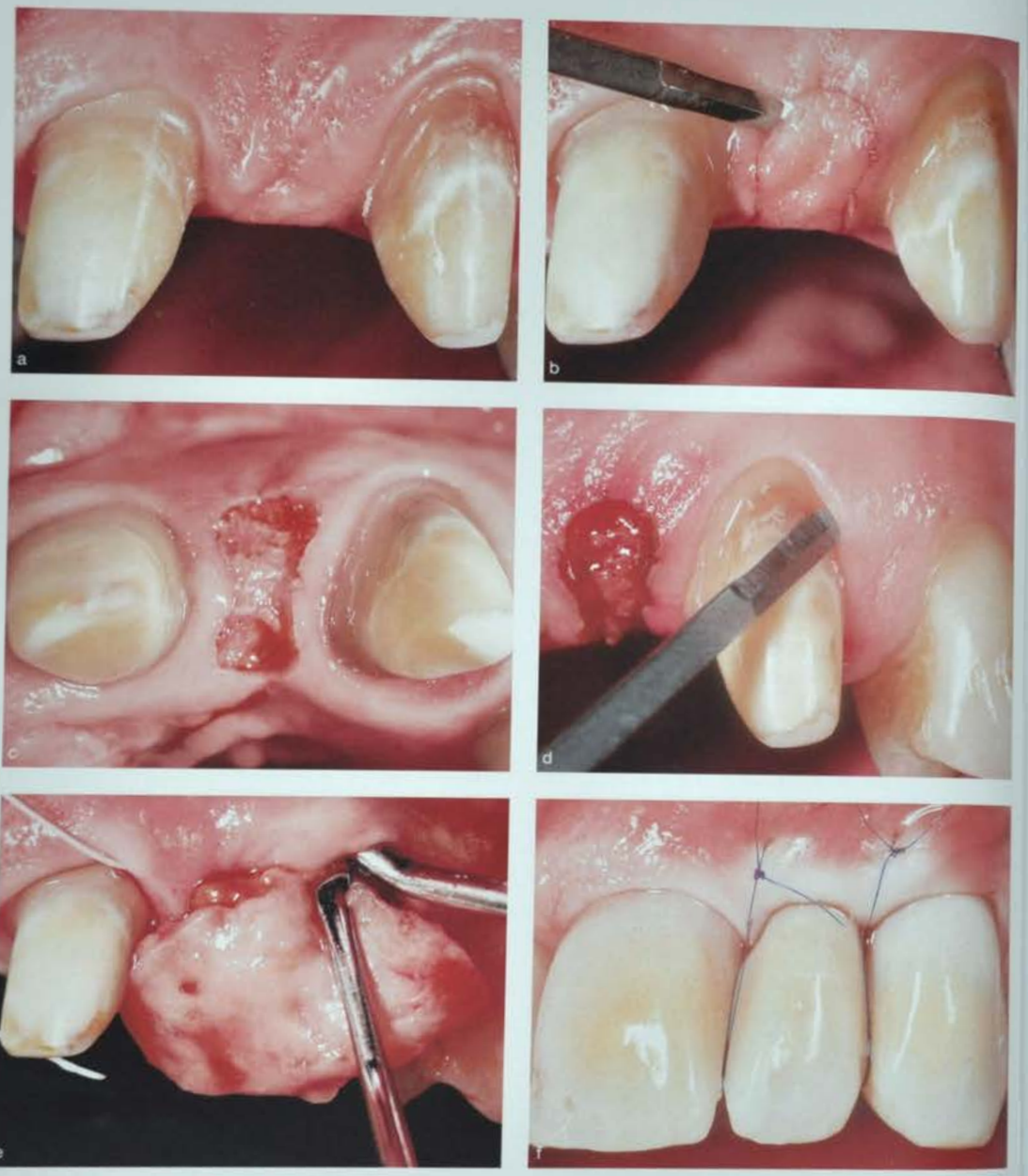


Fig 13-8 (a to f) Pouch technique. After de-epithelialization of an area of the alveolar ridge corresponding to the cross section of the tooth to be replaced, a buccal partial-thickness pouch is elevated. This allows definitive shaping and positioning of the provisional pontic immediately after insertion of the connective tissue graft, thus eliminating the need for postoperative soft tissue contouring in a secondary procedure.

The modified pouch technique has several advantages over the inlay grafting technique. A particular advantage is that less time is needed for soft tissue sculpting after the completion of surgery. However, clinical experience bas shown that the modified pouch technique does not provide sufficient flap mobility for coverage of large horizontal defects. Therefore, the inlay grafting technique is often indicated for treatment of more extensive Class I defects.

The final restoration can be fabricated 5 months after surgery, regardless of which procedure was performed. Soft tissue deficits can be expected in patients with a triangular tooth shape and high gingival scallop. These defects can be masked by lengthening of the interproximal contact points in the apical direction. If an adhesive fixed partial denture is used, composite resin can be added to lengthen the interproximal contact points of the teeth adjacent to the gap (see chapter 11).

Implants

When implants are used to restore Class I edentulous spaces, horizontal hard tissue augmentation is always required to achieve complete osseointegration of the implants. The presence of bone buccal to the implant shoulder is crucial to the esthetic outcome and long-term stability of peri-implant soft tissues.[42] However, a certain amount of tissue shrinkage must be expected during the healing period after hard tissue augmentation. Formation of the biologic width is also associated with the loss of peri-implant bone. For these reasons, it is crucial to augment hard tissue defects with a sufficient amount of overcompensation. The establishment of 2 to 3 mm of bone plate thickness buccal to the implant is considered ideal.[43]

Guided bone regeneration

Hard tissue augmentation for treatment of edentulous spaces is based on the principle of GBR. Preliminary animal studies of GBR procedures documented the fundamental efficacy of e-PTFE membranes for localized alveolar ridge augmentation.[44] Later clinical studies were conducted with the goal of developing a localized alveolar ridge augmentation protocol that provides predictable results in humans.[31,45–48] It was found that a successful outcome could not be expected if exposure and early loss of the membranes occur during the healing period.[49] The access incision and soft tissue management must ensure tension-free primary closure, which is the key to achieving primary healing without membrane exposure. It is also important that the space below the membrane can be maintained during healing. For this reason, autogenous bone and/or bone substitute material can be used to support the membrane (ie, keep it from collapsing into the regenerating wound) and accelerate the regeneration process. Before GBR materials are placed, it is advisable to use small drills to perforate the cortical bone in the defect area to induce adequate bleeding and thus ensure an early and adequate blood supply to the graft.[50,51]

Autogenous bone and bone substitute materials

Autogenous bone and/or xenogeneic bone substitute are the materials primarily used for GBR in implant dentistry. Autogenous bone can certainly be classified as the ideal material for GBR in terms of its osteogenic, osteoinductive, and osteoconductive potential. Nonetheless, the need to harvest the bone from a second surgical site and the limited availability of autogenous bone offset these positive material properties. Ideally, autogenous bone for GBR should be harvested from the angle of the mandible rather than from anterior mandibular symphysis to decrease the rate of complications (see chapter 7) (Fig 13-9).

Either autogenous bone particles or autogenous bone blocks may be used for alveolar ridge reconstruction, depending on the size and configuration of the defect. The use of bone blocks is advisable in cases where bone particles would not provide the necessary stability and immobility needed for successful bone healing. Autogenous bone blocks are mainly used for treatment of large defects and when midbuccal alveolar bone defects occur in the absence of the palatal or lingual alveolar wall. Stable fixation of the graft to the recipient bed with osteosynthesis screws is essential, and the bone blocks must be shaped accordingly. It is also necessary to adequately compensate for the extensive bone resorption that occurs after surgery by oversizing the bone block accordingly. To safely exclude nonosteogenic cells from the site during the healing period, a membrane should be placed over the augmented area, positioned for full coverage, and secured to the bony undersurface (preferably using bioabsorbable nails).

As bone block grafting does not allow for simultaneous implant placement with correct three-dimensional positioning and primary stability, the use of a single-stage approach is not possible. The extensive resorptive processes occurring during the healing period following

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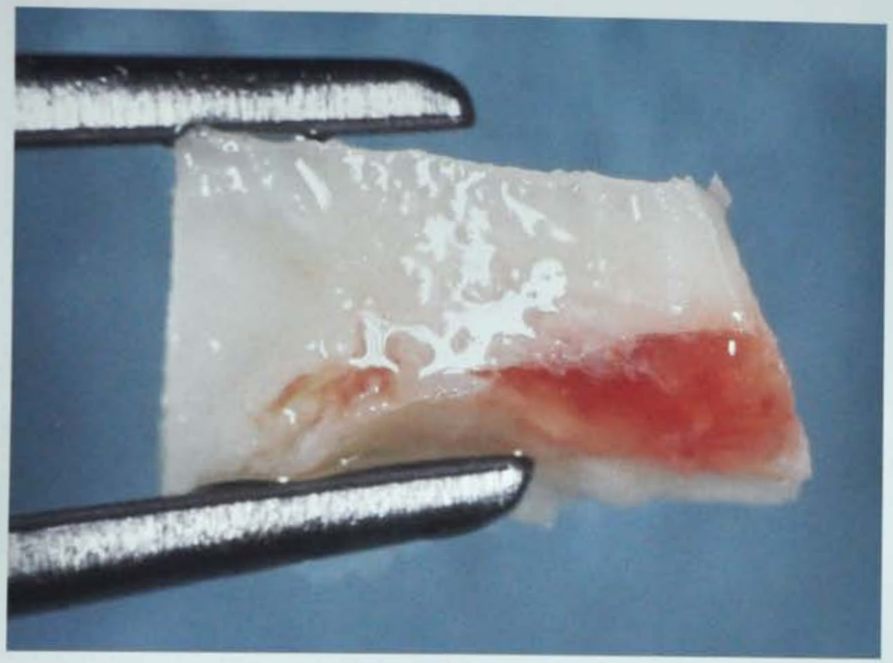


Fig 13-9 Ideally, to decrease the rate of complications, autogenous bone for GBR should be harvested from the angle of the mandible rather than from the anterior mandibular symphysis.

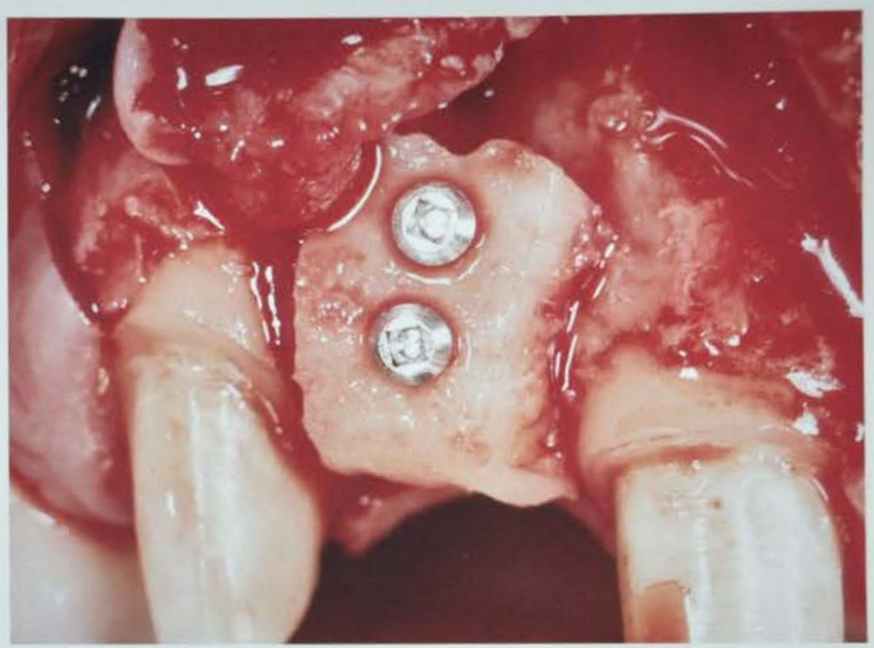


Fig 13-10 Becauses they are subject to extensive, long-term resorptive processes, autogenous bone block grafts do not appear to be the ideal material for augmentation, especially in the esthetic zone.

autogenous bone block graft procedures make it necessary to wait at least 6 to 7 months to allow for complete healing and maturation of the newly formed bone before the implant is placed. The osteosynthesis screws used to secure the bone block can be removed at the time of implantation.

Buser et al[52] evaluated the 5-year survival and success rates of 66 titanium implants placed in bone previously augmented with autogenous bone blocks (lateral augmentation) and nonresorbable e-PTFE barrier membranes in the scope of GBR in 40 partially edentulous patients. They found that the clinical results and prognoses of implants inserted in augmented bone were comparable to those inserted in nonaugmented bone.

Although the use of bone block grafts is a widespread and established clinical practice, block grafts are subjected to extensive long-term postoperative graft resorption, which can be very problematic, especially in the esthetic zone. *Maiorana* et al[53] demonstrated in a prospective clinical study that autogenous bone graft block resorption could be masked or reduced to a certain degree if gaps and spaces between the block graft and the recipient bed were filled and the bone block grafts were covered with very slowly resorbed deproteinized bovine bone mineral (DBBM) particles (Bio-Oss).

Unlike bone particles, bone block autografts are resistant to revascularization from the recipient bed. This is particularly true when their primary constituent is cortical bone, which is usually the case with mandibular block autografts. Resistance to revascularization can induce osteoblast death, particularly in the periphery of the graft.[54] This explains why bone block grafts have a low regenerative capacity in spite of their great osteoconductive, osteoinductive, and osteogenic potentials, and it appears to be the reason for the observed resorption of autogenous bone grafts and the impaired osseointegration of implants placed in bone regenerated with them (Fig 13-10).

Due to the above-mentioned problems, modified versions of the traditional autogenous bone block graft procedures have become popular in recent years. In the cortical bone plate method proposed by *Khoury*,[55] a bone block graft is harvested from the angle of the mandible, then cut in half lengthwise to yield two cortical bone plates, which are secured to the alveolar ridge with osteosynthesis screws. The space between the two plates is filled with autogenous bone particles for regeneration of the defect. This method optimally combines the advantages of dimensionally stable autogenous bone block grafts with those of particulate bone graft materials, which undergo a faster and more intensive revascularization and reorganization into a blood clot due to a larger graft surface area.[56]

In this defect reconstruction method, augmentation with simultaneous implant placement may be feasible in a few cases where osteosynthetic fixation of the cortical bone plates allows for primary stability and optimal three-dimensional positioning of the implant. In the vast majority of cases, however, it is necessary to wait at least 6 months for implant placement.

The extent to which the alternative or combined use of particulate xenogeneic bone substitute materials to fill the space between cortical bone plates or the additional use of membranes for graft coverage might be able to improve the treatment outcome has yet to be determined. In view of the lack of scientific evidence, the procedure can only be recommended based on the promising results observed in clinical practice. Scientific studies will also be needed to evaluate the feasibility of using synthetic bone graft substitutes made of polylactide/polyglycolide copolymers as an alter-

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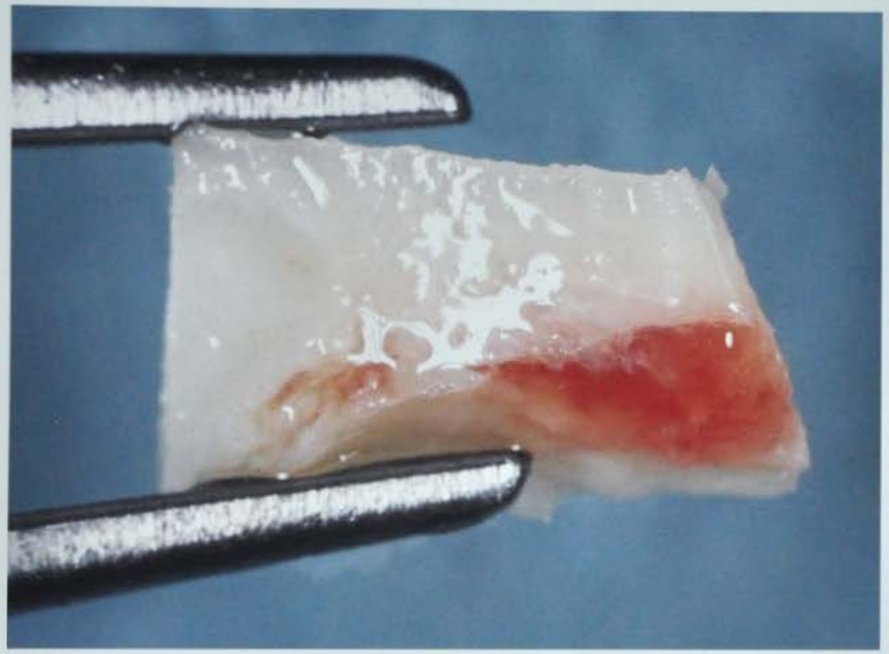


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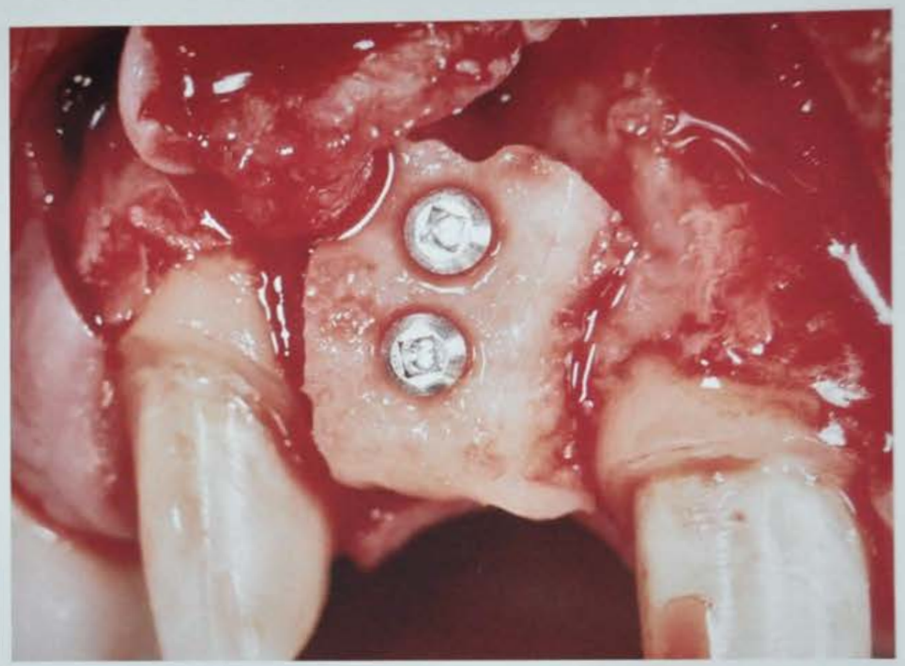


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Fig 13-11 In the cortical bone plate method proposed by *Khoury,*[55] a bone block graft is harvested from the angle of the mandible, then cut in half lengthwise and thinned. These cortical bone plates are secured to the alveolar ridge with osteosynthesis screws, ensuring that the defect area is adequately covered and stabilized. The space between the two plates is filled with autogenous bone particles for regeneration of the defect.

native to autogenous cortical bone plates in the future (Fig 13-11).

Of the numerous xenogeneic bone substitute materials available in the market, particulate DBBM is the best scientifically investigated and documented material (see chapter 7). The available scientific data suggest that, compared to GBR with autogenous bone grafts, the use of bone substitute materials alone does not have a negative effect on the survival rates of implants. However, there are significant differences in the healing patterns of bone substitute materials and autogenous bone grafts. Because bone substitute materials result in a reduction and a sharp delay in graft resorption,[57–59] they should be able to achieve much greater volume stability of the augmented site, which could prove to be important for the long-term success of implant therapy, particularly in the esthetic zone[60] (Fig 13-12). Xenogeneic bone blocks have not been established and validated as bone substitute materials for GBR in implant dentistry to date.

Barrier membranes

Barrier membranes used for GBR can be divided into two broad categories based on their chemical composition: resorbable and nonresorbable. Resorbable barrier membranes are made of enzymatically degradable (mainly collagen- or polylactide/polyglycolide-based) materials, while nonresorbable barrier membranes are made of PTFE, which is sometimes reinforced with titanium for improved stability of form. The main disadvantages of nonresorbable materials are that they must be removed after healing (which could require a second surgery, depending on the treatment protocol) and are associated with a relatively high rate of membrane exposure,[61,62] which leads to bacterial contamination and the need for early removal of the membrane. In a study of GBR with resorbable or nonresorbable membranes in combination with xenogeneic bone substitute (Bio-Oss) for treatment of peri-implant dehiscences, *Zitzmann* and colleagues[63] found that wound dehiscence and membrane exposure resulting in the need for early membrane removal occurred at 44% of sites treated with nonresorbable (e-PTFE) membranes but in less than 10% of sites treated with resorbable membranes.

To overcome these obstacles, researchers have been working on the development and implementation of resorbable membranes for GBR with characteristics resembling those of e-PTFE membranes.[64,65] Synthetic barrier membranes made of polylactide/polyglycolide copolymers and collagen membranes made of bovine and porcine type I and type II collagen are the most promising candidates so far. Currently, collagen membranes are the main focus of scientific and clinical efforts because of their ideal handling characteristics and good tissue integration. Collagen membranes undergo enzymatic degradation by tissue-specific proteases and collagenases.[64,66]



Fig 13-12 At present, there is no definitive scientific evidence clarifying the extent to which DBBM particles may be used in combination with or as a replacement for autogenous bone particles for GBR.

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Their lack of dimensional stability and rapid and uncontrolled absorption are two major disadvantages.[67,68] To ensure the proper regeneration and maturation of newly formed bone, a functioning barrier must be in place for at least 6 months; however, most of the adequately researched commercial collagen membranes begin to exhibit a loss of stability and resorption after only a few weeks in service.[69]

In an experimental study of the biodegradation of different cross-linked collagen membranes in rats, *Rothamel* et al[69] demonstrated that the differences between the various types of collagen membranes studied in terms of their biocompatibility, tissue integration, and biodegradation over time were very great. The combined use of two different types of membranes could have a synergistic effect. Therefore, *Hürzeler* et al[70] recommended a double-layer technique for GBR using particulate autogenous bone grafts or xenogeneic bone substitutes: The defect and bone or bone substitute material are covered with a slowly resorbing, cross-linked collagen barrier membrane, which is in turn covered with a second conventional, non-cross-linked collagen membrane. The objective of this approach is to compensate for the lack of dimensional stability and rapid resorption of the non-cross-linked collagen barrier membrane by combining it with a dimensionally stable and slowly resorbing collagen membrane but still to take advantage of the high biocompatibility, good tissue integration, excellent clinical handling, and other advantages of non–cross-linked collagen membranes.

The modified double-layer technique is an excellent method for performing horizontal hard tissue augmentation with simultaneous implant insertion, especially at sites with small defects. It makes it possible to achieve predictable horizontal alveolar ridge augmentation, even with bioabsorbable barrier membranes, provided that the body of the membrane is adequately supported and stabilized by bone graft or bone substitute materials[22] (Fig 13-13).

To avoid the second surgical site associated with bone block harvesting, many authors recommend bone splitting for horizontal hard tissue augmentation of local alveolar ridge defects in the esthetic zone.[71] However, possible changes in attachment level around the adjacent teeth could be a critical issue. The future will show whether bone-splitting techniques will make it possible to achieve predictable results similar to those of GBR.

One-stage versus two-stage procedures

Single-stage surgery in which augmentation is performed simultaneously with implant placement is preferable to a two-stage approach because of the shorter treatment duration and greater patient comfort but is not always clinically feasible. It is crucial that the hard tissue augmentation procedure be selected according to the individual defect anatomy. One-stage simultaneous augmentation and implant placement with primary stability and correct three-dimensional positioning of the implant is rarely possible when cortical bone plates are used and is never possible with autogenous block grafts. Conversely, for Class I defects with a preserved palatal or lingual bone plate, it is often possible to perform a one-stage procedure with particulate autogenous bone or xenogeneic bone substitute material and an appropriate barrier membrane for reconstruction of buccal bone defects.

Even after thorough clinical and radiographic preoperative examinations, it may become clear during surgery that the severity of the bony defect was misdiagnosed and that the planned one-stage implant procedure cannot be performed after all. These cases require a two-stage procedure in which hard tissue augmentation is performed in the first stage and implant placement is performed during a second surgery after an adequate healing period.

Single-stage horizontal hard tissue augmentation with simultaneous implantation can always be performed in a Class I environment provided that the palatal or lingual bone wall is preserved and the defect configuration (moderate midbuccal bone contour defects) makes it possible to obtain primary implant stability and correct implant positioning. Then, dehiscences or fenestrations almost always develop during implant placement because of the described defect anatomy in the bucco-oral direction. In other words, parts of the implant in the buccal region will not be covered by alveolar bone coronally, apically, or longitudinally (Fig 13-14).

Like local alveolar ridge defects, alveolar bone dehiscences and fenestrations can be reconstructed by GBR with e-PTFE membranes after implantation,[72–74] but the problems regarding nonresorbable membranes in terms of the need for a second surgery and the risk of membrane exposure still apply in this case.[73,74] However, because numerous studies have shown that comparable results can be achieved using resorbable collagen barrier membranes, it is no longer necessary to use nonresorbable barrier membranes for treatment of peri-implant dehiscences and fenestrations.[63,75–78] Nevertheless, it is important to support the space-preserving function of the membrane during healing by inserting a filling material between the exposed implant surface and the barrier.[79,80] Evidence suggests that perforating the cortical bone in the defect area around the inserted implant with small drills may contribute to ensuring an adequate blood supply to the augmented tissue.[50,51] The membrane is then secured to the augmented area, preferably using bioabsorbable nails.



Fig 13-13 In the modified double-layer technique, a non–cross-linked collagen barrier membrane is used in combination with a cross-linked collagen barrier membrane.

Especially in this indication for Class I defects to be treated in a single-stage procedure, the combined use of two overlapping membrane barriers seems to be superior to the use of a singular barrier membrane in terms of the final treatment outcome, as demonstrated with the modified double-layer technique for the combined use of a cross-linked lower and non–cross-linked upper collagen barrier membrane.[60,70] However, it is currently not possible to recommend this special two-membrane technique based on scientific evidence from randomized controlled trials (Fig 13-15).

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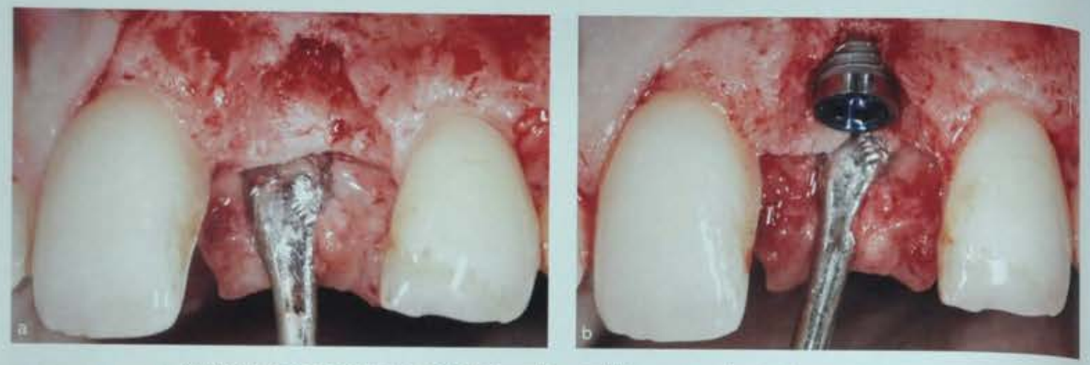


Fig 13-14 (a and b) If a single-stage procedure is used, the formation of dehiscences or fenestrations can be expected.



Fig 13-15 (a and b) In the modified double-layer technique, DBBM is inserted between the implant and the collagen barrier membranes to support the space-preserving function of the two membranes.

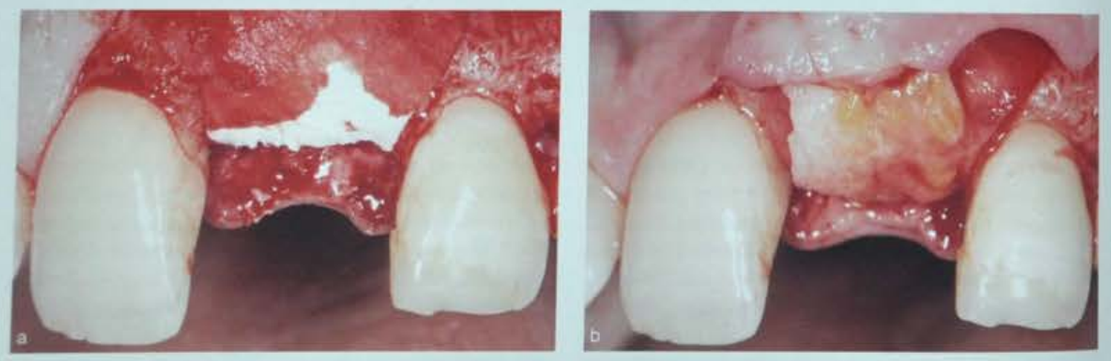


Fig 13-16 (a and b) Soft tissue augmentation with a free subepithelial connective tissue graft harvested from the palate or tuberosity area is performed simultaneously with hard tissue augmentation. The connective tissue graft is positioned so that it covers the alveolar ridge both buccally and below the incision line. This ensures closed healing of the implant and augmentation site, even if mild wound dehiscence occurs.



Fig 13-17 A mucosal punch procedure can be used to uncover the implant if a buccal peri-implant tissue deficit is no longer present.

Simultaneous augmentation of peri-implant hard and soft tissues is performed to optimize the volume of both the hard and soft tissues. For this purpose, a free connective tissue graft is harvested from the palate or tuberosity area, placed in the correct position on the inner surface of the buccal flap, and precisely sutured without tension. Periosteal slitting and other flap extension and mobilization measures may be required. The connective tissue graft is positioned so that it covers the alveolar ridge both buccally and below the incision line. This ensures closed healing of the implant and augmentation site, even in cases of mild wound dehiscence (Fig 13-16). In order to prevent postoperative complications, the provisional restoration must be modified after surgery to ensure that it is not exerting pressure on the surgical site.

The defect situation in the edentulous area is reassessed at second-stage implant uncovering surgery 5 months later. If a *buccal tissue deficit* is no longer present at that time, a minimally invasive mucosal punch procedure can be used to uncover the implant (Fig 13-17).

A modified roll flap technique can be used to compensate for *moderate tissue deficits* at second-stage

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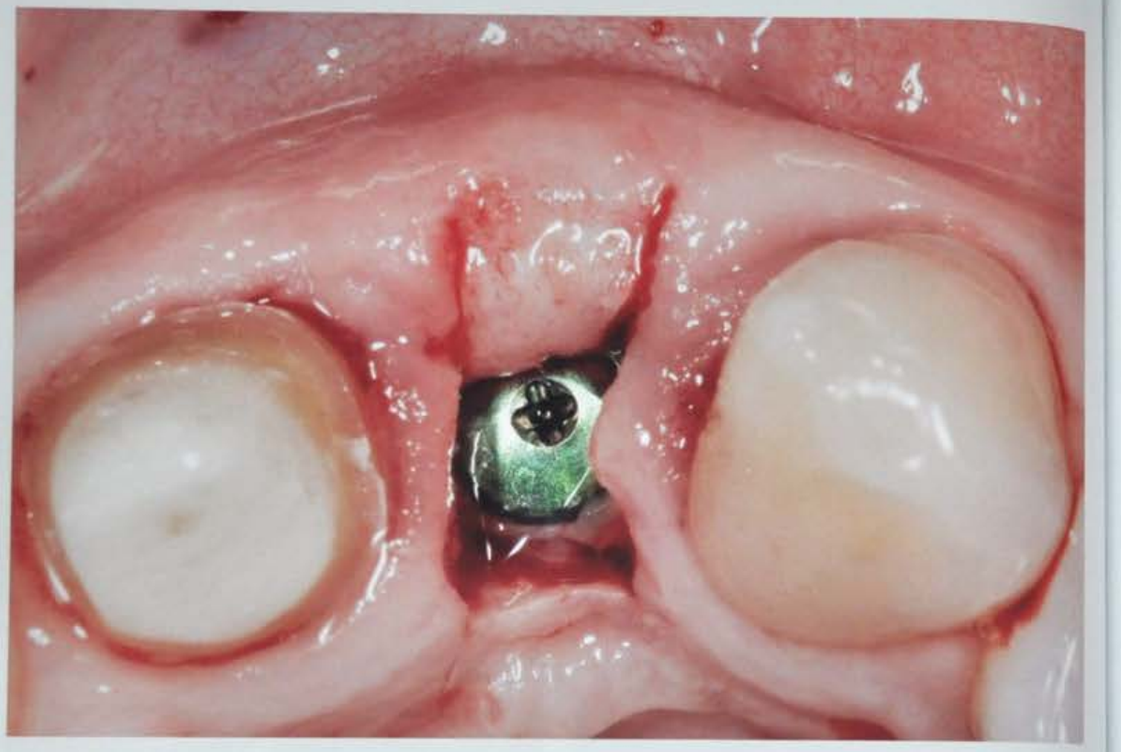


Fig 13-18 The modified roll flap technique can be used to compensate for moderate buccal tissue deficits at the time of second-stage implant uncovering surgery.

implant uncovering surgery.[81] First, the soft tissue in the area above the implant is de-epithelialized. The tissue around the implant shoulder in the palatal and interproximal areas is then dissected via a horizontal incision extending to the bone. A buccal pedicle flap is elevated, exposing the implant. Next, microblades and Tunneling Knives are used to elevate and undermine a buccal partial-thickness flap. The incision must be extended laterally to the adjacent teeth to ensure sufficient flap mobility. The non–de-epithelialized interproximal soft tissues in the edentulous area are also included in the incision until a soft tissue collar around the uncovered implant has been fully mobilized. The pedicle flap can now be rolled into the buccal pouch to compensate for the tissue deficit. In some cases, a palatal island flap may also be needed to cover exposed bone palatal to the implant shoulder and to release tension on the interproximal soft tissue[37] (Fig 13-18).

The presence of *extensive tissue deficits* when the implant is uncovered makes it necessary to perform further soft tissue augmentation with a free subepithelial connective tissue graft obtained from the palate or tuberosity region. A conventional mucosal punch is then placed, and a connective tissue graft is inserted into a prepared buccal pouch (Fig 13-19).

Regardless of the technique used to uncover the implant, the next step is to convert the existing provisional restoration into an implant-supported provisional. It



Fig 13-19 The presence of extensive tissue deficits when the implant is uncovered makes it necessary to perform further soft tissue augmentation with a free subepithelial connective tissue graft obtained from the palate or tuberosity region.

is important to consider that any subsequent alterations of the contours of the provisional after soft tissue healing always results in a change in the peri-implant soft tissue contours.[82,83] Therefore, the emergence profile of a provisional restoration, placed at the time of implant uncovering, should largely correspond to that of the definitive restoration, as will be described in detail in the section on the design of pontics and abutments. Ideally, the implant position should be transferred to a diagnostic cast at the time of implant placement through the use of an intraoperative index (ie, an impression post attached to the implant and splinted to the adjacent teeth using flowable composite). Instead of adapting the existing provisional prosthesis after the implant is uncovered, an ideally contoured (additional) laboratory-fabricated provisional restoration can be placed immediately after uncovering.

If the implant is uncovered by simple tissue punch, fabrication of the final restoration can begin 3 months later. However, if implant exposure was achieved with the modified roll flap technique or an additional connective tissue graft, fabrication of the final restoration should be postponed for 5 months.

Table 13-1 provides an overview of the different techniques of uncovering implants, selected in accordance with the buccal soft tissue conditions.

Two-stage implant placement is not performed at Class I defect sites unless one-stage implant placement is not

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Table 13-1

Techniques used for implant uncovering and their selection based on buccal soft tissue conditions

Buccal soft tissue deficit at time of implant uncovering	Technique
No deficit	Punch
Moderate deficit	Modified pouch technique
Extensive deficit	Punch with autogenous connective tissue graft

possible. *Two-stage* implant placement is always necessary in cases where the palatal or lingual bone wall is absent or when the defect anatomy does not permit primary stability of the implant in the prosthetically correct position.

In these cases, the defect size and configuration generally make it necessary to use an autogenous bone graft obtained from the lateral angle of the mandible. The graft may be manipulated to achieve the wound stabilization needed for successful bone healing. Because the cortical bone plate method was found to have many convincing theoretical and practical advantages over conventional GBR procedures using autogenous bone block grafts, it can be recommended as the current method of choice for first-stage surgery in two-stage implant placement in spite of the technical complexity of the procedure and the lack of scientific evidence. The space between the cortical bone plates is filled with a mixture of autogenous bone particles and DBBM and covered with a conventional non–cross-linked collagen barrier membrane (Fig 13-20).

After the first surgery, the provisional restoration must always be ground back to ensure that it is not exerting excessive pressure on the augmented tissue, which would impair healing. The soft tissue swelling expected to occur in the surgical site must be taken into account.

Implantation, implant uncovering, and further prosthetic procedures are performed as described for single-stage implant placement at sites with Class I defects.

Class II defects

Predictable esthetic success cannot be expected in a Class II environment. If hard tissue augmentation is planned, GBR and the cortical bone plate method are very well suited for the correction of vertical defects. Sandwich osteotomy and distraction osteogenesis can also be performed but can be technically difficult in certain cases. For details regarding the characteristics and correction of vertical alveolar ridge defects, see the section on Class III defects. The present section provides a brief description of the potentials, limitations, and problems associated with reconstruction of Class II defects. When Class II and Class III defects are treated, the first step is to determine whether a prosthetic solution is feasible. In Class II cases, prostheses with artificial gingivae rarely provide acceptable esthetics, whereas constructions with long interproximal contacts are often able to successfully mask interproximal tissue deficits (Fig 13-21). If the teeth adjacent to the gap are already prosthetically prepared and restored, orthodontic extrusion of the two adjacent teeth can be considered for vertical tissue augmentation.[84,85] Correct execution of the technique and a stabilization period of sufficient duration are crucial factors.

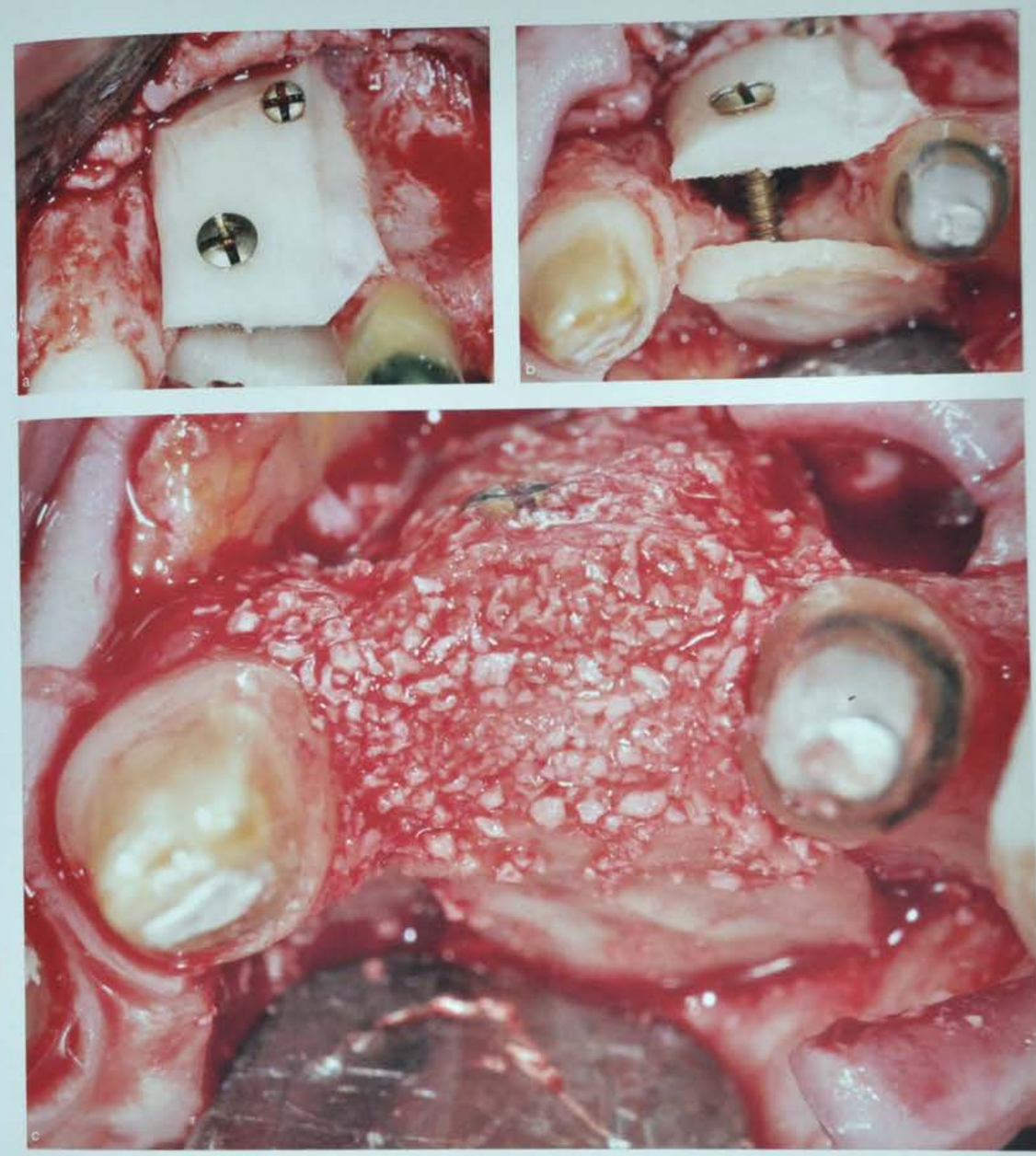


Fig 13-20 (a to c) Two-stage implant placement is unavoidable when a Class I site is characterized by the absence of the palatal or lingual bone wall in addition to the buccal wall or when the defect anatomy does not permit primary stability of the implant. In light of the described disadvantages of autogenous bone blocks, the cortical bone plate method is highly recommended for first-stage surgery under these conditions. The space between the cortical bone plates is filled with a mixture of autogenous bone particles and DBBM and covered with a conventional collagen barrier membrane.

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Fig 13-21 (a to f) Fabrication of a conventional fixed partial denture for a patient with Class II defects in the maxillary anterior region. Soft tissue augmentation alone improved the defect situation somewhat, and it was possible to mask the remaining interproximal tissue deficits to a certain extent by fabricating a restoration with long interproximal contacts. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

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Fixed partial dentures

Fixed partial dentures at Class II sites are subject to the same principles that apply to those in Class III situations. These principles are described in the following section. If the goal is only to improve the situation rather than to achieve the most perfect result, soft tissue augmentation alone will suffice. The procedure already described for fixed partial dentures in Class I cases is then used.

Implants

Implant placement at Class II sites is subject to the same rules that apply in Class III situations as described in later sections. Although horizontal hard and soft tissue augmentation procedures cannot achieve complete defect reconstruction, as was explained in the previous section on implant placement in Class I situations, they can help to improve the cosmetic outcome.

Class III defects

In patients with Class III defects, the fundamental potentials and limitations of vertical defect reconstruction must be thoroughly weighed before treatment. GBR with autogenous bone particles or bone substitute materials and e-PTFE membranes,[23,25] autogenous bone blocks with or without membranes,[23,29,86] the cortical bone plate method,[87] sandwich osteotomy,[28] and distraction osteogenesis[23,29,30,88] are the main hard tissue augmentation procedures currently discussed in the literature for correction of vertical tissue defects. While the survival rates for implants inserted in vertically augmented bone are very similar to those for implants inserted in nonaugmented bone, the few available long-term studies raise problems regarding the long-term prognosis of vertically augmented bone during the observation periods.

GBR with autogenous bone particles

Simion et al[25] evaluated osseointegrated implants inserted simultaneously with or subsequent to vertical ridge augmentation in a long-term retrospective clinical study of 123 implants with 1- to 5-year follow-up. Three ridge augmentation procedures were compared: e-PTFE membranes without additional filler material (group A), e-PTFE membranes with freeze-dried bone allografts as the filler (group B), and autogenous bone particles in combination with the membranes (group C). Bone loss during the observation period was a mean of 1.35 mm in group A, 1.87 mm in group B, and 1.71 mm in group C. Only 2 of 123 implants exhibited increased crestal bone loss (3.5 mm and 4.0 mm, respectively) at the 1-year follow-up. The radiographic analysis was not performed using a standardized method. Still, the authors concluded that the bone remodeling and resorptive processes occurring in vertically augmented bone after implantation are similar to those at implants placed in nonaugmented bone.

Autogenous bone blocks

In a prospective clinical study in 15 partially edentulous patients, *Cordaro* et al[26] observed extensive resorptive changes after vertical and horizontal alveolar ridge augmentation with autogenous bone blocks that were obtained from the lateral angle of the mandible and placed without membranes. The mean horizontal and vertical augmentation obtained was 6.5 mm and 3.4 mm, respectively, at the time of augmentation, but these amounts had decreased by 23.5% (horizontal) and 42.0% (vertical) 5 to 6 months later, at the time of implant insertion. *Nystrom* et al[27] used hip bone grafts to perform combined vertical and horizontal alveolar ridge augmentation in edentulous patients and observed a continuous decrease in bone level throughout the 3-year follow-up period.

Sandwich osteotomy

Jensen et al[89] observed 10 patients for 5 years following sandwich osteotomy for segmental anterior maxillary vertical augmentation prior to implant placement. They concluded that the esthetic outcome was satisfactory and stable in all patients throughout the observation period. However, the technique was limited to vertical augmentation of 5 mm in the maxillary anterior region because of the lack of elasticity of the palatal mucosa.

Distraction osteogenesis

In another 5-year prospective clinical study, *Jensen* et al[30] evaluated the results of 30 distraction osteogenesis procedures in 28 patients. The amount of distraction was less than 2.0 mm in the horizontal dimension, but a mean of 6.5 mm was achieved in the vertical dimension. The authors concluded that distraction osteogenesis was a suitable technique for vertical augmentation in the maxillary anterior region.

Chiapasco and colleagues[23,29] compared the efficacy of autogenous bone, GBR with autogenous bone particles, and distraction osteogenesis for reconstruction of vertical bone defects in two prospective clinical studies. Their comparison of distraction osteogenesis and GBR demonstrated that both procedures allow adequate correction of vertical tissue deficits but that distraction osteogenesis results in much fewer complications compared to GBR. In addition, the mean resorption over 3 years was significantly lower in the distraction osteogenesis group (1.93 mm) than in the GBR group (2.96 mm).[23] Fewer differences emerged in the comparison between distraction osteogenesis and autogenous bone block grafts. Although the mean resorption was significantly lower in the distraction osteogenesis group (0.3 mm) than in the autogenous bone block group (0.6 mm) from the time of augmentation until implant placement, statistically significant differences were no longer observed during the further course of follow-up (2 to 4 years).[23,29]

Based on the described scientific studies, it can be concluded that GBR, distraction osteogenesis, and sandwich osteotomy all allow for augmentation in the horizontal and vertical dimensions, which can lead to defect reconstruction that is more or less complete depending on the conditions at baseline. However, clinical experience has shown that treatment success cannot be expected, in particular, between two implants or two pontics or between an implant and a pontic.

Based on the available scientific evidence, sandwich osteotomy seems to offer the most advantages. However, if the dimension of the vertical defect component is more than 5 mm, distraction osteogenesis must be considered as an alternative to sandwich osteotomy. Only in cases where it is not possible to perform sandwich osteotomy or distraction osteogenesis can GBR with nonresorbable e-PTFE membranes and bone blocks used in conjunction with bone substitute materials be recommended. This also applies when vertical defects occur in combination with substantial horizontal defects. In such cases, sandwich osteotomy or distraction osteogenesis procedures would result in a need for second surgery for horizontal augmentation (ie, GBR). This additional cost and effort is hardly justifiable to the patient. Therefore, when vertical defects occur in combination with substantial horizontal defect components, the use of GBR procedures for combined horizontal and vertical augmentation should generally be given preference at the outset. From a scientific perspective, the effectiveness of the cortical bone plate method proposed by *Khoury*[55] for vertical augmentation in Class III situations is still unclear at present.

The long-term prognosis of vertically augmented tissue proves to be a particularly problematic issue. The remodeling and resorption that occur in the augmented tissues, even after placement of the final restoration, can be tolerated to a certain degree in areas outside the esthetic zone. Within the esthetic zone, however, problems emerge over the course of time as increasing exposure of the implants and implant components develops. Ultimately, before surgical procedures for correction of vertical defects are indicated, these problems must be taken into consideration with the fact that such procedures are associated with high postoperative morbidity and are very technique sensitive.

Consequently, none of the vertical augmentation procedures that are currently available can truly be recommended for routine use in the esthetic zone. If surgical correction of a Class III situation is planned in spite of this, *Khoury*'s cortical bone plate compact method[55] is considered by the authors to be the most likely method of choice—after all advantages and disadvantages are carefully weighed. Although scientific data on this method are currently lacking, positive clinical experiences with the procedure as well as many biologic bases suggest that the cortical bone plate method can be used with the described alternative methods of vertical hard tissue augmentation in a practicable and promising manner.

Because of the described inadequacies of the available vertical augmentation procedures, the possibility of a prosthetic solution should always be considered first in Class III situations. The use of pink ceramic material to mask tissue defects is always an option in cases where it is possible to place the junction between the artificial and natural gingivae in an area that will not be visible, even when the patient is laughing. Furthermore, it must be possible to practice adequate oral hygiene with lip support. If these conditions are met, nearly perfect esthetic results and long-term stability can be achieved at relatively low cost and effort (Fig 13-22).

Fixed partial dentures

The requirements for a prosthetic solution for Class III sites are determined by esthetic and functional factors as well as by the need for adequate oral hygiene. In any case, it is advisable to first test the functionality and acceptance of a prosthetic solution by fabricating a provisional restoration. From an esthetic point of view, the junction between the artificial and natural gingivae should not be visible when the patient is smiling. The higher the smile line and the more central the gap, the harder it is to achieve this goal. To avoid disharmonious

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Fig 13-22 (a to c) An implant-supported prosthesis with ceramic artificial gingivae is used to restore a Class III site. The junction between artificial and natural gingivae is not visible when the patient is smiling. (Dental technician: *Rainer Janousch*, Munich, Germany.)



Fig 13-23 It can be helpful to perform horizontal soft tissue augmentation prior to prosthetic treatment to establish sufficient lip support without compromising oral hygiene. This also allows the positioning of convex pontics in the augmented soft tissues, which effectively prevents food retention and phonetic problems.

junctions, it is advisable to use artificial gingivae when the pontics and the crowns on abutment teeth are fabricated.

As the pink ceramic components of the prosthesis also contribute to the lip support, they must have an adequate horizontal dimension. This can cause oral hygiene problems in patients with extensive horizontal defects. Therefore, it is better to perform horizontal soft tissue augmentation using a connective tissue graft obtained from the palate or tuberosity area before a prosthetic solution is attempted (Figs 13-23 and 13-24). This makes it possible to properly position the base of convex pontics in the soft tissues to prevent the food retention and phonetic problems associated with the presence of gaps and spaces between the base of the pontic and the alveolar ridge. In addition, the horizontal tissue gain makes it easier to obtain an adequate horizontal dimension of the artificial gingivae without compromising oral hygiene. The surgical and prosthetic procedures correspond to the procedures described for fixed partial dentures in Class I situations.

The more apical the base of the fixed partial denture is positioned, the better from an esthetic point of view but the worse for the ease of oral hygiene by the patient. Insertion aids can be integrated in the base of the prosthesis for ease of cleaning (Fig 13-25).

If the prosthetic solution tested with the provisional restoration did not yield acceptable results, a decision as to

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Fig 13-24 A fixed partial denture has been fabricated with artificial gingivae for restoration of a Class III site. Horizontal soft tissue augmentation was performed prior to fabrication of the fixed partial denture, which facilitates oral hygiene with the fixed partial denture. (Dental technician: *Rainer Janousch*, Munich, Germany.)

whether surgical correction of the defect would lead to relevant improvement of the outcome from the patient's perspective must be made; the previously mentioned limitations and the patient's input must be taken into account. If the decision is in favor of corrective surgery, it is important to perform hard tissue augmentation with one of the aforementioned procedures as the first step. After adequate time for healing (3 months after sandwich osteotomy or distraction osteogenesis, and 6 months after GBR or the cortical bone plate procedure), horizontal soft tissue augmentation procedures (inlay graft or pouch procedure) can be performed and the final restoration fabricated, as was described in the section on fixed partial dentures for Class I defects. Becvause long-term resorption must be expected in vertically augmented hard tissue, it is advisable to wait as long as possible before the final restoration is fabricated in these cases.

Implants

The diagnostic procedure for implant placement in Class III sites is analogous to that for fixed partial dentures. First, the acceptability of a purely prosthetic solution should be evaluated with a provisional restoration, as was described. If the decision is in favor of a prosthetic solution without surgical defect correction, then implant position will be crucial from a functional perspective. Due to the morphology of the defect in these cases, there is a risk that the implant or implants will be inserted too far palatally, especially in the maxilla. The consequences would be hard-to-clean implants and a palatally overextended dental prostheses, which could later lead to functional and phonetic impairments. Therefore, horizontal soft tissue augmentation in combination with horizontal hard tissue augmentation may be needed to achieve acceptable implant positioning within the framework of prosthetic solutions. The corresponding surgical and prosthetic procedures are analogous to that described previously for implant placement in Class I sites.

If a prosthetic approach is used, the junction between the implant reconstruction and the adjacent teeth poses a problem. If the teeth have already been prosthetically prepared, splinting of implant- and tooth-supported prostheses can be considered to extend the artificial gingiva portion of the implant reconstruction to harmonize with the junctions on the tooth-supported prosthesis. If the adjacent teeth are intact, a gingival mask (pink composite resin) can be added to the apical region of the teeth adjacent to the gap in an attempt to achieve a harmonious junction. To ensure adequate oral hygiene, a slight gap must remain open between the composite and the implant-supported prosthesis.

If the prosthetic solution tested with the provisional restoration does not yield the desired result, the question of whether surgical correction of the defect should be performed and, if so, which type of procedure should be used must be carefully assessed. If surgery is deemed necessary, the first step must be to perform hard tissue augmentation with one of the procedures previously described. After adequate time is allowed for healing (3 months after sandwich osteotomy or distraction osteogenesis, and 6 months after GBR or the cortical bone plate procedure), further treatment can be initiated as described in the section on implant restorations for Class I defects (Fig 13-26).

Peri-implant soft tissue recession is difficult to correct. Therefore, it is imperative to ensure that abutments and implant-supported prostheses are designed in such a way that at least minor tissue losses can occur without



Fig 13-25 It has proved helpful to integrate insertion aids into the base of prostheses fabricated with artificial gingivae to make it easier for the patient to clean the prosthesis.

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Fig 13-26 (a to d) Clinical example of a surgical solution in combination with implant placement at a Class III site. (a and b) A patient presented with a provisional restoration in the maxillary anterior region. Many years earlier, the maxillary left central incisor had been replaced with an implant because of traumatic tooth loss. (c and d) Six weeks earlier, the right central incisor had been extracted by another practitioner because of a vertical root fracture. The patient reported that a dramatic loss of hard and soft tissues had occurred shortly after extraction.



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Fig 13-26 (e to g) A provisional restoration was fabricated to test the acceptability of a purely prosthetic solution. Because it was not possible to hide the junction between the artificial and natural gingival tissue during smiling, a surgical alternative was preferred.



Fig 13-26 (h to j) An implant was used to replace the maxillary right central incisor. After a 3-month healing period, volume tomography was performed as part of distraction osteogenesis planning. Orthodontic distalization of the roots of the two lateral incisors was necessary to ensure that vertical osteotomy could be performed without damaging the adjacent teeth. Due to the proximity to the nasal cavity, it was also decided to cut the implant in the region of the left central incisor in the scope of distraction and to leave the apical portion of the implant in the bone.









Fig 13-26 (k to n) After completion of the osteotomy, a special screw distractor was attached to the mobilized piece of bone. The screw was inserted through an opening made in the provisional restoration for this purpose; the bone fragment was moved coronally by turning of a nut on the buccal side of the provisional restoration. (m and n) Ten days later, the provisional was modified to allow for fine adjustment of the mobilized bone fragment via an orthodontic appliance. Once the distracted bone fragment reached the desired position, the device was left in place for 5 months for stabilization purposes. The implant in the region of the left central incisor was removed, and horizontal soft tissue augmentation was performed during this time.

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Fig 13-26 (o and p) Clinical appearance immediately before the impressions for the final restoration were taken.





Fig 13-26 (q and r) Final result after the completion of treatment. (Dental technician: *Rainer Janousch*, Munich, Germany.)

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Table 13-2

Fundamental features of clinical procedures for the replacement of missing teeth with fixed partial dentures and implants, according to defect class

Defect	Socket morphology	Fixed partial denture protocols	Implant protocols	Prognosis
Class I	▪ Single tooth missing ▪ CEJ–AC ≤ 1 mm	▪ **Soft tissue augmentation alone** *Moderate defect:* Pouch technique *Extensive defect:* Inlay technique	▪ **Hard and soft tissue augmentation** *Hard tissue:* Single-stage: Double-layer technique Two-stage: Cortical bone block procedure *Soft tissue:* Connective tissue graft at the time of implantation and, if necessary, at the time of implant uncovering	▪ Good
Class II	▪ Single tooth missing ▪ CEJ–AC > 1 mm	▪ **Hard and soft tissue augmentation** *Hard tissue:* Cortical bone block procedure *Soft tissue:* Inlay or pouch technique ▪ **Prosthetic measures** Long interproximal contact points	▪ **Hard and soft tissue augmentation** *Hard tissue:* Single-stage: Cortical bone block procedure Two-stage: Cortical bone block procedure *Soft tissue:* Connective tissue graft at the time of implantation and, if necessary, at the time of implant uncovering ▪ **Prosthetic measures** Long interproximal contact points	▪ Fair
Class III	▪ Multiple teeth missing	▪ **Hard and soft tissue augmentation** *Hard tissue:* Cortical bone block procedure *Soft tissue:* Inlay or pouch technique ▪ **Prosthetic measures** Long interproximal contact points and artificial gingiva (gingival ceramics)	▪ **Hard and soft tissue augmentation** *Hard tissue:* Single-stage: Cortical bone block procedure Two-stage: Cortical bone block procedure *Soft tissue:* Connective tissue graft at the time of implantation and, if necessary, at the time of implant uncovering ▪ **Prosthetic measures** Long interproximal contact points and artificial gingiva (gingival ceramics)	▪ Poor

CEJ–AC: distance between the cementoenamel junction and the interproximal alveolar bone crest.

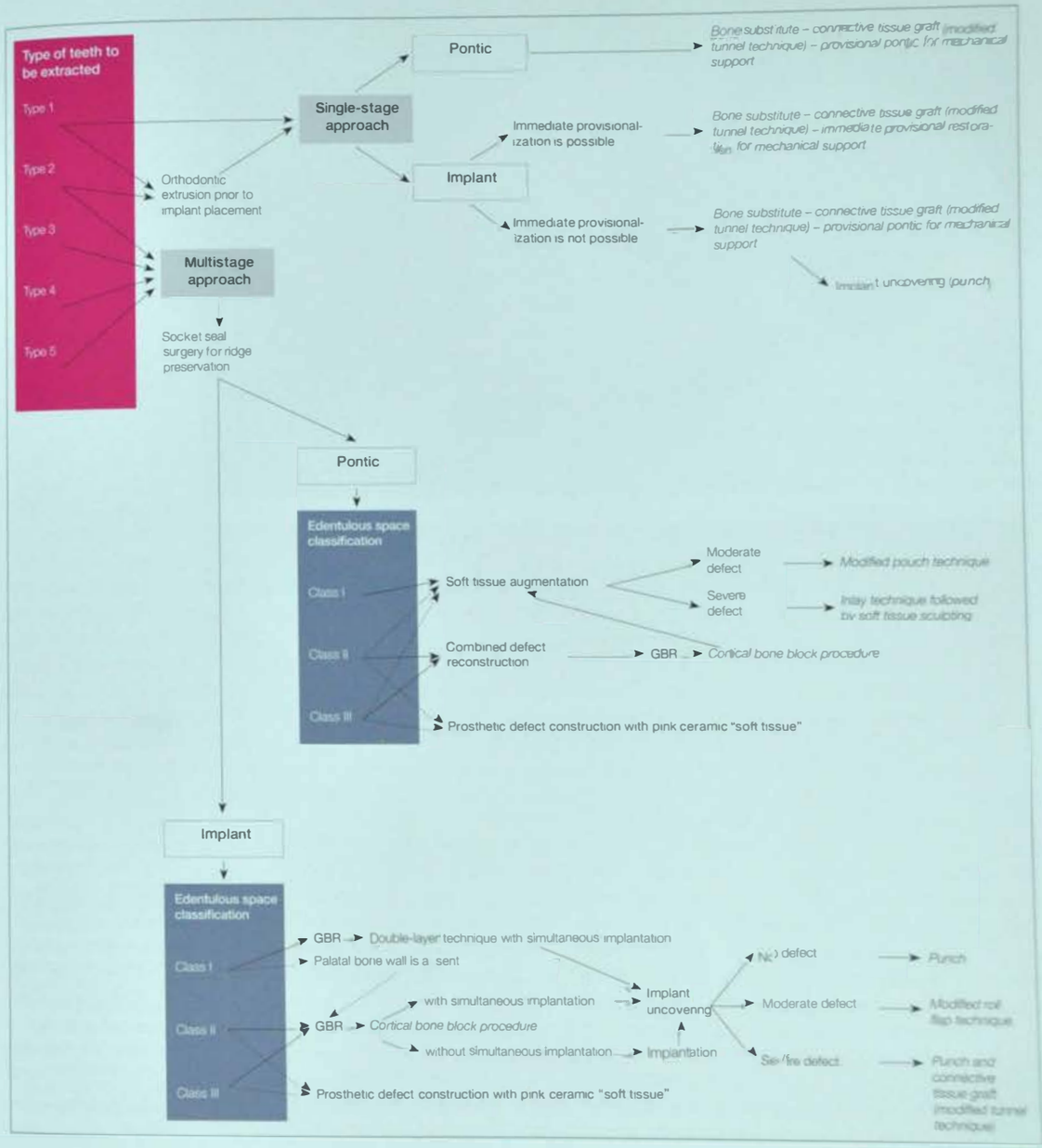
resulting in visibility of their metal and zirconia components (see the section on abutment and pontic design), especially in Class III situations after surgical reconstruction of defects.

The most important features of the clinical procedures for the different defect classes are shown in Table 13-2.

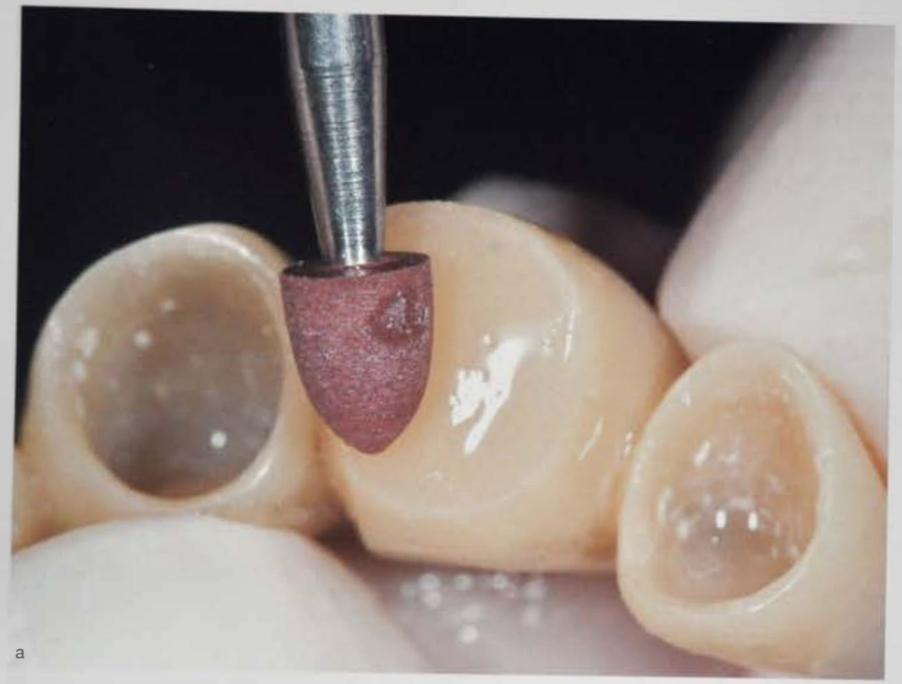
Table 13-3 provides an overview of the clinical concept for treatment of edentulous patients presented in this book. A summary and systematic review of fundamental principles will be presented again based on the *hopeless tooth classification* presented in chapter 12 and the *edentulous space classification* described previously. The very rapid emergence of new scientific and clinical developments in the field of plastic-esthetic periodontal and implant surgery, especially those related to postextraction defect prevention and augmentation surgery, must be taken into consideration. Therefore, the corresponding treatment concepts must be dynamically reviewed, adapted, and modified regularly as new developments emerge.

Table 13-3

Overview of the treatment decision-making process based on the *classification of teeth to be extracted* presented in chapter 12 (pink field) and the *classification of edentulous spaces* (blue field). If the tooth was extracted long before the start of prosthetic rehabilitation, the blue field is the starting point for decision making.



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a



b

Fig 13-27 (a and b) Soft tissue sculpting by the application of controlled pressure is tremendously time-consuming. The successive build-up of flowable composite resin during multiple consecutive appointments results in gradual transformation of the originally ground-back pontic into a modified ovate pontic design. Care must be taken to ensure that pressure exerted by the pontic on the augmented tissue does not cause anemia of more than 5 minutes' duration.

13.1.4 Soft Tissue Sculpting in Edentulous Areas

The task of sculpting the soft tissue in edentulous areas is usually accomplished by applying *controlled pressure* during the early healing phase after soft tissue augmentation (fixed partial dentures) or implant uncovering (implant-supported restorations). To prevent excessive apical displacement of the reconstructed tissues, soft tissue sculpting must be performed in small increments over several consecutive appointments. The corresponding time requirements for the dentist and the patient are enormous. Therefore, all implant uncovering procedures recommended in this book allow for immediate provisionalization with an implant-supported restoration featuring the definitive emergence profile. When the modified pouch technique is used for augmentation of soft tissue beneath pontics, it is possible to fabricate a provisional pontic with the definitive contour, thus eliminating the need for time-consuming soft tissue contouring.

The only case in which a definitively contoured pontic cannot be fabricated immediately is when a fixed partial denture is planned and the inlay grafting technique of soft tissue augmentation must be performed because of the size of the defect. Pressure on the freshly augmented tissue, which can be intensified by postoperative swelling, could lead to pressure necrosis, thus compromising the surgical outcome. Step-by-step conditioning of the augmented soft tissue can rarely be avoided in these cases. *Immediately after surgery*, the provisional pontic must be initially ground back at the base far enough to prevent the impairment of healing associated with the inlay grafting technique, as was described previously. It is necessary to create an adequate safety margin commensurate with the expected extent of postoperative swelling.

Soft tissue sculpting can be initiated *2 weeks after surgery*. This can be accomplished by various methods. The traditional approach consists of *pressure contouring* of the reconstructed soft tissue. This is accomplished by repeatedly applying flowable composite resin to the base of the pontic during multiple consecutive appointments to gradually develop a modified ovate pontic shape (see the section on pontic and abutment design). Several try-ins and adjustments are made to ensure that there is a large area of contact between the adjusted pontic base and the augmented site. The interproximal and facial soft tissues should protrude slightly over the edge of the pontic base in the coronal direction. The pressure exerted by the pontic on the augmented tissue must not cause anemia of more than 5 minutes' duration.[90] It is crucial to ensure that the pontic base is smooth and well polished before insertion.

Two to three biweekly appointments for adaptation of the pontic base are usually needed to create the desired shape. A new layer of composite is applied to the pontic base at each visit. For better control of layer thickness, different composite resin shades should be used at the different appointments (Fig 13-27).

Soft tissue sculpting can also be accomplished by attaching a pin to the pontic base. This reduces the risk of apical displacement of the tissue considerably. Instead of directly transforming the pontic into a modified ovate pontic while applying controlled pressure, the alternative method starts by providing the pontic with a lancetlike pin that extends into the augmented soft tissue with minimal pressure. During two to three appointments at 2-week intervals, the apical end of the pontic is gradually shortened and the lateral surfaces are successively built up with composite resin until the desired modified ovate pontic design has been achieved. In other words, pressure is exerted in the lateral direction rather than in the apical direction. Clinical experience has shown that this method makes it easier to stabilize the augmented tissue in a coronal position during conditioning, especially at sites with Class II or Class III ridge defects (Fig 13-28).

The only way to avoid the substantial treatment time associated with the aforementioned methods of soft tissue contouring (pressure sculpting and pin sculpting) is to use a method by which the final contours of the pontic can be established in the augmented soft tissues in a single step some weeks after augmentation surgery. This is generally accomplished by using an electrotome, microblade, or coarse diamond bur to remove a piece of soft tissue corresponding to the size of the pontic base from the augmented site and immediately inserting a provisional fixed partial denture with the definitively contoured pontic. However, experience has shown that neither the exact position of the pontic base in the augmented soft tissue nor the exact geometric shape of the excised tissue can be estimated precisely enough. Consequently, this alternative method is highly prone to error and lacks adequate predictability (Fig 13-29).

The *"cookie cutter" technique* has successfully reduced the time required for soft tissue contouring following

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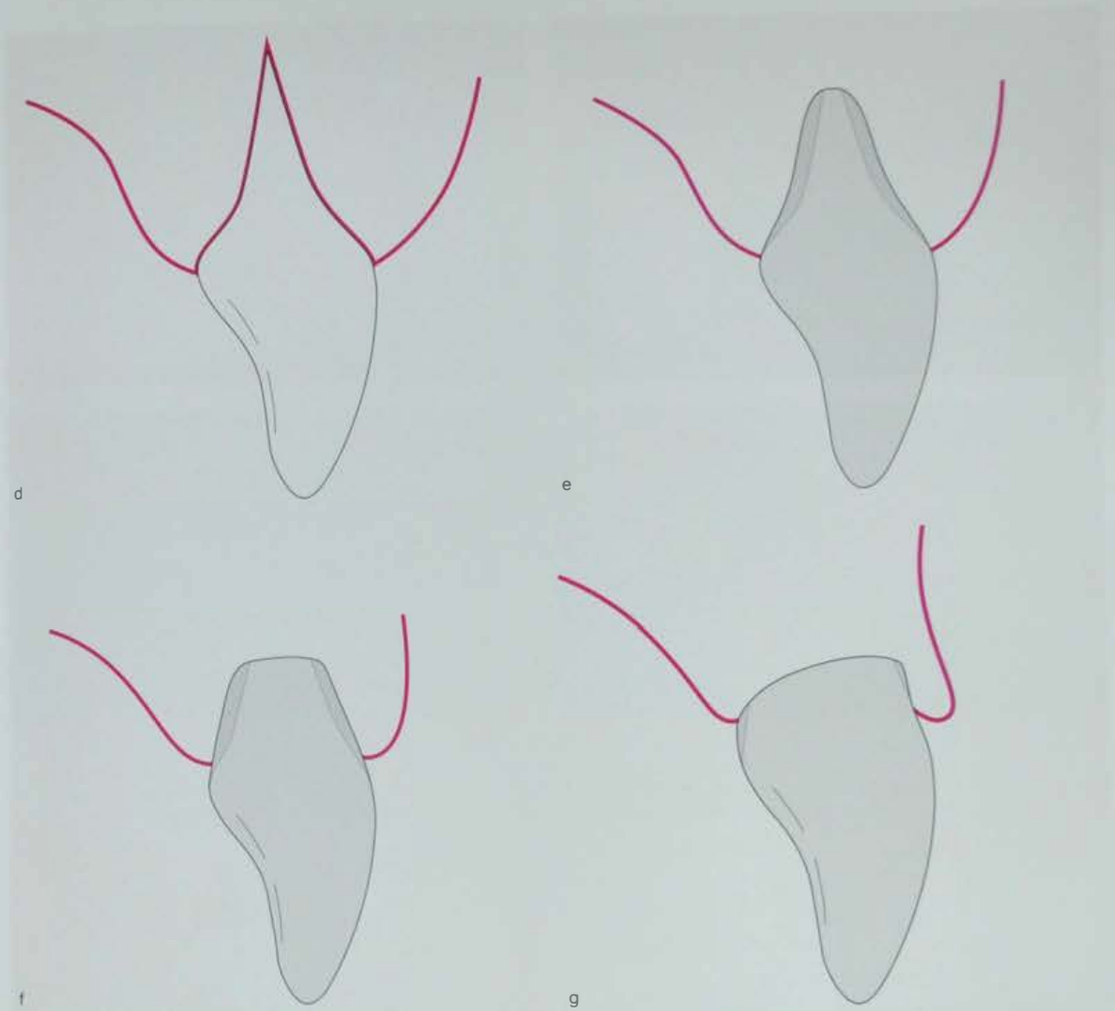


Fig 13-28 (a to g) Class II ridge defect corrected by the inlay grafting technique of soft tissue augmentation. To prevent apical displacement of the soft tissue during soft tissue contouring, the pontic base is designed with a lancetlike pin that extends into the augmented soft tissue with minimal pressure. At biweekly intervals, the pin is gradually shortened and the pontic is built up laterally until the desired modified ovate pontic design has been achieved. Like conventional pressure sculpting, this approach to contounng the augmented soft tissue is very time-consuming.

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Fig 13-28 (h to j) Final result after the completion of treatment. (Dental technician: *Rainer Janousch*, Munich, Germany.)



Fig 13-29 The only way to avoid the substantial treatment time associated with pressure sculpting and pin sculpting is to use a method by which the final contours of the pontic can be established in the augmented soft tissues in a single step some weeks after augmentation surgery. An electrotome, a microblade, or a coarse diamond bur is generally used to remove a piece of soft tissue corresponding to the size of the pontic base from the augmented site, but this method is highly prone to error and lacks adequate predictability.

the inlay grafting technique while still providing a good clinical outcome with predictable success. The provisional pontic is still immediately altered to yield a modified ovate pontic but, unlike the previous methods, the inside is hollowed out, leaving only the outer walls of the pontic base. Approximately 2 weeks after surgery, the modified provisional restoration is gently pressed against the augmented soft tissue to mark the exact position and outline of the pontic. A microblade is used to make deep cuts along the outline, creating a tightly fitting space to accommodate the pontic in the augmented soft tissue. Soft tissue inside the pontic base area is then removed, starting from the palatal aspect and proceeding along the external margin of the pontic base. After the hollow pontic has been filled with flowable composite, the provisional restoration can be placed in the augmented tissue without pressure.

The cookie cutter technique makes it possible to place a pontic with the final contours approximately 2 weeks after augmentation in a single step, reducing chair time for the patient and the dentist significantly. Furthermore, it permits a very high degree of precision and predictability of soft tissue excision, both in terms of the position of the pontic in the augmented tissue and in terms of the match between the shapes of the pontic base and the excised tissue (Fig 13-30).

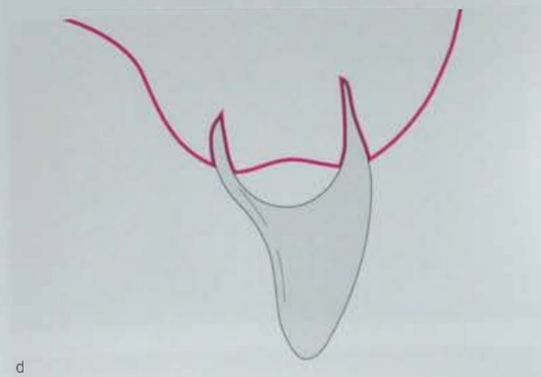
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Fig 13-30 (a to c) The cookie cutter technique has successfully reduced the time required for soft tissue contouring following the inlay grafting technique while still providing a good clinical outcome with predictable success. The provisional pontic is first hollowed to create the outline of the final contours and then pressed against the augmented tissue to mark the exact position and outline of the pontic base. Next, a microblade is used to make deep cuts along the outline, creating a tightly fitting space to accommodate the pontic in the augmented soft tissue.







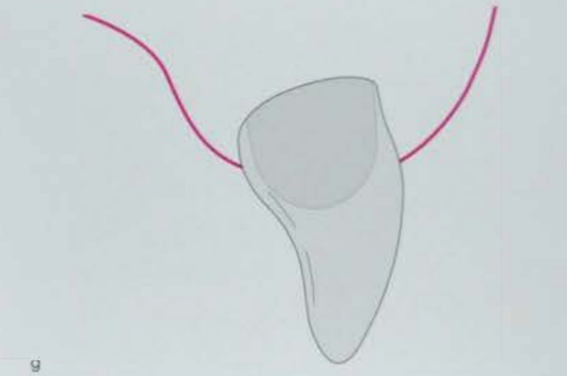




Fig 13-30 (d to h) Soft tissue inside the pontic base area is removed, starting from the palatal aspect and proceeding along the external margin of the pontic base. After the hollow pontic has been filled with flowable composite resin, the provisional fixed partial denture can be placed in the augmented tissue. This technique makes it possible to place a pontic with the final contours in the augmented tissue in a single step without pressure.

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Fig 13-30 (i to k) Final result after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

Fabrication of the final restoration must be postponed for least at 5 months to allow for complete healing of the soft tissue until no further shrinkage is expected. If the contour of the provisional restoration is not ideal and requires adjustment at that time, the definitive restoration can only be inserted at the risk of changes in the soft tissue margin. To prevent this, it is essential that the shape of the implant-supported provisional restoration at the time of surgical implant exposure and the shape of the provisional pontic at the time of soft tissue grafting or on completion of soft tissue contouring meet all contour-related requirements that will apply to the final prosthetic restoration (Fig 13-31).

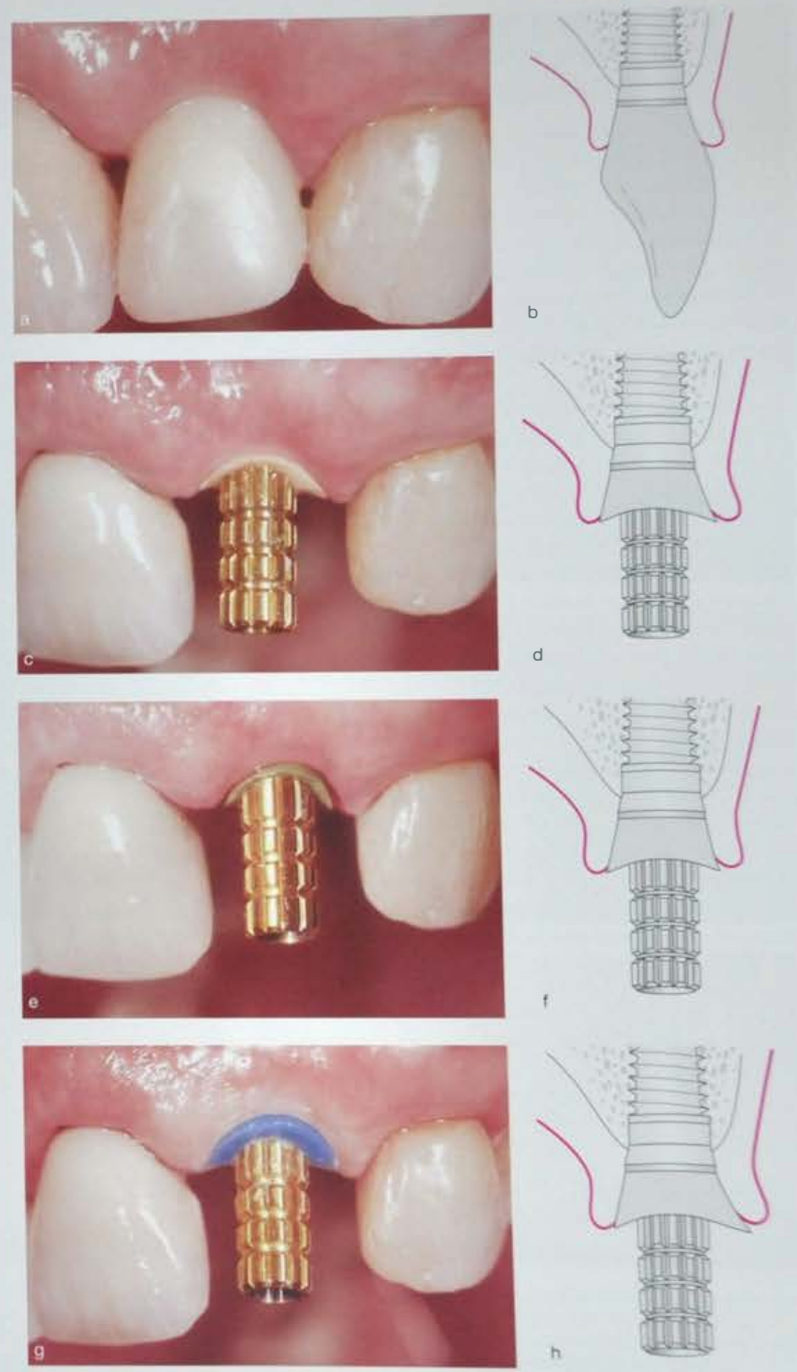


Fig 13-31 Once healing is completed, the contour of the restoration can no longer be changed without altering the soft tissue margins. (a and b) An implant-supported provisional restoration is shown 5 months after surgical exposure. (c and d) If the emergence profile of the provisional restoration has been precisely duplicated, later changes in the soft tissue margin are unlikely. Apical migration of the peri-implant soft tissue can occur as a result of undercontouring (e and f) or overcontouring (g and h).

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Fig 13-30 (i to k) Final result after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

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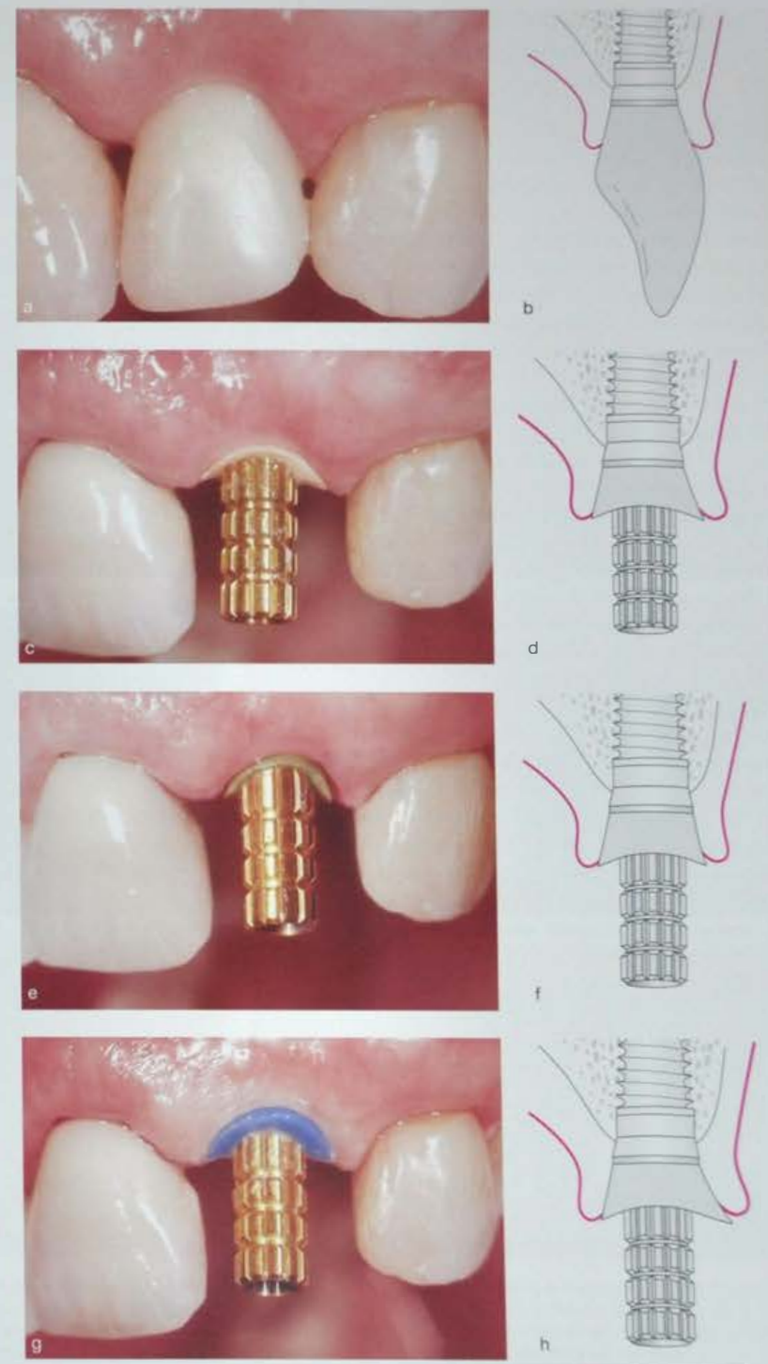


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Fig 13-32 (f to k) After removal of the provisional restoration, a punch is used (f and g) to carefully remove the soft tissue above the implant shoulder. (h to k) After the temporary abutment has been attached, the provisional restoration (ground on the inside) is repositioned and attached to the temporary abutment with flowable composite resin. Subsequently, the implant-supported restoration is finished outside of the patient's mouth.



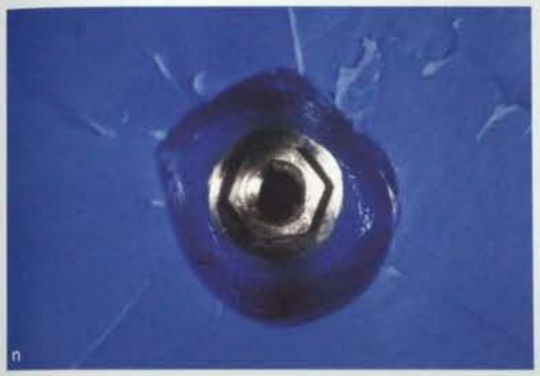



Fig 13-32 (l to o) To fabricate a custom impression post, the implant-supported provisional restoration is screwed on an implant analog (l), and impression material is injected around it (m) without covering the screw access hole or incisal third of the crown. (n) After the impression material has set, the provisional restoration is removed. The external contour of the implant-supported provisional restoration then becomes visible in the impression material down to the shoulder of the analog. (o) An impression post is screwed on the implant analog.

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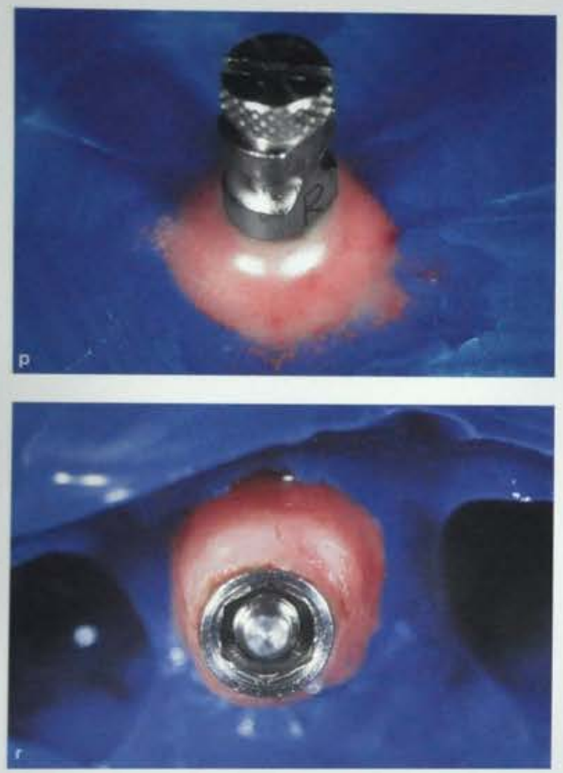






Fig 13-32 (p to s) The spaces between the impression material and impression post are filled with wax (p), resulting in a custom impression post, the shape of which matches the contour of the implant-supported provisional restoration. (q) The correctness of transfer can be checked against the soft tissue contour with the impression post in place. Once the impression has been taken (r), the modified provisional restoration is attached to the implant (s).







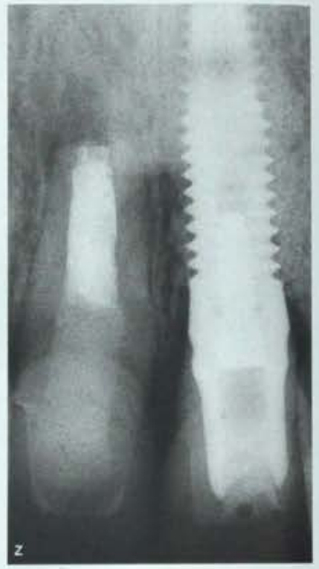
Fig 13-32 (t to v) Casting of the impression yields a model (t) that accurately reproduces the peri-implant soft tissue situation in the patient's mouth. (u and v) The custom abutment can now be fabricated without the need for additional try-ins.

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w


x


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z


aa


bb


cc


dd

Fig 13-32 (w to dd) Results after placement of the definitive restoration. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

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Transferring the contours of provisional pontics

One way to transfer the contour of a provisional pontic is to take an impression of the final pontic base included in the relined and polished provisional restoration after final preparation and impression taking. This is accomplished by mixing silicone putty and shaping it into a cuboid form matching the size of the provisional fixed partial denture to be fabricated.

At the same time, low-viscosity silicone is injected into the internal surfaces of the provisional crowns and on the surface of the provisional pontic base. These surfaces are pressed into the not yet hardened silicone putty. Once the silicone has set, the provisional prosthesis can be removed and inserted in the patient's mouth. The key objective is to obtain a silicone model that will serve as a working cast for fabrication of the definitive pontic base.[93]

A more elegant and accurate solution is to fabricate a modified custom impression tray. This is accomplished by taking an alginate impression over the provisional restoration in the patient's mouth. The provisional restoration is then removed and repositioned in the alginate impression for pouring, which, like the silicone model discussed earlier, results in a stone cast that should accurately reflect the intraoral tissue situation around the pontic. This cast is used to fabricate a custom tray, which will include a gap in the extension area precisely reflecting the position and shape of the provisional pontic base. Conditions must allow for reliable and unambiguous visual verification of seating of the extension tray during impression procedures. The accuracy of transfer can be verified against the soft tissue margin when the tray is tried in the mouth. This procedure should yield a working cast that accurately reproduces both the prepared teeth and the conditioned soft tissues. Casts prepared in this manner can be used as a matrix for fabrication of the final pontic base (Fig 13-33).





Fig 13-33 (a to c) Transfer of the contours of a provisional pontic to a working cast for fabrication of the final restoration in the laboratory. (a and b) Baseline clinical conditions. (c) Results 5 months after provisional restoration and periodontal surgery for treatment of gingival recession around the left canine and an alveolar ridge defect in the area of the missing right central incisor.

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Fig 13-33 (d to h) The fabrication of a custom impression tray (d) starts with an alginate impression taken over the provisional restoration in the patient's mouth. The restoration is then removed from the mouth and repositioned in the impression. (e) The impression is poured, yielding a cast that accurately reproduces the intraoral soft tissue conditions around the provisional pontic. (f) The cast is subsequently used to fabricate a custom tray for the final impression. (g and h) The tray includes an extension for the contour of the provisional pontic base.








Fig 13-33 (i to n) Conditions must allow for visual verification of seating of the extension tray during impression taking. (n) The resulting cast, which accurately reproduces the intraoral soft tissue conditions around the provisional pontic, is used to fabricate the definitive restoration. Therefore, no additional try-in is needed for fabrication of the definitive pontic.

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Fig 13-33 (o to t) Clinical appearance before and after placement of the definitive restoration. The soft tissue contours around the definitive pontic are unchanged from those around the provisional restoration.





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Fig 13-33u Patient at the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

13.1.6 Pontic and Abutment Design

Regardless of whether implants or fixed partial dentures are used to replace missing teeth, the esthetic goal of treatment is to mimic the missing teeth as perfectly as possible. First, the pontic or abutment must be *contoured* in such a way that it blends harmoniously with the surrounding tissue, imitating the gingival margin around the natural teeth. Second, the restorative *materials* used must provide adequate mechanical stability and maximal biocompatibility to the restoration while simultaneously matching the natural teeth in terms of color and light-optical properties.

Designs used for pontics and implant abutments

Pontics

Dental pontics must meet a number of mechanical, functional, hygienic, and esthetic requirements.[94] Functional requirements dictate that an ideal pontic must have punctiform or linear contact with the alveolar ridge, exerting little or no pressure on the tissues,[95] while esthetic requirements dictate that an ideal pontic must be embedded in the soft tissues because this is the only way for the pontic to both imitate the contours of and support the surrounding gingiva of the natural teeth.[94] The esthetic ideal calls for intimate contact between the pontic base and the surrounding mucosa, which is questionable from the functional and biologic perspectives.[95–98]

However, various studies have shown that the relationship between the pontic base and the soft tissues is not a major factor in periodontitis. The crucial factors are a pontic shape that is conducive to good oral hygiene and the patient's oral hygiene compliance: ie, the patient must be able to clean the area under the pontic regularly with normal dental floss or Super Floss.[99,100] Neither the materials used to manufacture the pontic base[95,101,102] nor the pressure exerted on the gingival tissues by cosmetic pontics seems to induce any major inflammatory responses in patients with adequate oral hygiene.[103] Still, many variations of the basic design of cosmetic pontics have been proposed, the most important of which are discussed here.

Total ridge lap pontics seem to offer a number of esthetic advantages, but adapting them to the edentulous ridge usually requires the use of a concave pontic base, which is extremely difficult for the patient to clean.[95] As a result, plaque accumulates beneath the pontic, which can lead to inflammation, ulceration, and changes in the soft tissue margin.[96,104]

Modified ridge lap pontics are designed with a convex base, and tissue contact is limited to the buccal side of the ridge crest. The design meets all functional and biologic requirements in terms of promoting good oral hygiene and preventing soft tissue irritation,[95,96] but the esthetic downside is that it does not allow for the lengthening of interproximal contact points for closure of black triangles. Furthermore, the palatal design of these pontics results in an increased risk of food impaction and phonetic problems.

Ovate pontics provide the best balance between esthetics and function.[34] They are designed so that the tooth-root contour extends into the soft tissue for buccal and interproximal tissue support; at the same time, the pontic base of ovate pontics is convex to ensure a large area of soft tissue contact while sufficient accessibility is maintained for good oral hygiene, thus reducing the risk of inflammation. *Zitzmann* et al[105] conducted a prospective clinical study to determine whether an ovate pontic design that touched the underlying soft tissue interfered with long-term mucosal health. Their 12 patients received either implant- or tooth-supported maxillary fixed partial dentures. The ovate pontics were adapted for tight but noncompressive contact with the underlying mucosa. The patients received thorough oral hygiene instruction, including directions on how to use Super Floss to clean the space under the pontic once daily.

After 12 months, the fixed partial dentures were removed and tissue biopsies were obtained. The histologic analyses showed that the pontic sites had thinner keratin layers and slight changes in the composition of the subepithelial connective tissue compared to the controls (masticatory tissue samples from adjacent sites not in contact with the pontics). The clinical analysis, on the other hand, showed that the restoration of an edentulous space with an ovate pontic supported by adequate oral hygiene measures was not associated with overt clinical signs of inflammation. The authors concluded that the long-term health of the soft tissues around ovate pontics can be maintained when the area under the pontic is flossed regularly with Super Floss[105] (Figs 13-34).

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Fig 13-34 (a to d) Ovate pontics are designed with a convex shape and do not cause functional or biologic problems if flossed regularly with Super Floss. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

Modified ovate pontics have an esthetic edge over conventional ovate pontics.[106] Because they slightly overlap the alveolar ridge buccally, they do not require as much faciolingual thickness to create an emergence profile that more closely resembles the gingival margin of the natural teeth (Figs 13-35 and 13-36).

Abutments

Unlike the contour of a tooth root, the base of an abutment is circular and smaller because its diameter cannot be greater than that of the implant shoulder. The abutment mimics the three-dimensional shape of the tooth to be replaced from the implant shoulder to its point of emergence from the soft tissue. The *emergence profile* is defined as the contour of the abutment between these two reference points. As moderate soft tissue recession often occurs after placement of the definitive implant-supported restoration,[9] it would appear prudent to design an abutment so that its contours already match those of the replaced tooth slightly apical to the point of emergence from the soft tissue. This compensates for mild peri-implant recession in many cases, especially when the coronal portion of the abutment is tooth colored. If the implant-supported restoration was undercontoured,

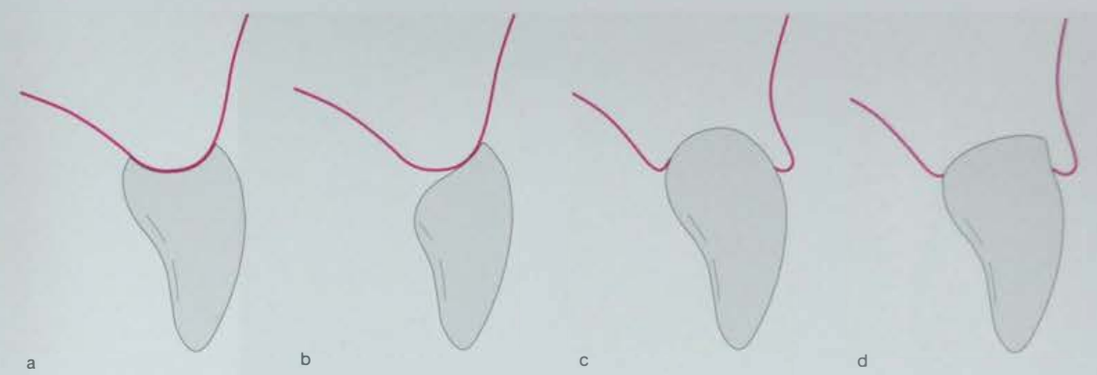


Fig 13-35 (a to d) Compared to total ridge lap pontics and modified ridge lap pontics, ovate pontics provide the best balance between esthetics and function. Modified ovate pontics offer additional esthetic advantages and are thus the favored option today.

the esthetic consequences of recession-related exposure would be much worse. In the orofacial and mesiodistal dimensions, the outer contour of the coronal section of the abutment—like that of the natural teeth—should form a *convex line* that becomes slightly *concave* more apically, in the area of the implant shoulder (Fig 13-37). Prefabricated abutments are rarely able to meet the requirements for an ideal emergence profile. Therefore, the use of *custom implant abutments* may be crucial in the esthetic zone.[107]

Pontic and abutment materials

Most dental pontics are made by fusing porcelain to the metal pontic base. Such porcelain-fused-to-metal pontics meet all of the functional, biologic, mechanical, and esthetic requirements discussed (Fig 13-38).

Abutments must meet a number of requirements. The implant-abutment interface must provide good fit and stability, the abutment must be made of a material that ensures long-term stability and biocompatibility, and it must satisfy esthetic demands. A number of studies on the biocompatibility of different abutment materials have demonstrated that neither ceramic (alumina and zirconia) nor titanium abutments induce adverse reactions in peri-implant soft tissues or marginal bone.[108–110] In an animal study of different abutment materials and their effects on peri-implant transmucosal attachment, *Abrahamsson* et al[108] observed that the biologic width established around titanium and ceramic abutments is similar to that around natural teeth, whereas the biologic width around abutments made of gold alloy and dental porcelain is associated with epithelial downgrowth, soft tissue recession, and increased peri-implant bone loss. Other studies have produced similar results.[109,110]

Although titanium abutments have excellent biocompatibility and other material characteristics that provide a number of important advantages, they can produce visible gray shadows around implants at sites with thin soft tissues, which is a major problem in the esthetic zone (see chapter 8). Because all-ceramic abutments provide excellent esthetics, biocompatibility, and long-term stability, they should be used for restorations in the esthetic zone. Because of its superior material properties, zirconia (ZrO_2) is preferred over alumina (AlO_2).[111] Given the high quality and homogeneity of industrially manufactured and milled ceramic materials, computer-aided design/computer-aided manufacturing technology should be employed whenever custom zirconia abutments are called for.

To optimally meet the functional, biologic, mechanical, and esthetic requirements for an ideal abutment, the current evidence suggests that it is best to have the crown directly fused to the custom zirconia abutment

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Fig 13-36 In the esthetic zone, the contours of the pontic should optimally match the cervical contours of the natural tooth roots. Because it slightly overlaps the alveolar ridge buccally and has a convex base, the modified ovate pontic design provides optimal esthetic results.



Fig 13-37 The contours of abutments in the esthetic zone should resemble the contours of the roots of the natural teeth. Therefore, the outer contour of the coronal section of the abutment should form a convex line that becomes slightly concave more apically, in the area of the implant shoulder.

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Fig 13-38 Conventional porcelain-fused-to-metal pontics meet all functional, biologic, mechanical, and esthetic requirements.

to yield a one-piece *screw-retained implant-supported restoration*. This type of design makes it possible to avoid the problems associated with cemented implant restorations.[112,113] Furthermore, it is easy to remove and reinsert screw-retained restorations in the event of complications such as screw loosening and ceramic fracture. Also, studies suggest that the use of modern ceramic materials decreases the susceptibility of screw-retained implant-supported crowns to fracture[114] (Fig 13-39).

One-piece screw-retained restorations are not practicable unless the implant position allows the screw access hole to be positioned on the palatal aspect of the crown. Because this often is not the case, two-piece implant restorations must be used in many patients, in spite of the advantages of a one-piece design. Two-piece restorations are normally constructed from a screw-retained custom zirconia abutment and a *cemented* all-ceramic crown. To meet all functional and biologic requirements and to enable the controlled removal of excess cement, the corresponding abutments must be designed so that they meet the crown at a level only slightly apical to the soft tissue margin (Fig 13-40).

It can be useful to fuse high-fluorescence shoulder porcelains to the junctions between the abutment and the implant-supported crown to improve light transmission properties through zirconia abutments in certain cases.[82] The fluorescent layers of ceramic improve the transmission of light from the crown into the abutment, giving the peri-implant mucosa a more natural appearance. They also make it virtually impossible to distinguish the junctions between the crown and the abutment, which reduces the esthetic consequences of any soft tissue recession that might occur. To avoid biologic consequences, it is important to keep the dimensions of the fused implant shoulder as small as possible in the apicocoronal direction and to make the surface as homogenous and smooth as possible (Fig 13-41).



Fig 13-39 A transocclusal one-piece screw-retained implant-supported crown directly fused to a custom zirconia abutment is the ideal type of implant-supported restoration from functional, biologic, mechanical, and esthetic perspectives.



Fig 13-40 Cemented all-ceramic restorations on screw-retained custom zirconia abutments provide good results at esthetic sites where the use of one-piece screw-retained implant-supported crowns is not feasible.

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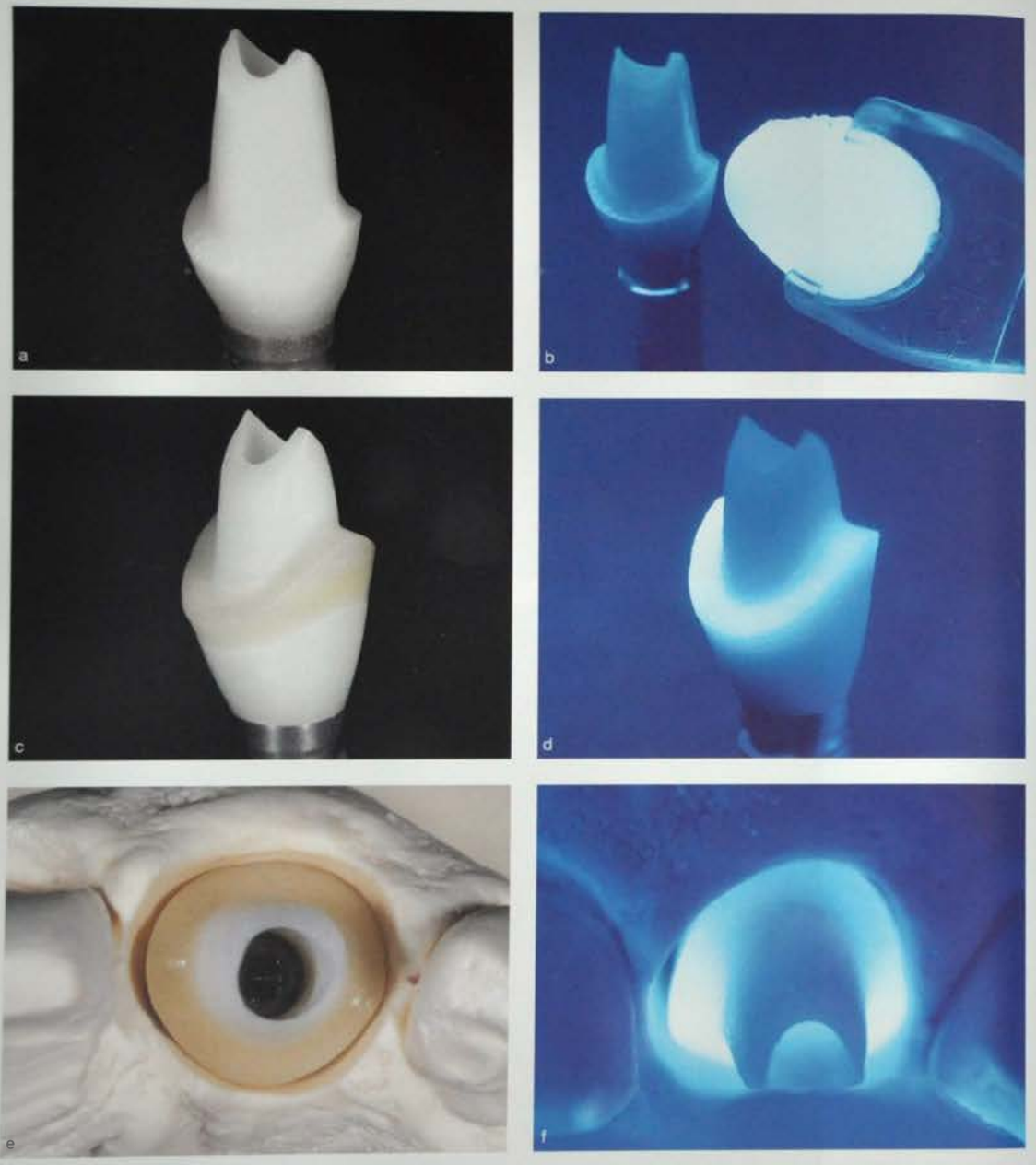


Fig 13-41 (a to f) It can be useful to fuse high-fluorescence shoulder porcelains to the junctions between the abutment and the implant-supported crown to enhance light transmission through zirconia abutments in certain cases. The effect is clearly visible under fluorescent light.

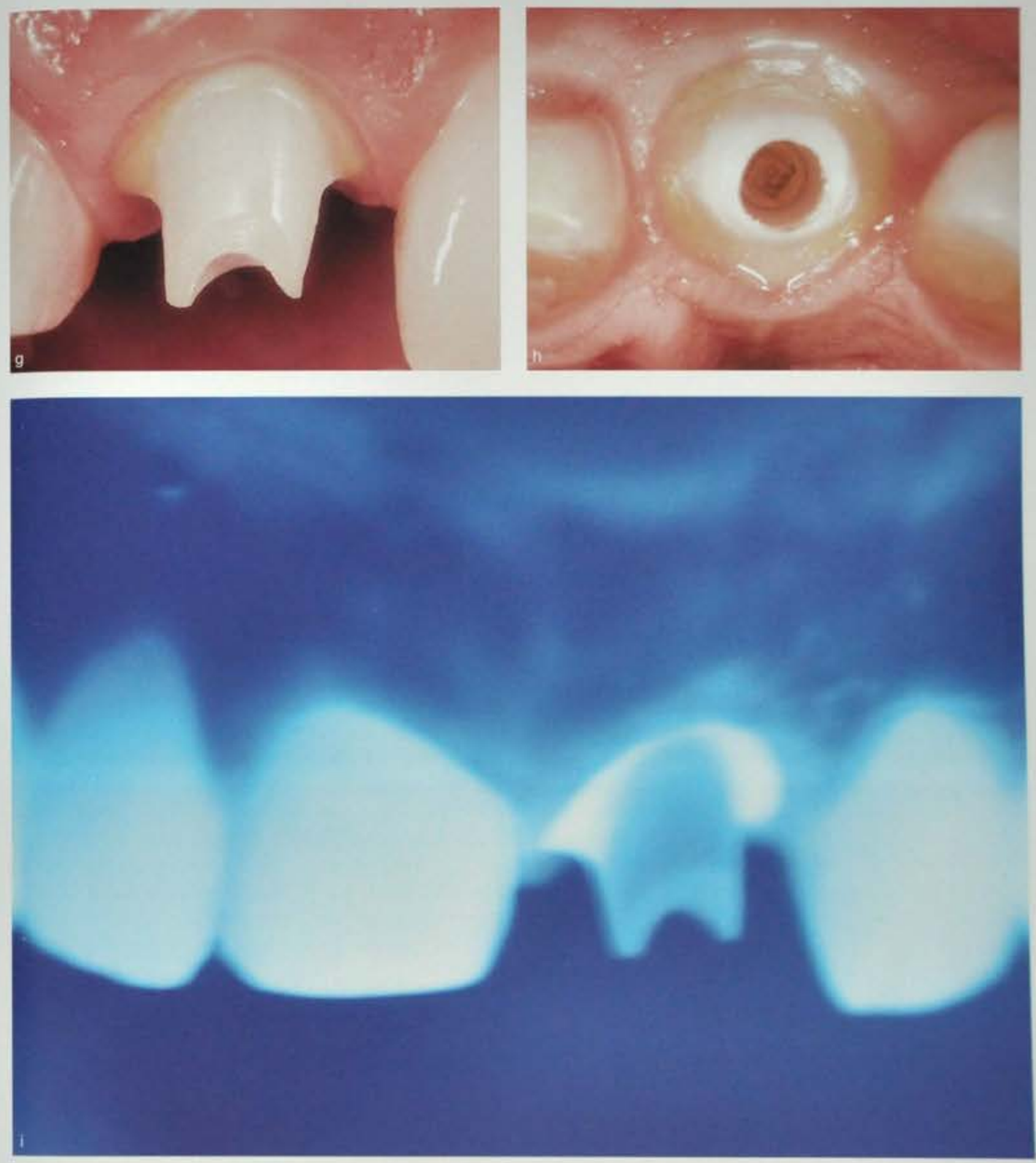


Fig 13-41 (g to i) The fused shoulder porcelain gives the peri-implant mucosa a very natural appearance. (i) A photograph taken under fluorescent light after intraoral placement of the abutment demonstrates the similarity of light transmission through the abutment and the natural teeth. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

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13.1.7 Special Considerations in Implant Therapy

Implant selection and positioning

For successful implant therapy, it is crucial to ensure that the position of the endosseous implant makes it possible to manufacture and place a restoration that meets all functional, hygienic, and esthetic requirements. Regardless of which implant system is used, the three-dimensional position of the implant shoulder and the direction of the implant axis must be set to ensure that the implant is the apical extension of the future restoration and not the other way around.[1] Improper implant positioning can lead to serious prosthetic problems that cannot be corrected after osseointegration of the implant. Therefore, the preparation of a diagnostic wax-up or set-up and the use of radiographic and surgical templates with or without computer navigation are integral components of the diagnostic and therapeutic approach to modern dental implant dentistry.[115]

Radiographic and surgical templates

Radiographic templates are used for preoperative assessment of bone volume at the prosthetically correct implant position. Surgical templates are used for intraoperative visualization of the dimensions and positional relationship of the planned prosthesis and to guide implant bed preparation via drilling sleeves, thus facilitating clinical implementation of preoperative planning.

The widespread use of three-dimensional radiographic imaging systems (digital volume tomography) and digitally supported planning systems now makes it possible to optimally unite the ideal prosthetic solution, as determined from the diagnostic wax-up or set-up in the preoperative stage, with the ideal implant position, as determined based on the available bone structure. In *computer-assisted* or *computer-navigated template-guided implant placement*, the diagnostic wax-up or set-up is integrated in three-dimensional imaging via a radiopaque template, and planning software is subsequently used to virtually simulate and define the ideal implant position. A drill guide is fabricated to transfer the defined ideal implant position to the clinical situation. A standardized system with harmonized individual components is needed to transfer the simulated implant position with maximum precision. However, a number of studies have shown that the precision of all currently available navigation systems is subject to deviations.[116,117] Consequently, these systems should be considered useful and helpful surgical tools, but they cannot replace the skill and experience of the surgeon.

In *manual implant dentistry*, the preoperative wax-up or set-up is used to fabricate a surgical template that allows clear and unequivocal identification of the position and soft tissue contours of the planned restoration, making it possible to establish an ideal three-dimensional implant position. The template must offer adequate leeway for intraoperative adjustments, particularly of axial inclination of the implant in the orofacial dimension. The surgical template must not obstruct the view of the depth marks on the implant drills.

Radiographic and surgical templates must be designed not only for easy insertion and removal but also for unequivocal and stable fixation in the patient's mouth. To reduce diagnostic time and effort, it is advisable to convert the radiographic template into a surgical template once the radiograph has been obtained. Good results have been achieved with heat-sterilizable resins that maintain their shape at high temperatures. Barium sulfate or radiopaque gutta-percha pins are added to make the template materials radiopaque (Fig 13-42).

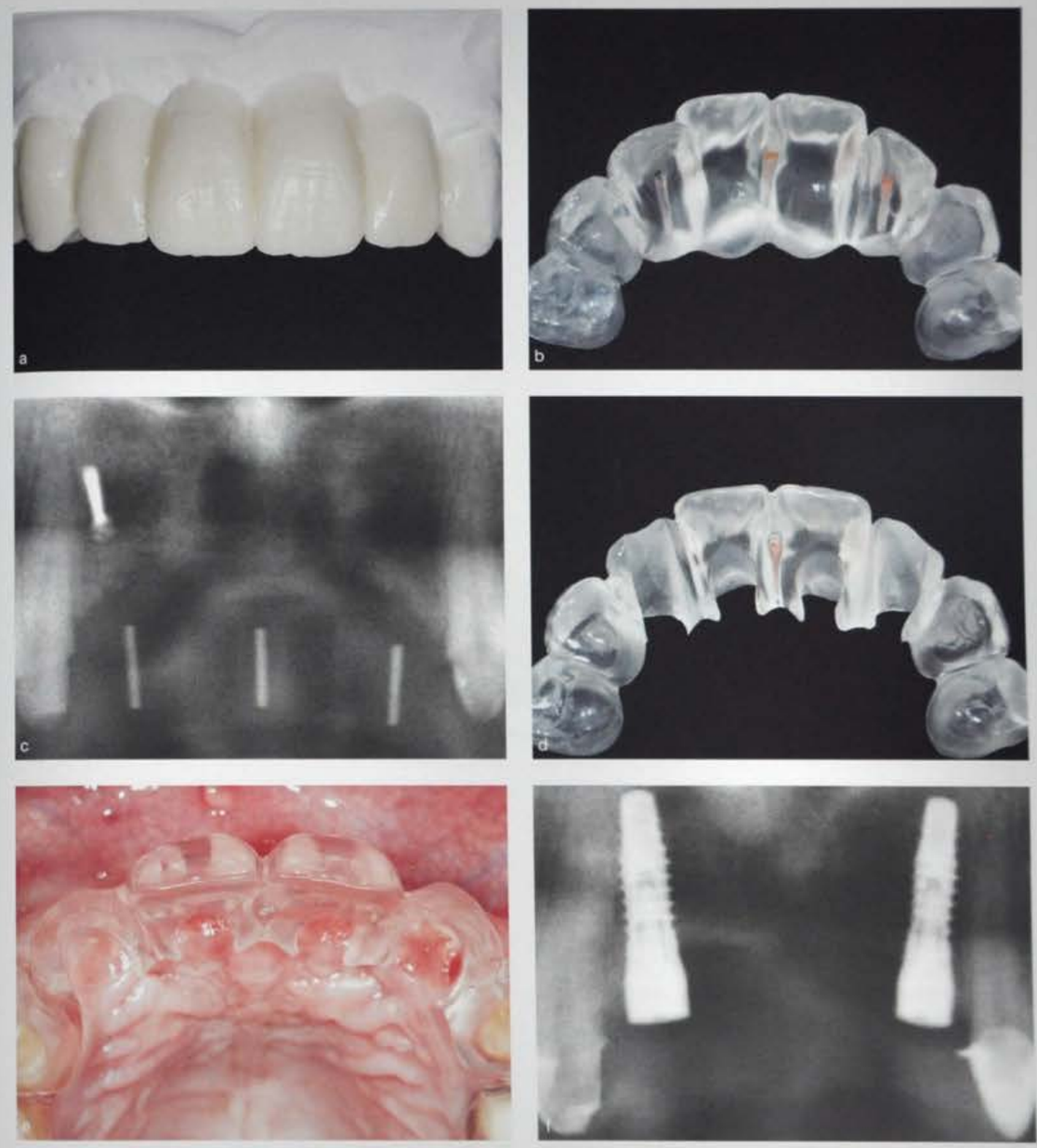


Fig 13-42 Fabrication of radiographic and surgical templates. (a and b) The first step is preparation of a diagnostic wax-up. (c) A radiographic template is then fabricated based on the wax-up. (d) Reference markers (gutta-percha pins) incorporated into the radiographic template are clearly visible on the radiograph. (e) The radiographic template is converted into a surgical template to reduce diagnostic time and effort. (f) Radiographic appearance after insertion of the implants.

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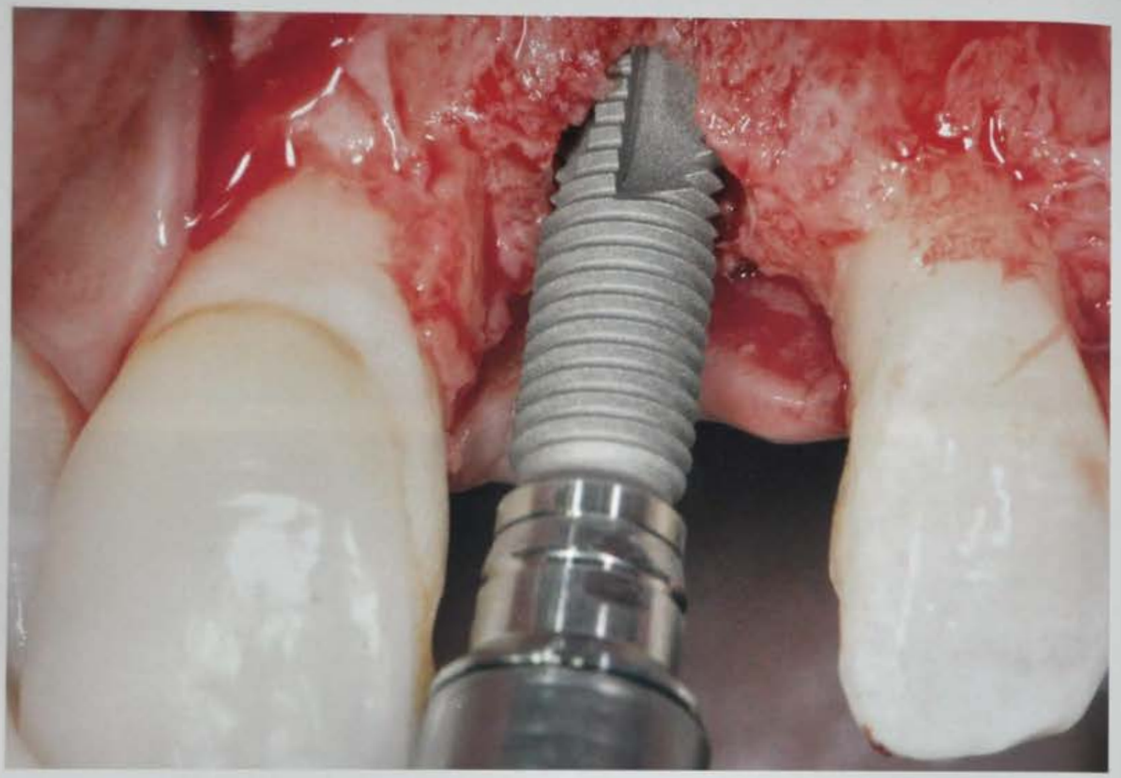


Fig 13-43 Placement of the implant shoulder in the correct three-dimensional position is crucial to the esthetic success of implant therapy.

Guidelines for implant selection and positioning in the esthetic zone

While the position of implants at sites outside the esthetic zone is determined mainly by functional and biologic criteria, that of implants in the esthetic zone is mainly determined by esthetic criteria. When implants are placed in the esthetic zone, the ultimate goal of treatment is to achieve the best possible imitation of the intact, natural, original conditions. In addition to the surgical limitations associated with the defect configuration at the beginning of treatment, the formation of the biologic width around implants is generally associated with circular bone loss around the implant shoulder, which can also impair the peri-implant soft tissue contours (see chapter 1). These are critical issues that could make it difficult to achieve a good esthetic outcome. Placement of the implant shoulder in the correct three-dimensional position is therefore crucial to the esthetic success of implant treatment (Fig 13-43). *Buser* et al[43] defined comfort and danger zones for proper implant positioning in the esthetic zone, providing useful clinical tools for practicing dentists.

For ideal positioning, the implant shoulder must be evaluated in all three spatial dimensions: orofacial, mesiodistal, and apicocoronal.

Orofacial

From a prosthetic and hygienic perspective, the implant should ideally be perfectly centered below the planned implant crown. Conversely, formation of the biologic width leads to the circumferential thinning of peri-implant bone, which can result in the formation of alveolar bone dehiscences, especially at sites with thin buccal bone plates. These dehiscences can, in turn, lead to soft tissue recessions, which are not only very difficult to treat but also can result in the exposure of implant components. Furthermore, dark metal parts of some implant components can cause shadowing at sites with thin soft tissues.

To prevent such esthetic complications, ideally a facial bone thickness of 2 to 3 mm should be established buccal to the implant.[42] Therefore, placement of the implant *too far facially* must be avoided. Based on the current data, *shifting the implant position slightly more palatal* appears to be the ideal solution. This makes it possible to establish an adequate distance from the intact buccal plate in immediate implant placement and makes it easier to regenerate adequate bone plate thickness buccal to the implant in delayed implant placement.

Palatally, there is about 2 mm of insertion tolerance.[43] Violation of this tolerance range could result in palatally overcontoured restorations that can narrow the tongue space, impair phonetics, and make it difficult to establish an adequate emergence profile. The further palatal the implant is placed within the 2-mm tolerance range, the deeper the implant must be inserted in the apicocoronal dimension to achieve an acceptable emergence profile. Because of the anatomy of the alveolar ridge, it is advisable to place the implant axis at a *slight buccal tilt relative to the tooth axis*; prosthetic compensation for the tilt should be easy to accomplish if the implant shoulder is correctly positioned (Fig 13-44).

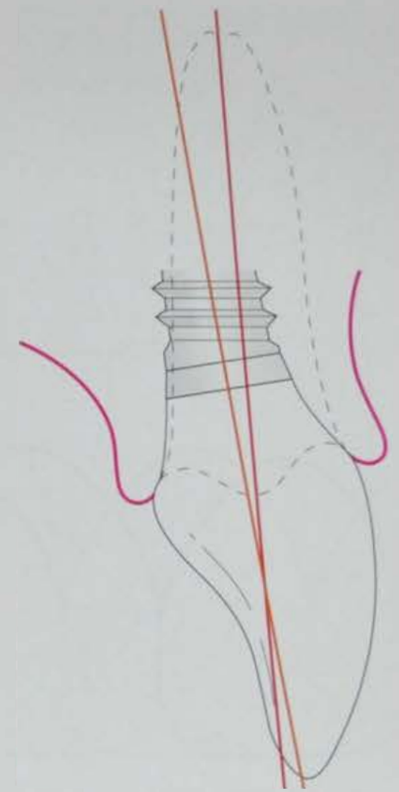


Fig 13-44 The implant is positioned slightly palatally in the orofacial dimension. The implant axis is often placed at a slight buccal tilt relative to the tooth axis in the anterior maxilla.

Mesiodistal

Because of the changes in peri-implant bone associated with formation of the biologic width, the distances between an implant and the adjacent teeth or between two implants is an important factor (see chapter 1).

Placement of an implant too close to the adjacent teeth will result in vertical bone loss around the tooth during the development of biologic width around the implant. This often leads to the loss of interproximal soft tissue between the tooth and the implant. This has esthetic consequences because the bony attachment remaining on the tooth is the main structure preserving the vertical soft tissue dimensions.[118,119] Though urgently needed, there are still no clear guidelines on the minimum distance needed between an implant and the adjacent teeth to ensure the full preservation of attachment and alveolar bone of the affected tooth. Based on clinical experience, a minimum distance of 1.5 mm seems to be effective. If this minimum distance is lacking, it will be necessary either to enlarge the space orthodontically or to employ one of the alternative methods of implant placement described earlier (Fig 13-45).

The distance between two adjacent implants is even more critical, yet clear guidelines for the minimum distance between two implants are also lacking. A mini-

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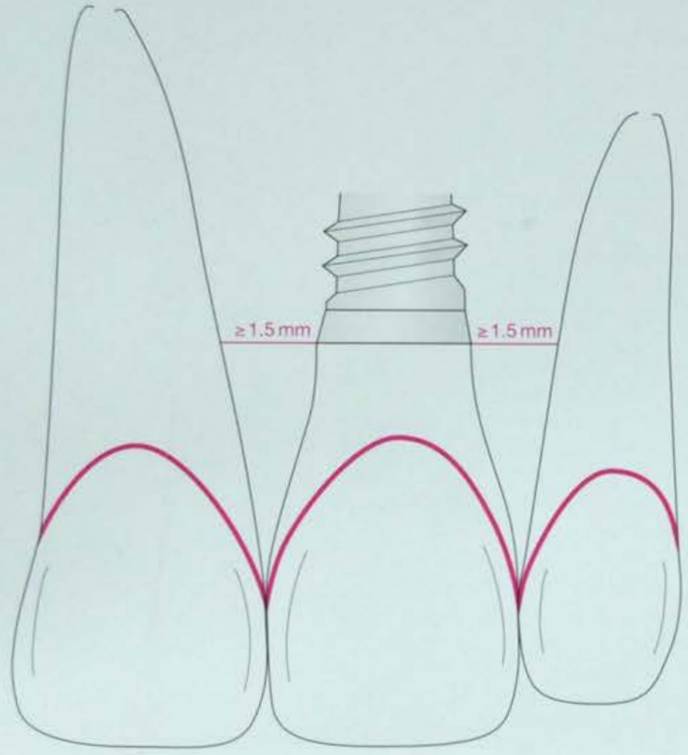


Fig 13-45 A minimum distance of 1.5 mm is needed between an implant and the adjacent teeth to prevent interproximal hard and soft tissue loss.

mum distance of 3.0 mm between adjacent implants has been recommended based on the horizontal extent of bone loss occurring in the course of the remodeling processes (from 1.0 to 1.5 mm to the level of the implant shoulder).[120] However, this recommendation is hardly practicable in many cases. An additional complicating factor is the fact that the dental arch space available for implantation is reduced by the horizontal tissue resorption that normally occurs after extraction. Moreover, the recommendation to place maxillary implants slightly palatally decreases the amount of space available in the mesiodistal dimension. Therefore, it is currently recommended that the placement of two implants side by side in the esthetic zone be avoided. The alternating placement of implants and pontics could prevent vertical interproximal bone loss, at least to a certain extent, which could make it possible to obtain scalloped and harmonious soft tissue contours more predictably (Fig 13-46).

Generally speaking, implant number, size, and positioning are governed by the location and number of teeth to be replaced.[121] The rule of thumb for the replacement of multiple implants in the esthetic zone is the fewer implants used, the better. In this context, the planning of cantilever prostheses can be useful, depending on the clinical conditions at baseline. The more distal the implant positions, the better the conditions for achieving an acceptable esthetic outcome. The use of implants of adequate size, due consideration to the material and technical limitations, and the control of static and dynamic occlusal contacts also play important roles in this context.

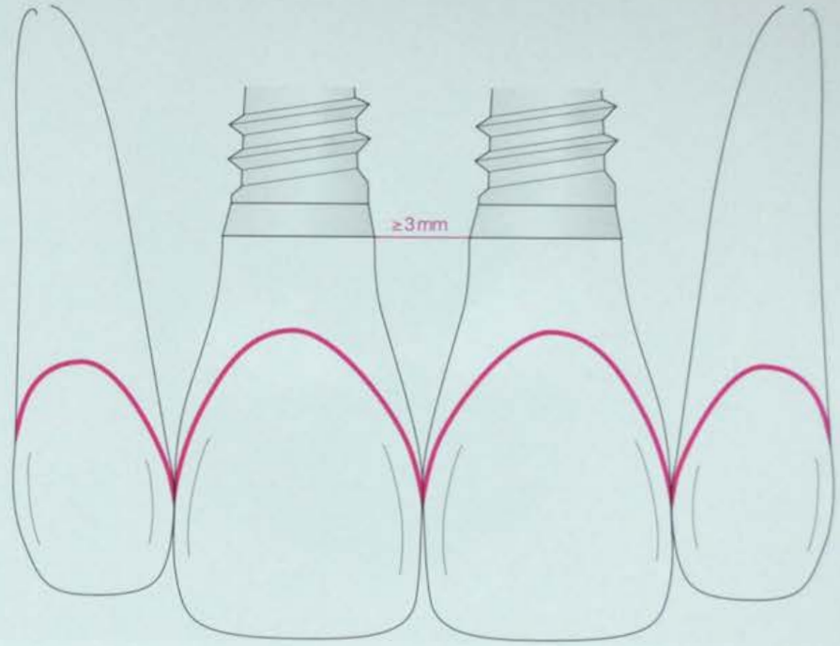


Fig 13-46 In many cases, it is not possible to maintain a minimum distance of 3 mm between two directly adjacent implants because of anatomical constraints. Therefore, side-by-side placement of implants in the esthetic zone should be avoided.

Apicocoronal

Precise positioning of the implant shoulder in the vertical direction is another important factor. Placement of the implant shoulder *too far coronally* can lead to prosthetic problems associated with the establishment of a correct emergence profile and visibility of sections or components of the implant. If the implant shoulder is positioned *too far apically*, formation of the biologic width will result in undue bone loss, which could lead to alveolar bone dehiscence and soft tissue recession buccal to the implant.

To determine whether an intracrevicular position of the restoration margin could lead to inflammation and changes in the hard and soft tissue contours around implants in the esthetic zone over the long term, *Giannopoulou* et al[14] studied 45 patients with a total of 61 single-tooth implants in the anterior maxilla. Clinical, biologic, and biochemical parameters were compared at baseline and follow-up (mean of 6.8 years). All implants had been in function for at least 1 year prior to the baseline examination. The only statistically significant differences between measurements at baseline and follow-up were a slight increase in the probing depth and the distance between the implant shoulder and the mucosal margin (mean of 0.2 mm). No statistically significant changes in the other clinical, microbiologic, or biochemical parameters were observed. The authors concluded that an intracrevicular position of the restoration margin has no adverse effects on peri-implant health and stability in patients with adequate oral hygiene.

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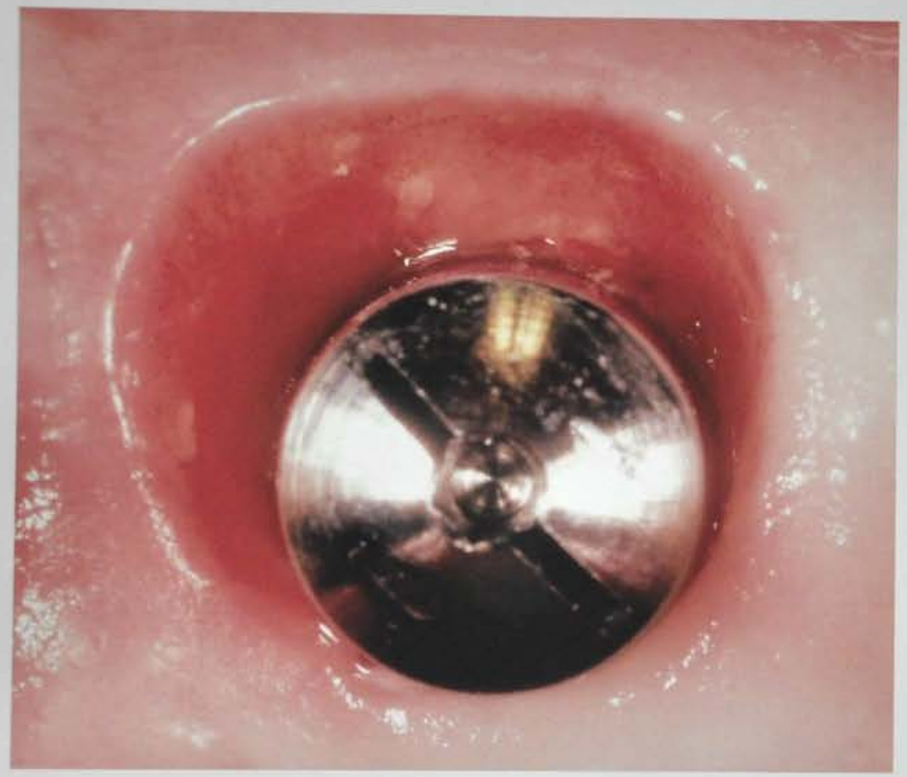


Fig 13-47 The implant must be positioned far enough apically to ensure that the round and undersized implant shoulder will fit in the cervical contours at the point of emergence of the affected tooth through the soft tissues. The diameter of the healing cap shown corresponds to that of the implant and illustrates the enormous differences between the cross sections of the implant and the tooth to be replaced.

Still, the implant shoulder should only be placed *as far apically as absolutely necessary.* The minimum depth requirement is defined by the diameter of the implant shoulder and the cervical contour of the affected tooth at the site where it emerges through the soft tissue. There must be adequate vertical distance between the implant shoulder and the point of emergence of the restoration through the soft tissues to ensure that the round and undersized cross section of the implant shoulder can be fitted in the contours of the affected tooth via an abutment (Fig 13-47).

To meet this requirement, it is recommended that the implant shoulder be positioned *3 mm apical to soft tissue margin around the future implant reconstruction.* The use of fabricated surgical templates that ideally should precisely reflect the soft tissue margin determined from the wax-up or set-up and used for the future reconstruction is thus of fundamental importance for intraoperative determination of implant position in the apicocoronal direction (Fig 13-48).

Key points:

The greater the diameter of the implant, the higher the risk that the danger zones will be entered buccally, mesially, or distally. *The smaller the diameter of the implant*, the more apically the implant must be positioned to establish an adequate emergence profile. Oversizing or undersizing of the implant diameter can reduce the predictability of achieving an esthetic gingival margin around the future implant reconstruction. Replacement of maxillary premolars, canines, and central incisors with standard implants with a diameter of about 4.0 mm, which are positioned 3.0 mm apical to the future gingival margin, has proved to be a good compromise.

Ideally, the mesiodistal gap size should be 8.0 to 9.0 mm. To avoid problems, the gap width should be no smaller than 7.0 mm. Smaller implants must be used for replacement of maxillary and mandibular lateral incisors and mandibular central incisors. Implants with a diameter of about 3.3 mm seem to provide adequate stability and material quality for these indications.[122–126]

The vertical position of the implant shoulder is determined according to the rules for standard implants. The ideal alveolar ridge width is 7.0 to 8.0 mm. The mesiodistal space should be no less than 6.5 mm.

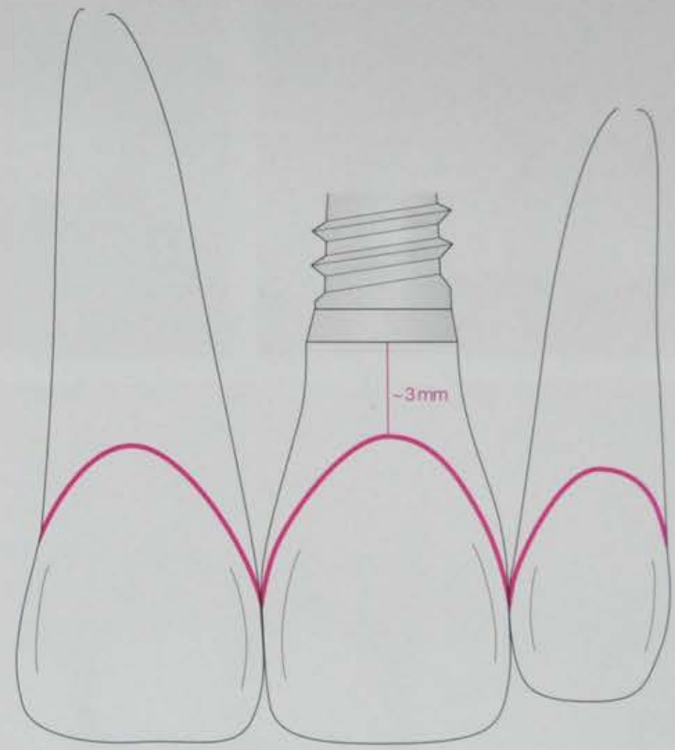


Fig 13-48 In the apicocoronal direction, the implant shoulder should lie about 3 mm apical to the planned soft tissue margin around the future implant reconstruction.

Implants in young patients

Implants must not be used in individuals whose growth is not yet completed. *Rossi* and *Andreasen*[127] followed a patient for 15 years after replacing his maxillary central incisor with an implant. The incisal edge and gingival margin position around the implant-supported crown was at the level of that of the adjacent teeth at the time of implant placement but was located 9 mm more apically 15 years later. Such frequently observed findings can be explained by the fact that ankylosed implants are unable to participate in the dentoalveolar growth processes that still occur in this area.[128–132] Placement of dental implants in young patients can result in serious periodontal, occlusal, restorative, and esthetic complications[133] (Fig 13-49).

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Fig 13-49 (a to c) Situation 8 years after the placement of implants to replace the two maxillary central incisors of a young woman who was 19 years old at the time of implantation. Clearly, the positions of the teeth adjacent to the implants have changed considerably, although it could be assumed that the patient's skeletal growth was completed at the time of implant placement.

Most girls have completed growth by the age of 17 years, whereas boys often continue to grow until the age of 25 years.[131,134] The decision of whether an implant can be placed or whether it is necessary to wait is not determined by the patient's chronologic age but rather by proof of the completion of skeletal growth.[131,135] Implant therapy should not be performed until two lateral teleradiographs or two manual radiographs taken 1 year apart demonstrate the absence of skeletal changes and, thus, the completion of skeletal growth.

Because changes in the facial skeleton can still occur for a while after skeletal growth is completed, it is advisable to wait a little longer before implant treatment is started.[136] However, it should be made clear to the patient that the skull and facial skeleton are subject to lifelong growth and adaptive processes that may, at some point, lead to visible changes in implants and the surrounding natural teeth, at least to a small extent.[131]

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13.2 Procedures

13.2.1 Modified Pouch Technique of Soft Tissue Augmentation

KEY POINTS

01. Select the technique based on the *classification of edentulous spaces* and *defect size*.

02. *De-epithelialize* an area of the alveolar ridge corresponding to the cross section of the tooth to be replaced.

03. Elevate a partial-thickness flap/pouch:
- Extend it *buccally* and *apically* beyond the mucogingival junction.
- Extend it *laterally* at least one tooth width beyond the planned augmentation site.
- Completely mobilize the *papillae* of the teeth adjacent to the gap.

04. Elevate a full-thickness flap:
- Completely *dissect the periosteum* at the base of the papillae lateral to the teeth adjacent to the gap.
- Mobilize the *buccal papillae* lateral to the adjacent teeth.

05. Make a vertical releasing incision in the fold apical and lateral to the defect.

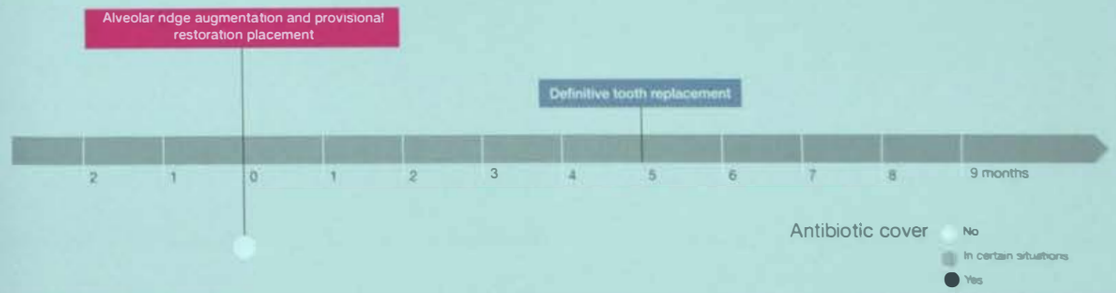
06. Harvest a subepithelial connective tissue graft *corresponding to the size of the defect* and insert the graft in the defect region via the vertical releasing incision. It should be slightly oversized for the necessary *overcorrection*.

07. Use vertical double-crossed sutures to *secure* the flap and the graft.

08. Apply *gentle pressure* to the wound for several minutes.

09. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Tunneling Knives I and II
4. Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, and 7-0 Serafit DS-12
5. No. 15 macroblade and Keydent microblade
6. Glass slab
7. 0.1% chlorhexidine solution in a metal dish
8. Sterile water in a metal dish
9. Blunt cannula
10. 10-mL syringe
11. Local anesthetic
12. Large and small pledgets
13. Periodontal stent



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STEP-BY-STEP PROCEDURE







Figs 13-50 to 13-55 Initial clinical presentation of a 25-year-old patient with congenitally missing maxillary lateral incisors. After completion of orthodontic treatment, adhesive fixed partial dentures had been used to close the gap 10 years previously. However, alveolar ridge defects apical to the pontics left the patient with impaired esthetics. Therefore, the modified pouch technique of alveolar ridge augmentation is performed before fabrication of two new adhesive fixed partial dentures.

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Figs 13-56 to 13-60 After careful removal of the old adhesive fixed partial dentures, composite resin is used to lengthen the interproximal contact points between the two central incisors. The goal is to correct the orientation of the axes of the two central incisors, at least optically, because the patient does not want to undergo orthodontic treatment again. Subsequently, impressions are taken for fabrication of a long-term provisional, and the patient is instructed to use the removable provisional restoration until the next appointment.









Figs 13-61 to 13-64 Clinical findings immediately before surgical soft tissue augmentation. According to the edentulous space classification, these are moderate Class I defects.

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Figs 13-65 to 13-68 Beginning on the right side, a microblade is used to de-epithelialize an area of the alveolar ridge corresponding to the cross section of the tooth to be replaced at its point of emergence.



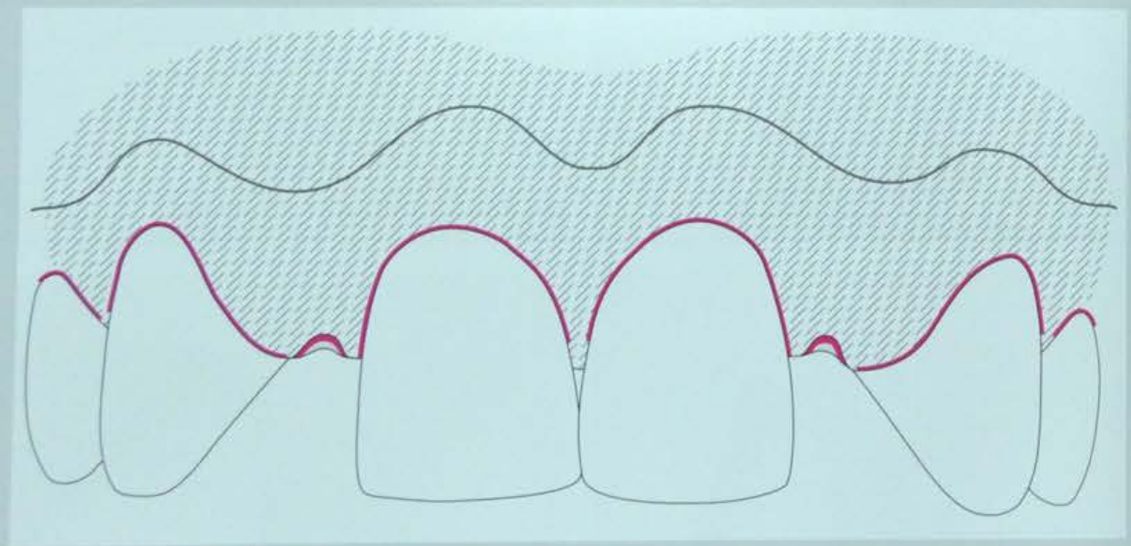

Figs 13-69 and 13-70 The same procedure is repeated on the opposite side.





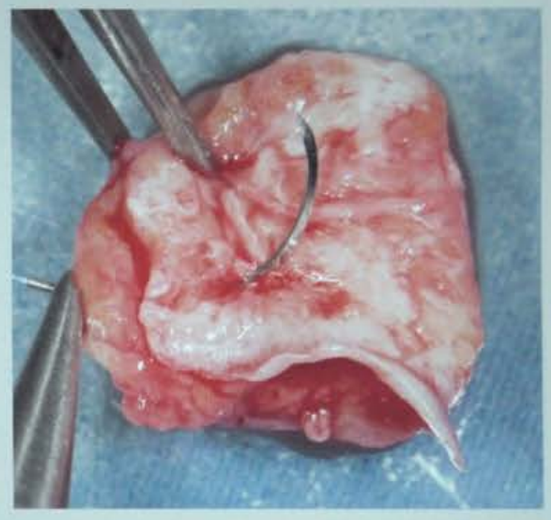

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Figs 13-71 to 13-76 A buccal partial-thickness pouch is reflected and extended from the first premolar on the left to the first premolar on the right. Microblades and Tunneling Knives are used for this purpose. The periosteum at the base of the papillae is dissected and the papillae themselves are elevated as a full-thickness flap. To achieve adequate flap mobility, the papillae of the teeth immediately adjacent to the gap must also be sharply dissected over the periosteum and fully incorporated into the flap.









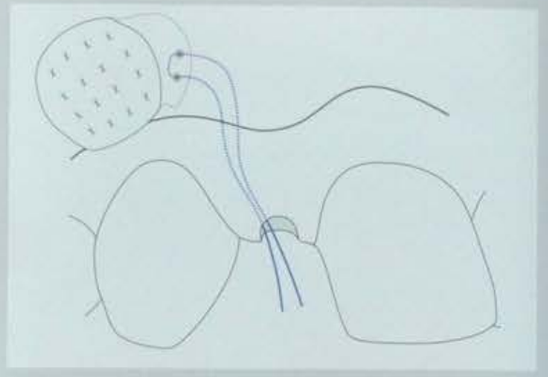
Figs 13-77 to 13-80 Connective tissue grafts of maximum volume are now harvested from the left and right sides of the palate. The grafts are trimmed to shape outside of the mouth. The grafts are then folded over themselves to form the appropriate size and shape before being secured with the aid of 7-0 Serafit DS-12 absorbable sutures.

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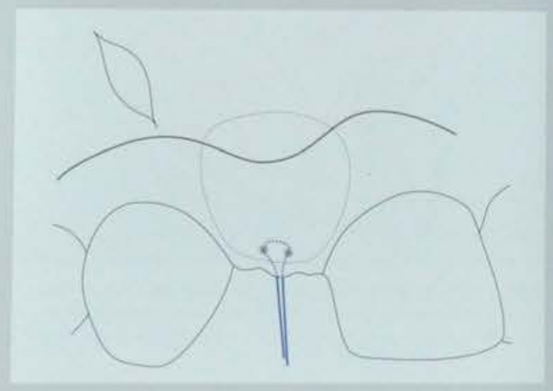












Figs 13-81 to 13-86 Because of the size of the connective tissue grafts, vertical releasing incisions are needed to facilitate graft insertion. The incisions are made apical to the defect and extended distally in the alveolar mucosa. Positioning sutures must be used for precise placement and fixation of the connective tissue grafts in the desired position. A needle with Gore-Tex CV-5 suture material is passed back-first through the de-epithelialized area on the alveolar ridge, below the flap, and is brought back out through the vertical incision. At that point, the needle engages the graft and returns by the same route. The grafts can then be inserted and positioned in the tunnel through gentle pulling on the positioning sutures.





Figs 13-87 and 13-88 The same procedure is repeated on the opposite side.

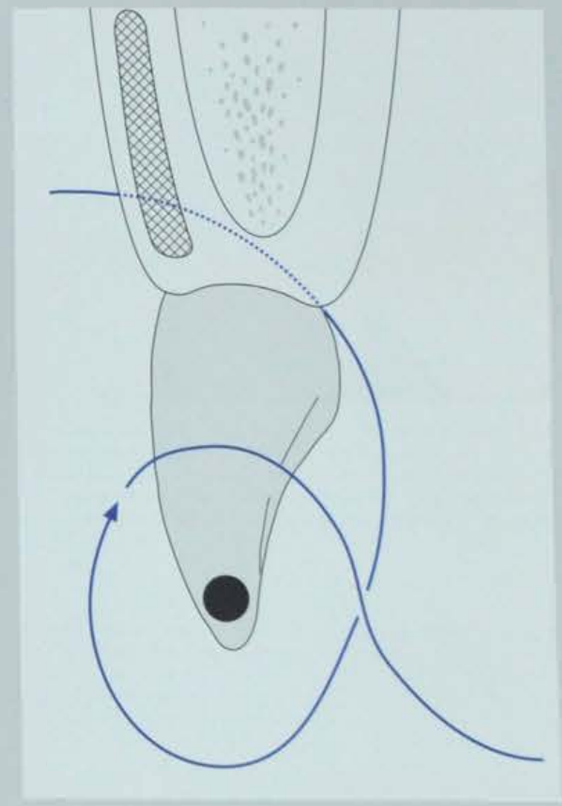
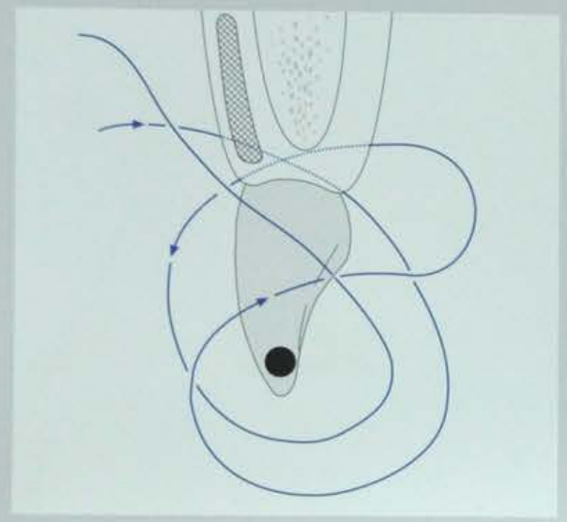
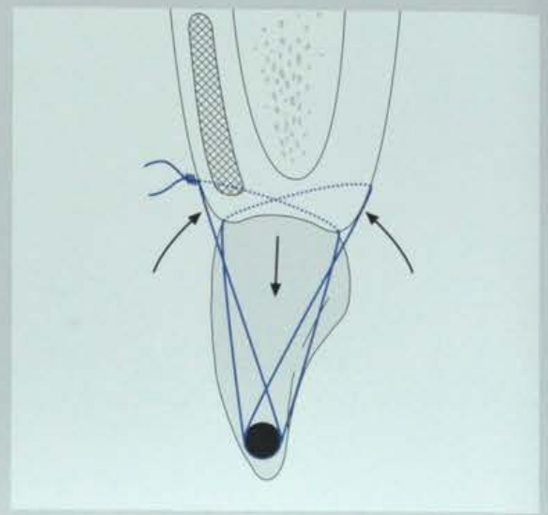


Fig 13-89 Subsequently, the provisional adhesive fixed partial dentures are tried in and placed. It is important to check for congruence between the base of the pontic and the de-epithelialized area. Care is taken to ensure that the wound is not exposed to phosphoric acid during placement of the provisional adhesive fixed partial dentures. Vertical double-crossed sutures (6-0 Seralene DS-15) are used to close the site with an adequate degree of overcorrection. The needle is first inserted on the buccal side, at the level of the mucogingival junction. It engages the connective tissue graft and passes below the interproximal contact point between the provisional pontic and the adjacent tooth to the palatal side, where it emerges slightly apical to the tip of the papilla. Next, the needle passes over the incisal edges and returns to the buccal side. It is then inserted back-first (without engaging the tissue), below the contact point, and passed again to the palatal side.

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Figs 13-90 to 13-93 From the palatal side, the needle enters at the base of the papilla and emerges on the buccal side, slightly apical to the tip of the papilla (it is not necessary to engage the connective tissue graft). To prevent unwanted folds in the buccal flap, it is important that the needle exit through the mobilized flap area. Next, the needle is returned to the palatal side and is again passed back-first underneath the contact point (without engaging the tissue) and returned to the buccal side. After the suture is tied and a second sling suture is completed, the positioning sutures are removed and gentle pressure is applied to the wound for several minutes.





Figs 13-94 and 13-95 Suture closure is performed on the opposite side in the same manner.

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Figs 13-96 to 13-99 Clinical appearance 1 week after surgery, just before suture removal.







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Figs 13-100 to 13-109 Complete healing is observed 5 months after surgery, at the time the final impressions are taken. The two canines are prepared for inclusion in single-retainer, all-ceramic adhesive fixed partial dentures.





Figs 13-110 to 13-115 Final result after the completion of treatment.

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Fig 13-116 Patient at the completion of treatment. (Composite resin restorations: *Bärbel Hürzeler*, Munich; dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 8. Chapter 1. Modified Pouch Technique of Soft Tissue Augmentation."

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3.2.2 Soft Tissue Augmentation by Inlay Graft and Palatal Island Flap

KEY POINTS

01. Select the technique based on the *classification of edentulous spaces* and *defect size*.

02. Always place alveolar ridge incisions in *keratinized tissue*.

03. Extend the buccal *partial-thickness tunnel* laterally at least one tooth width beyond the planned augmentation site.

04. Dissect the periosteum at the base of the papillae lateral to the teeth adjacent to the gap and elevate the buccal papilla as a *full-thickness flap*.

05. Elevate a palatal island flap after checking the *tissue thickness*.

06. Harvest a subepithelial connective tissue graft *corresponding to the size of the defect*. It should be slightly oversized for the necessary degree of *overcorrection*.

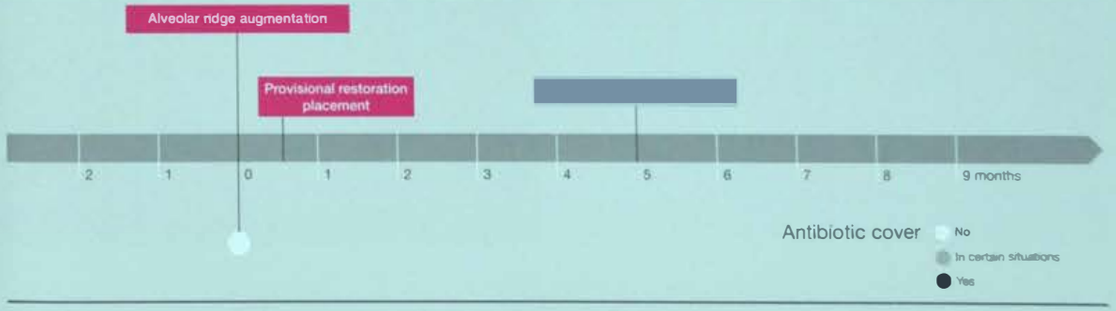
07. Place sutures:
- Use double-sling sutures and interrupted sutures to *immobilize* the flap and connective tissue graft.
- Small parts of the graft can be left *uncovered*.

08. Ensure that there is *no contact* between the provisional restoration and the wound.

09. Apply *gentle pressure* to the wound for several minutes.

10. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Tunneling Knives I and II
4. Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, 7-0 Seralene DS-12, and 7-0 Serafit DS-12
5. No. 15 macroblade, Keydent microblade, and flexible Keydent microblade
6. Bending pliers
7. Glass slab
8. 0.1% chlorhexidine solution in a metal dish
9. Sterile water in a metal dish
10. Blunt cannula
11. 10-mL syringe
12. Local anesthetic
13. Large and small pledgets
14. Periodontal stent



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STEP-BY-STEP PROCEDURE









Figs 13-117 to 13-120 A 32-year-old man has a failing fixed partial denture in the maxillary anterior region. The inlay grafting technique of soft tissue augmentation is to be performed before placement of a new fixed prosthesis.

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Figs 13-121 to 13-124 A No. 15 macroblade is used to make an initial crestal incision without touching the underlying bone. The incision should be performed in keratinized tissue with the surgical blade held perpendicular to the tissue surface.



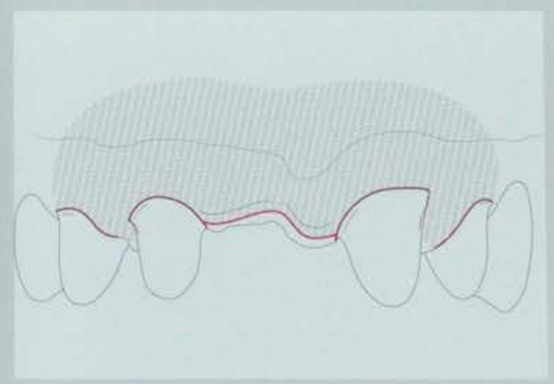
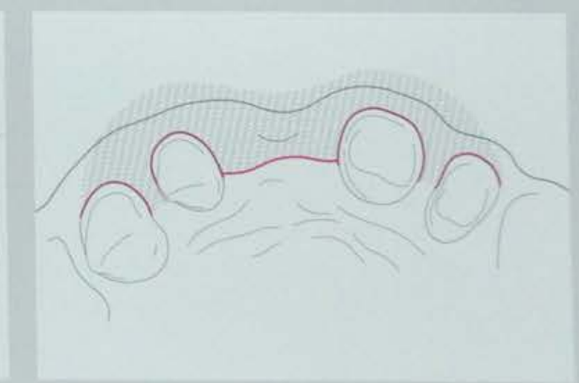

Figs 13-125 and 13-126 Before a partial-thickness flap is begun, the microblade is used to place an intrasulcular incision at the teeth adjacent to the edentulous area.




Figs 13-127 and 13-128 A flexible microsurgical Tunneling Knife is used to make a partial-thickness undermining incision on the buccal aspect. This incision is extended to at least one tooth mesial and distal to the edentulous area. In this way, no vertical releasing incisions are needed to mobilize the flap.




Figs 13-129 and 13-130 The incision is extended apically and laterally until sufficient flap mobility has been achieved.

Figs 13-131 and 13-132 Schematic representations of the buccal aspect of the undermined partial-thickness flap.

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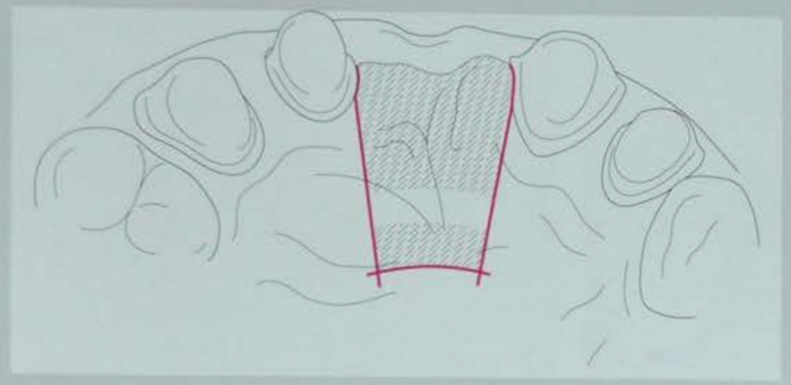

Figs 13-133 to 13-136 A palatal island flap is elevated to achieve additional flap mobility on the palatal side. Two strictly parallel incisions are used for this purpose. They should be made with the blade held perpendicular to the tissue surface and without touching the bone, starting from the palatal aspect and proceeding toward the proximal surfaces of the teeth adjacent to the edentulous area. The apical ends of the two parallel incisions are connected by a horizontal incision, which also must be performed at a right angle to the tissue surface. The incisions must overlap.





Figs 13-137 to 13-139 The crestal incision is extended apically to create a superficial partial-thickness flap, which should end at least 5 mm before the apical horizontal incision. The flap thickness should be no less than 1 mm throughout. In the deeper tissues (just above the periosteum), the apical horizontal incision is sharply extended no more than 2 to 3 mm in the opposite direction, in the apical to coronal direction, until a certain degree of flap mobility has been achieved. The flexible microsurgical Tunneling Knives are well suited for this purpose because they can be adjusted to the specific anatomical conditions.

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Figs 13-140 and 13-141 Schematic representations of the palatal island flap technique.



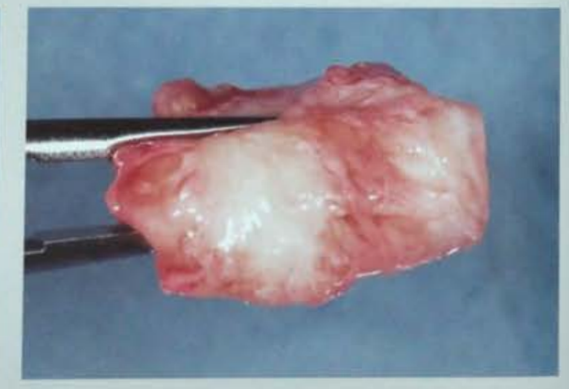


Figs 13-142 to 13-147 After completion of flap elevation, a connective tissue graft is harvested from the palate. To better adapt it to the anatomy of the defect, the graft is folded and stabilized in the desired shape with resorbable 7-0 sutures









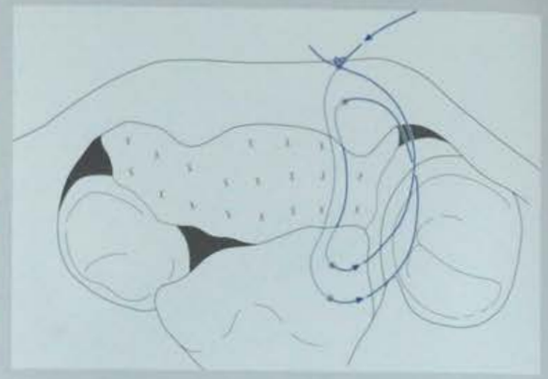


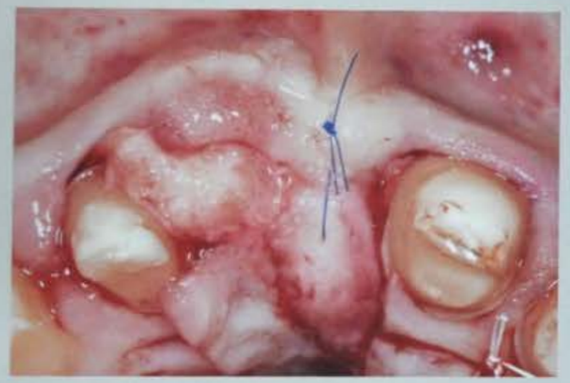


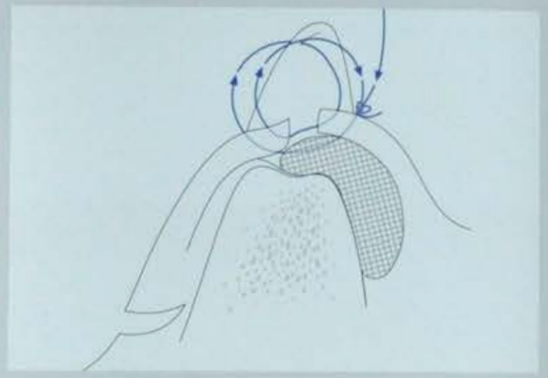
Figs 13-148 and 13-149 Closure is accomplished with double-sling sutures (6-0 Seralene DS-15). The needle enters the outer surface of the buccal flap (at a level slightly coronal to the mucogingival junction), engages the graft so that it is fixed in the desired position, and passes through the palatal flap before it emerges on the outside. Even spacing (bite size) of the needle entry and exit points on either side of the flap is crucial.

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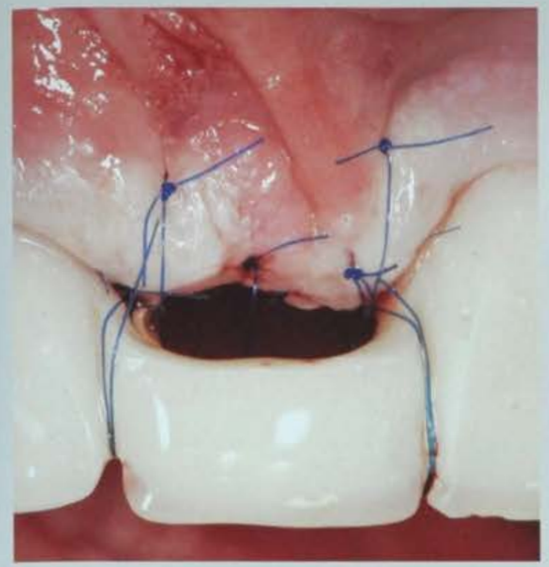


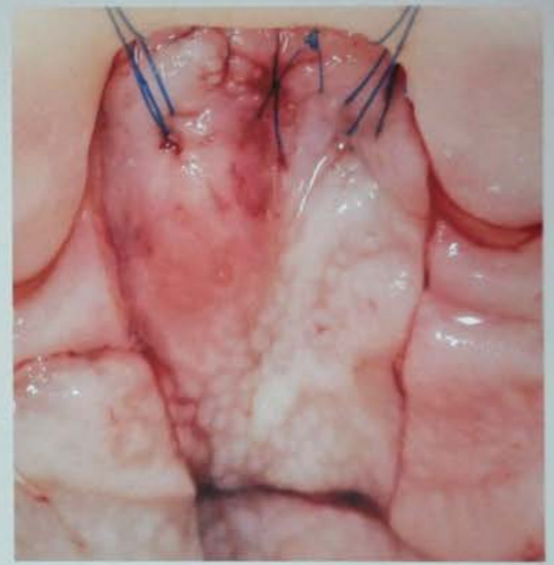
Figs 13-150 to 13-153 Subsequently, the needle enters the buccal flap a second time (this time closer to the flap margin) and passes palatally though both flaps without engaging the graft. Again, uniform bite size is crucial. Because both flaps have sufficient flap thickness, the suture remains inside of the flap margins.





Figs 13-154 and 13-155 Closure is accomplished by placing interrupted sutures (7-0 Seralene DS-12) between the double-sling sutures.





Figs 13-156 and 13-157 After surgery, the provisional restoration must be shortened to allow sufficient space between the restoration and the surgical site to compensate for the anticipated postoperative swelling. Two additional vertical double-crossed sutures (6-0 Seralene DS-15) are needed to stabilize the soft tissue graft in a coronal position in this patient.





Figs 13-158 and 13-159 Healing progress is shown at the 1-week postoperative examination, just prior to suture removal.

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Figs 13-160 to 13-164 One week later, the cookie cutter technique of soft tissue sculpting is initiated with a laboratory-manufactured long-term provisional restoration (modified ovate pontic with a hollowed interior). When pressed against the augmented tissues, the sharp edges of the pontic leave marks delineating the outline of the pontic base. A microblade is used to cut out the outline, creating a space that snugly accommodates the provisional restoration.









Figs 13-165 to 13-168 The next step is to remove the augmented soft tissue within the boundaries of the hollow pontic base. This is accomplished by using a flexible microblade for controlled removal of the soft tissue. The incision is started on the palatal aspect and extended around the pontic base to cut out the tissue in the desired shape.

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Figs 13-169 to 13-171 Once the pontic has been filled with composite resin, the long-term provisional restoration can be placed.







Figs 13-172 to 13-175 Clinical appearance 5 months later, at the time of the final impression.

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Figs 13-176 to 13-178 Results after the completion of treatment.

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Fig 13-179 Patient after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 8, Chapter 2: Soft Tissue Augmentation by Inlay Graft and Palatal Island Flap."

13.2.3 Modified Double-Layer Technique for Horizontal Ridge Augmentation with Simultaneous Implant Placement

KEY POINTS

01. Select the procedure based on the *classification of edentulous spaces*.

02. Always place the alveolar ridge incision in *keratinized tissue*; a *vertical releasing incision* distal to the edentulous area is usually sufficient.

03. Elevate a *full-thickness flap* on the buccal and palatal sides. *Periosteal slitting* followed by *mucoperiosteal/mucosal flap elevation* is recommended for mobilization of the buccal flap.

04. Undermine the *partial-thickness flap* mesially for increased flap mobility.

05. Perforate the cortical bone in the defect area to induce *adequate bleeding*.

06. *Place the implant* in the prosthetically correct position.

07. Trim a *non–cross-linked collagen membrane* to size according to the anatomical dimensions of the defect and secure the membrane in place, ideally using bioabsorbable pins.

08. Fill the defects around the implant with *bone substitute material* and ensure that there is sufficient *overcorrection*.

09. Trim and place the second *cross-linked collagen membrane*.

10. Use a subepithelial connective tissue graft to augment the *soft tissue volume* and ensure *closed healing* of the augmentation site.

11. Place sutures:
- Use *horizontal mattress sutures* to stabilize the flap on the alveolar ridge.
- Use *double-loop sutures* for primary closure of the flap.
- Use *interrupted sutures* to close the vertical releasing incisions.
- Use *vertical mattress sutures* to close the mobilized papillae.

12. Grind back the provisional restoration such that it *does not come in contact* with the surgical site.

13. Apply *gentle pressure* to the wound for several minutes.

14. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Macrosurgical instrument set
2. Microsurgical instrument set
3. Tunneling Knives I and II
4. Handpiece with pin drill
5. Implant motor with contra-angle handpiece and implantation set
6. Selection of implants (within reach)
7. Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, and 7-0 Serafit DS-12
8. No. 15 macroblade and Keydent microblade
9. Glass slab
10. 0.1% chlorhexidine solution in a metal dish
11. Sterile water in a metal dish
12. Metal dish for bone substitute material
13. Blunt cannula
14. 10-mL syringe
15. Bone substitute material
16. Insulin syringe
17. Collagen membranes
18. Pin set
19. Local anesthetic
20. Large and small pledgets
21. Periodontal stent



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STEP-BY-STEP PROCEDURE

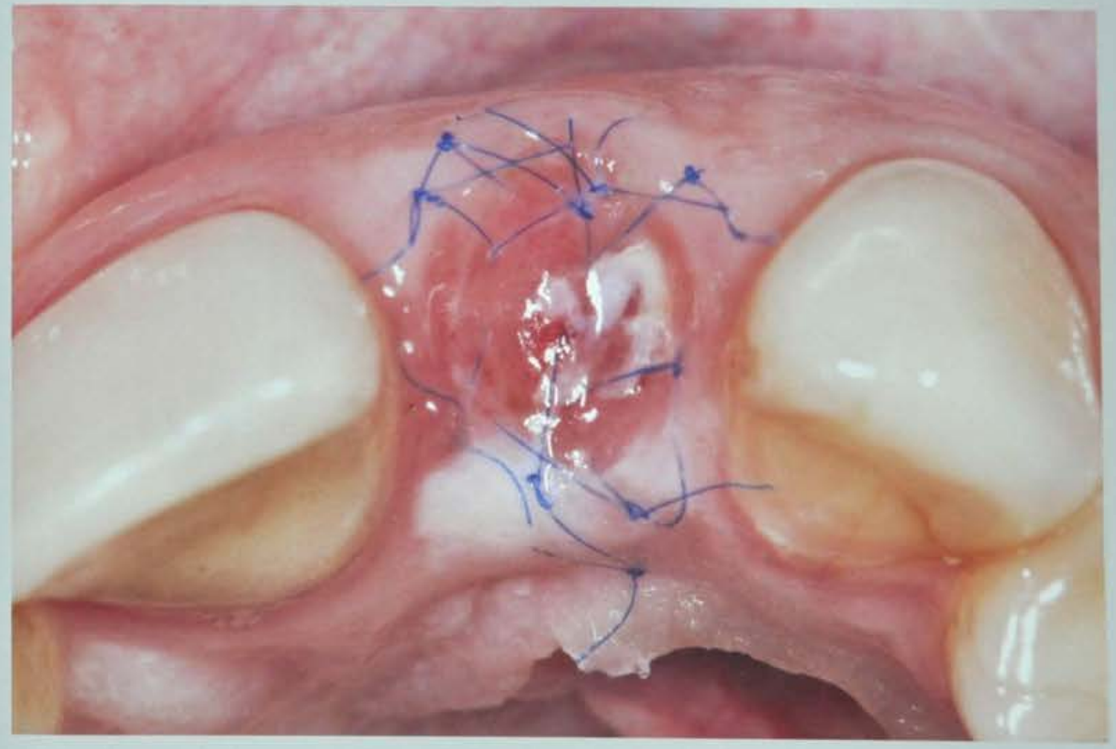




Figs 13-180 to 13-182 The maxillary left lateral incisor is fractured at the gingival level and is to be extracted and replaced with an implant. The extraction site is classified as Class II, so two-stage implant surgery is planned. Tooth extraction and a socket seal procedure will be performed in the first stage.







Figs 13-183 to 13-185 Clinical appearance 1 week after surgery, immediately prior to suture removal.

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Figs 13-186 and 13-187 Complete healing is observed 8 weeks after extraction, at the time of implant placement and reconstruction of the alveolar ridge.



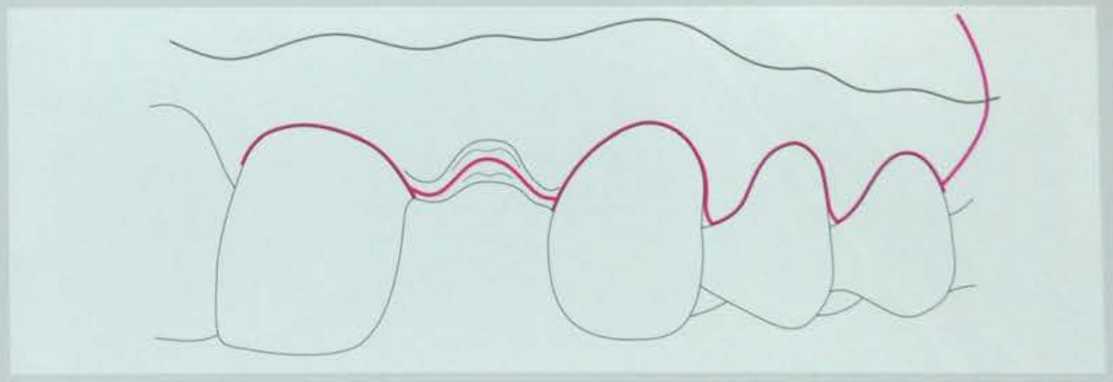












Figs 13-188 to 13-194 A microblade is used to place an intrasulcular incision at the teeth adjacent to the gap. Vertical releasing incisions are needed to ensure sufficient ridge visualization and flap mobility. To ensure optimal preservation of the blood supply to the flap and to prevent scarring in the esthetic zone, only one vertical releasing incision is made, distal to the second premolar. A crestal alveolar ridge incision is made with the blade held perpendicular to the tissue surface. Figure 13-194 (bottom) shows a schematic illustration of the site after completion of the incision design.

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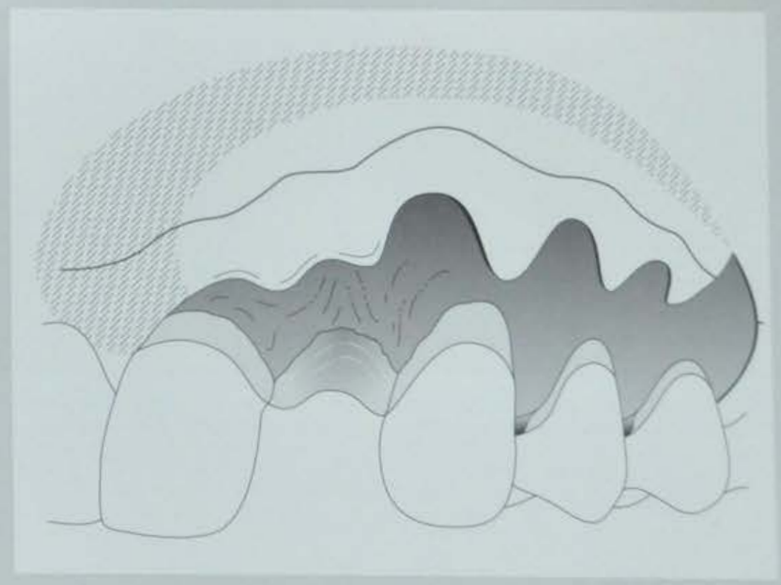
Figs 13-195 to 13-197 A full-thickness flap is now reflected. A papilla elevator and a periosteal elevator are used to enable distal visualization of the defect. The palatal flap is mobilized only as far as necessary for good visualization of the alveolar bone in the region of the defect.





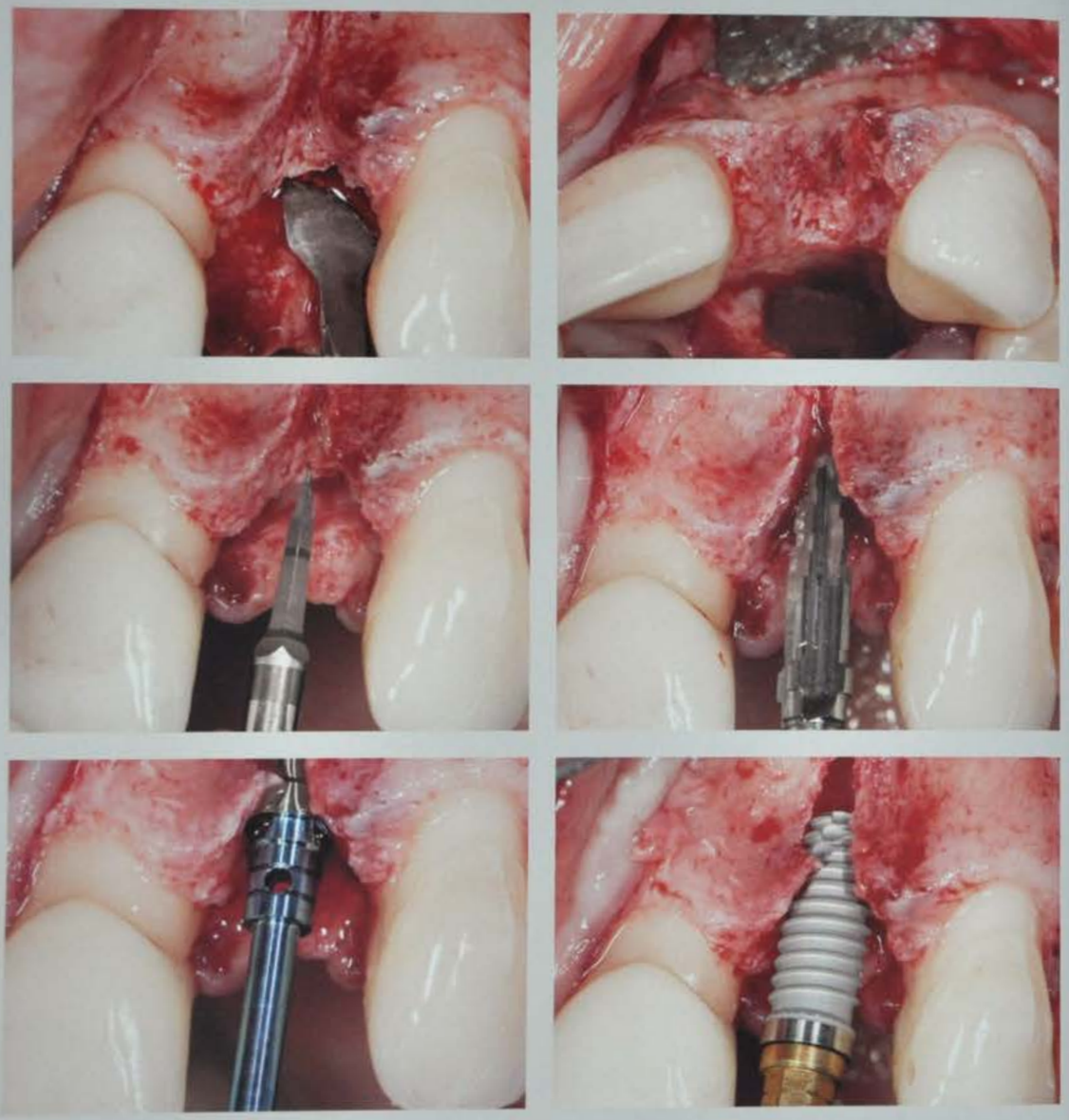






Figs 13-198 to 13-202
No incision is to release the papilla between the maxillary central incisors. To provide the flap with adequate mobility from this side, a vertical incision is made internally to dissect and undermine the periosteum and is extended to the right central incisor region. For additional flap mobility, the periosteum is slit at the base of the buccal flap, and the flap is utilized to create a mucoperiosteal-mucosal flap. Figure 13-202 (right) shows a schematic illustration of the site after completion of the flap design.

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Figs 13-203 to 13-211 Now the implant bed can be prepared and the implant placed in its correct three-dimensional position. A technique for indexing the implant position is performed to ensure that the provisional restoration will have an emergence profile that is as perfect as possible when the implant is uncovered. In the procedure, an impression post is screwed onto the implant. Light-curing composite resin material is used to splint the post to the teeth adjacent to the gap in such a way that it can be unambiguously positioned on a cast for fabrication of an implant-supported provisional restoration. It is advisable to perforate the cortical bone in the defect area with small drills at this time to induce sufficient bleeding for later defect reconstruction.

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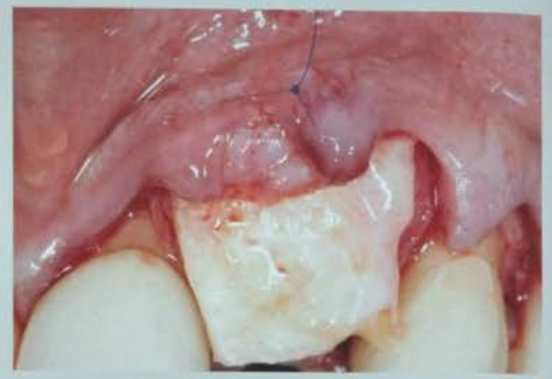




Figs 13-212 to 13-218 After a conventional, non-cross-linked collagen barrier membrane (Bio-Gide) is trimmed and fixed with titanium pins, DBBM (Bio-Oss) is placed on the exposed implant surface and buccal bone. Care is taken to ensure a sufficient degree of overcompensation. Once this is completed, a cross-linked collagen barrier membrane (Ossix) is inserted between the bone substitute material and the non-cross-linked barrier membrane. Before placement, the second barrier membrane is trimmed to ensure that it is completely covered by the first barrier membrane (after the first membrane has been placed over the implant and bone substitute material and under the palatal flap).

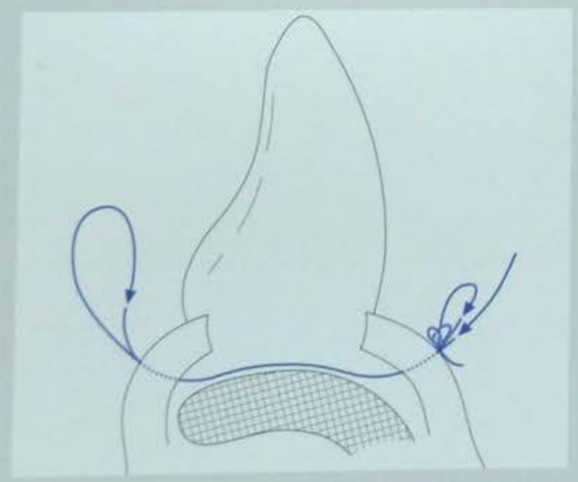
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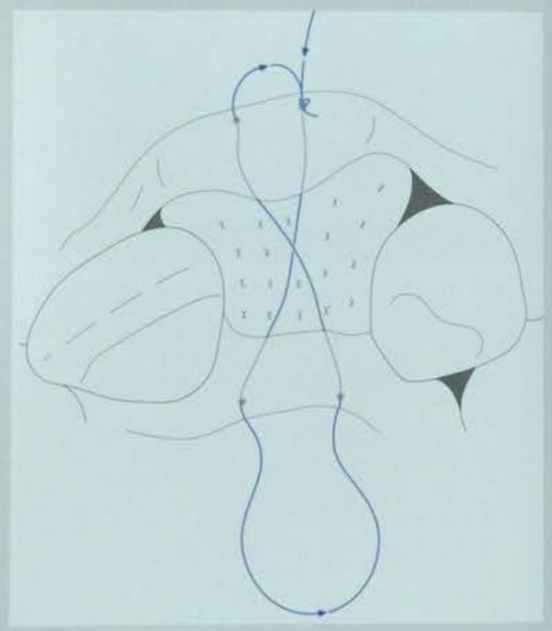




Figs 13-219 and 13-220 To perform soft tissue augmentation simultaneously with hard tissue augmentation and to predictably achieve closed healing of the augmentation site, a free subepithelial connective tissue graft is harvested from the palate, positioned to ensure that it will cover the alveolar ridge both buccally and below the incision line, and secured to the buccal flap with a 7-0 Seralene DS-12 suture.

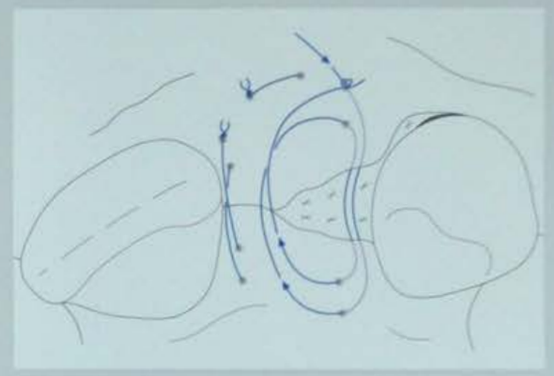




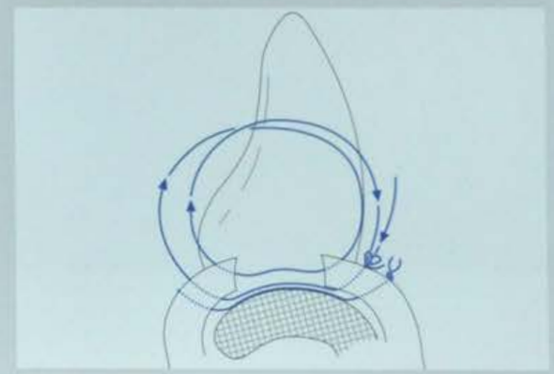


Figs 13-221 to 13-223 Suture closure: First, a crossed horizontal mattress suture is placed. The suture (6-0 Seralene DS-15) enters the buccal flap on the distal aspect from the outer surface and emerges on the mesial side, passing through the inner surface of the palatal flap. On the distal side, the needle passes through the palatal flap from the outer surface, and, on the mesial side, it again passes through the buccal flap from the inner surface. Figures 13-222 (right) and 13-223 (left) show the crossed mattress suture over the connective tissue graft before the suture is tied.









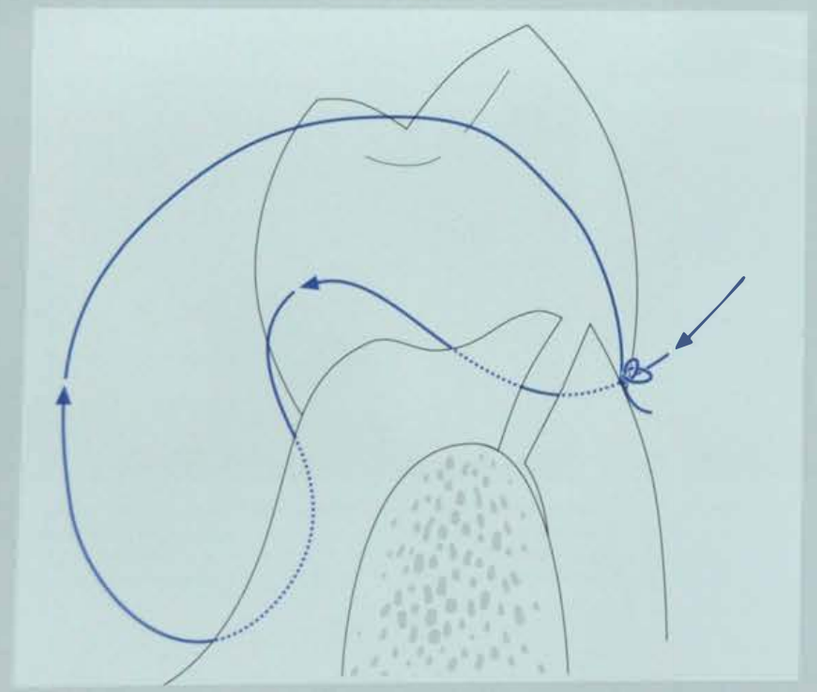




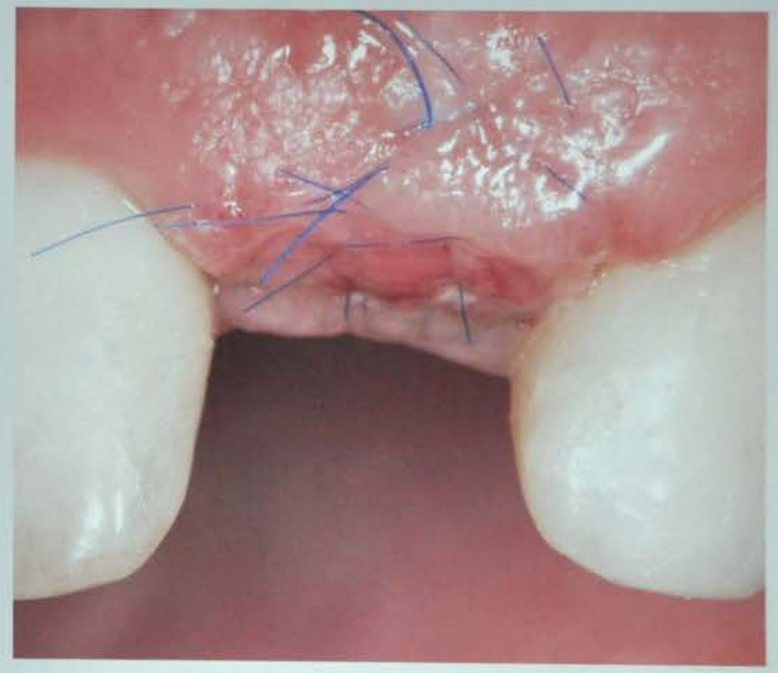
Figs 13-224 to 13-229 Four double-sling sutures are placed for fixation of the flap edges. A 6-0 Seralene DS-15 suture is used for this purpose. The needle enters the outer surface of the buccal flap, approximately 3 mm from the flap margin, and passes through the inner surface of the palatal flap. Next, the needle passes through both flap components in the same direction, at a distance of about 1 mm from the incision line, and the suture is tied. Care should be taken to ensure a uniform bite size. Due to the thickness of the two flaps, the second suture is placed within the two flap ends.

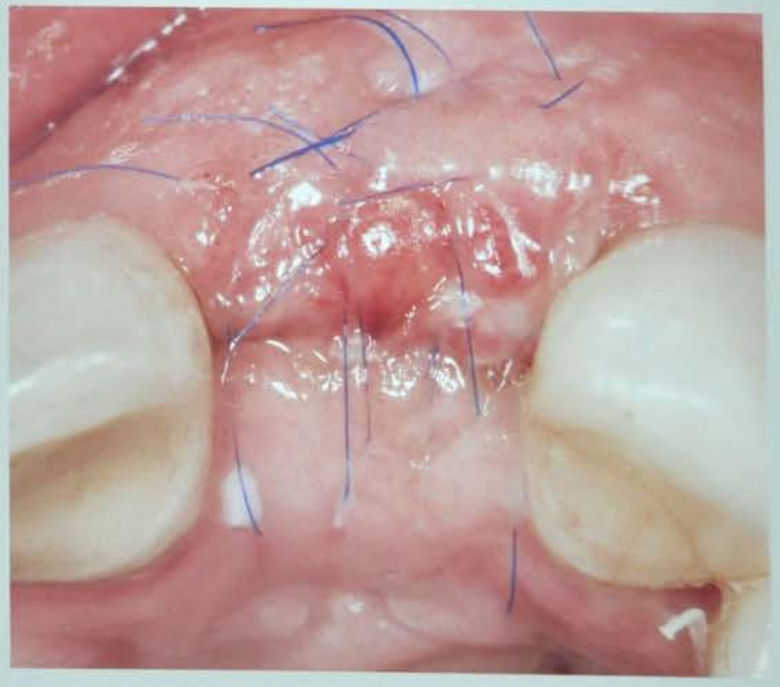
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Figs 13-230 and 13-231 The vertical releasing incision is closed with microsurgical interrupted sutures (7-0 Seralene DS-12) placed in the keratinized gingiva and macrosurgical sutures (Gore-Tex CV5) placed in the alveolar mucosa. The papilla is adapted with vertical mattress sutures made of 7-0 Seralene DS-12 material. When the removable provisional restoration is placed, there must be sufficient space between the surgical site and the base of the pontic.





Figs 13-232 and 13-233 Clinical appearance immediately prior to suture removal, 1 week after surgery.

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Figs 13-234 to 13-243 Clinical findings 5 months later, immediately before and after the implant is uncovered by means of the modified roll flap technique. Based on implant indexing at the time of implant placement, it is now possible to create an implant-supported provisional restoration with an ideal emergence profile.

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Figs 13-244 to 13-245 Another 5 months later, impressions for the final restoration are made using a customized impression post.

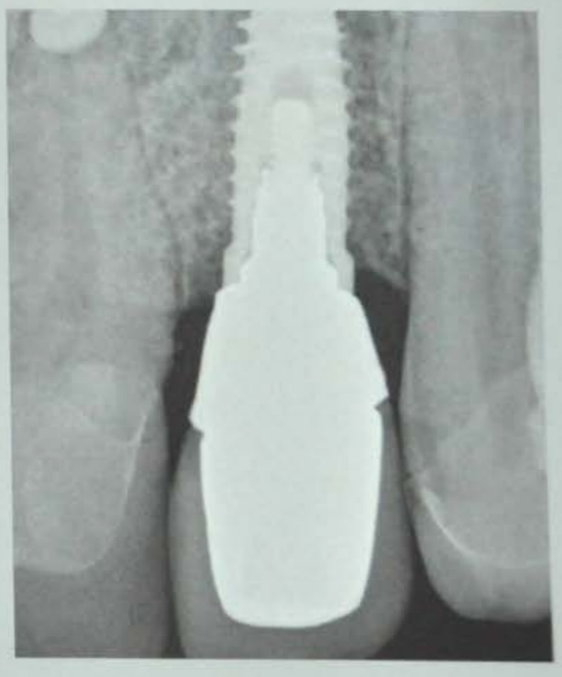












Figs 13-246 to 13-251 Results after the completion of treatment.

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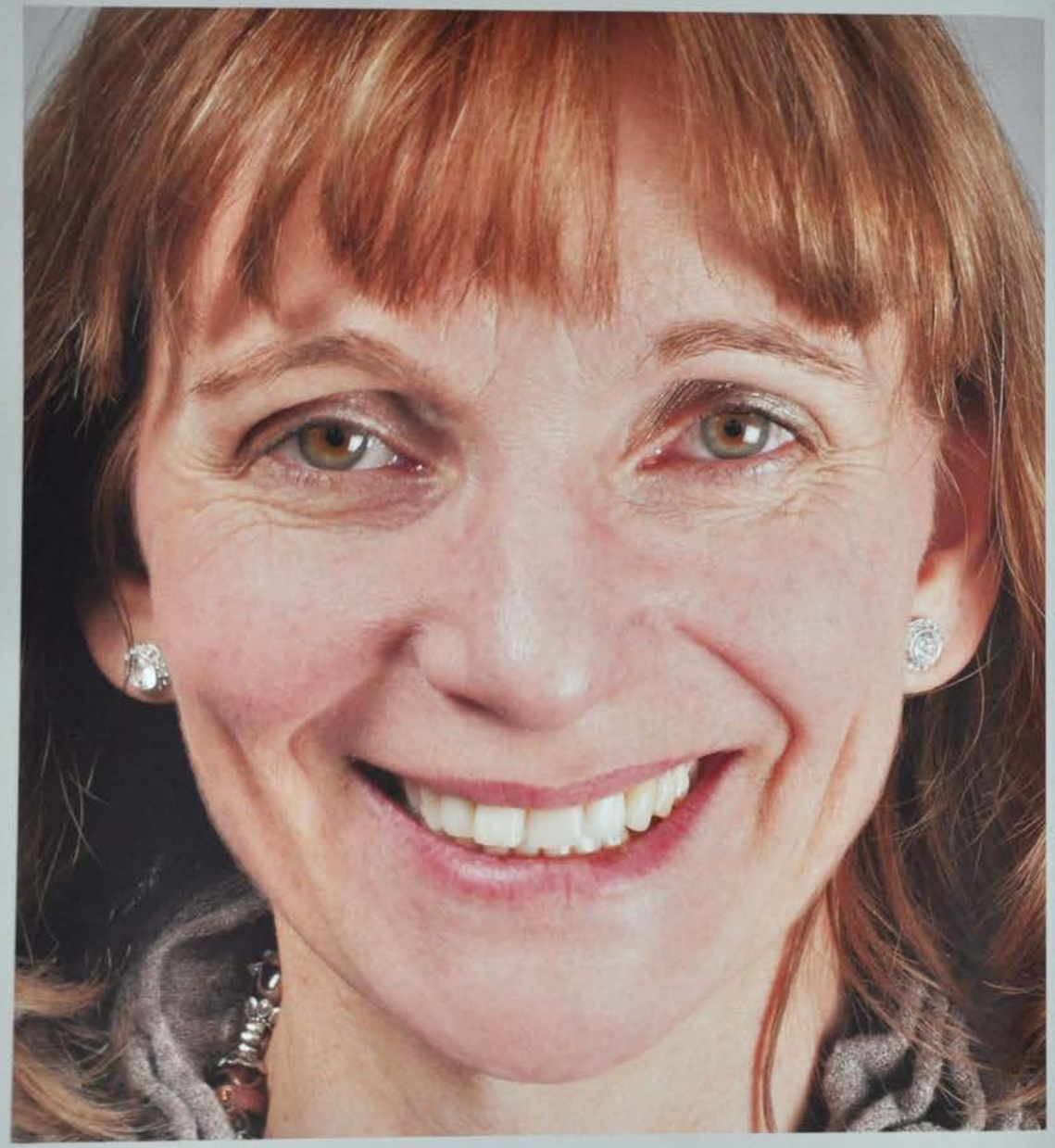


Fig 13-252 Patient after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 9, Chapter 1: Modified Double-Layer Technique for Horizontal Ridge Augmentation with Simultaneous Implant Placement."

13.2.4 Cortical Bone Plate Method for Simultaneous Implant Placement and Vertical Ridge Augmentation

KEY POINTS

01. Select the procedure based on the *classification of edentulous spaces*.

02. Always place the alveolar ridge incision in *keratinized tissue*. The placement of two *vertical releasing incisions* lateral to the edentulous area is frequently unavoidable.

03. Elevate a *full-thickness flap* on the buccal and palatal side. *Periosteal slitting* followed by *mucoperiosteal/mucosal flap elevation* is recommended for mobilization of the buccal flap.

04. Perforate the cortical bone in the defect area to induce *adequate bleeding*.

05. Harvest the *bone graft* from the angle of the mandible and divide it sagittally.

06. Secure the *cortical bone plates* over the defect area with osteosynthesis screws. Ensure that the bone plates provide *stable fixation* and *adequate coverage* of the defect.

07. Depending on the configuration of the defect and the position of the osteosynthesis screws, *simultaneous insertion of the implant* or implants may be possible in some cases.

08. Fill the space between the cortical bone plates and the niches and spaces buccal to the bone plates with a mixture of *particulate autogenous bone* and *bone substitute material*. Ensure that there is sufficient *overcorrection*.

09. Trim a *non–cross-linked collagen membrane* to size according to the anatomical dimensions of the defect. Ideally, use bioabsorbable pins for fixation of the membrane.

10. Use a subepithelial connective tissue graft to augment the *soft tissue volume* and to ensure *closed healing* of the augmentation site.

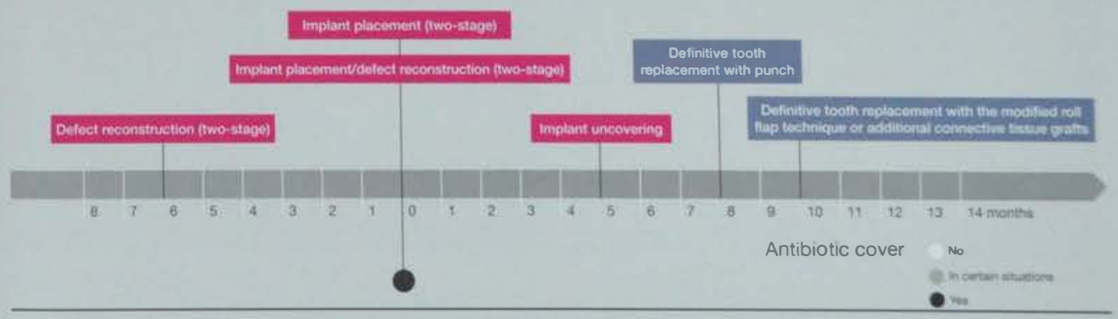
11. Place sutures:
- Use *horizontal mattress sutures* to stabilize the flap on the alveolar ridge.
- Use *double-loop sutures* for primary closure of the flap.
- Use *interrupted sutures* to close the vertical releasing incisions.
- Use *vertical mattress sutures* to close the mobilized papillae.

12. Grind back the provisional restoration such that it *does not come in contact* with the surgical site.

13. Apply *gentle pressure* to the wound for several minutes.

14. Give the *patient* complete and comprehensive *postoperative instructions*.

TIME MANAGEMENT



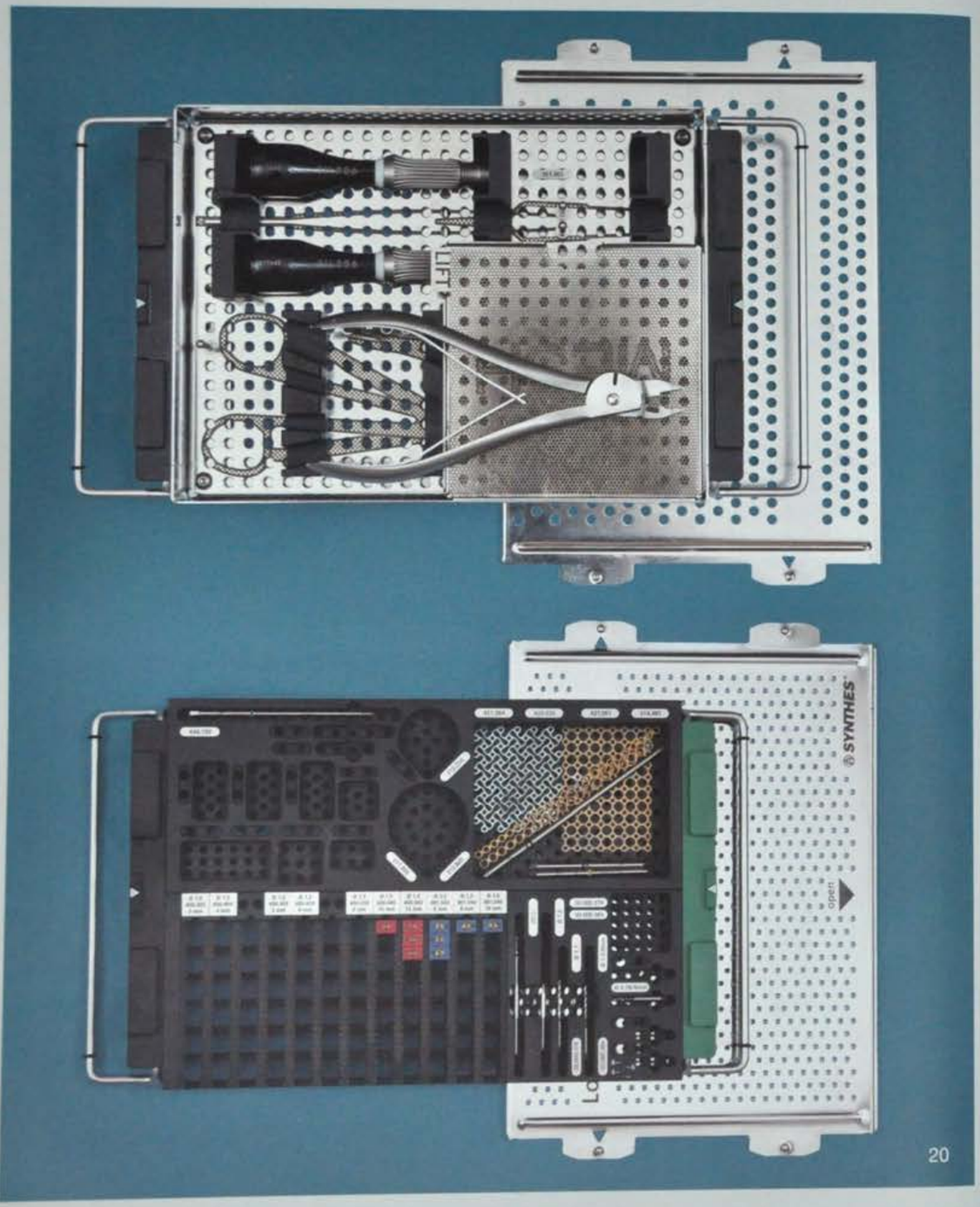
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WORKPLACE PREPARATION CHECKLIST

1 Macrosurgical instrument set
2 Microsurgical instrument set
3 Handpiece with a pin drill, *Lindemann* bur, round carbide bur, and diamond disk
4 Extraction elevator
5 Implant motor with contra-angle handpiece and implantation set
6 Selection of implants (within reach)
7 Suture materials: Gore-Tex CV-5, 6-0 Seralene DS-15, and 7-0 Serafit DS-12
8 No. 15 and 12D macroblades and Keydent microblade
9 Glass slab
10 0.1% chlorhexidine solution in a metal dish
11 Sterile water in a metal dish
12 Metal dish for bone substitute material
13 Blunt cannula
14 10-mL syringe
15 Bone filter
16 Bone substitute material
17 Insulin syringe
18 Collagen membrane
19 Pin set
20 Osteosynthesis screws (set)
21 Local anesthetic
22 Large and small pledgets
23 Periodontal stent



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STEP-BY-STEP PROCEDURE





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Figs 13-253 to 13-255 Both maxillary central incisors in a 26-year-old woman have been lost to trauma; they have been replaced with a provisional removable restoration by another practitioner. The missing teeth are to be replaced with implants. The edentulous space is classified as Class III and will be reconstructed using the cortical bone plate method.

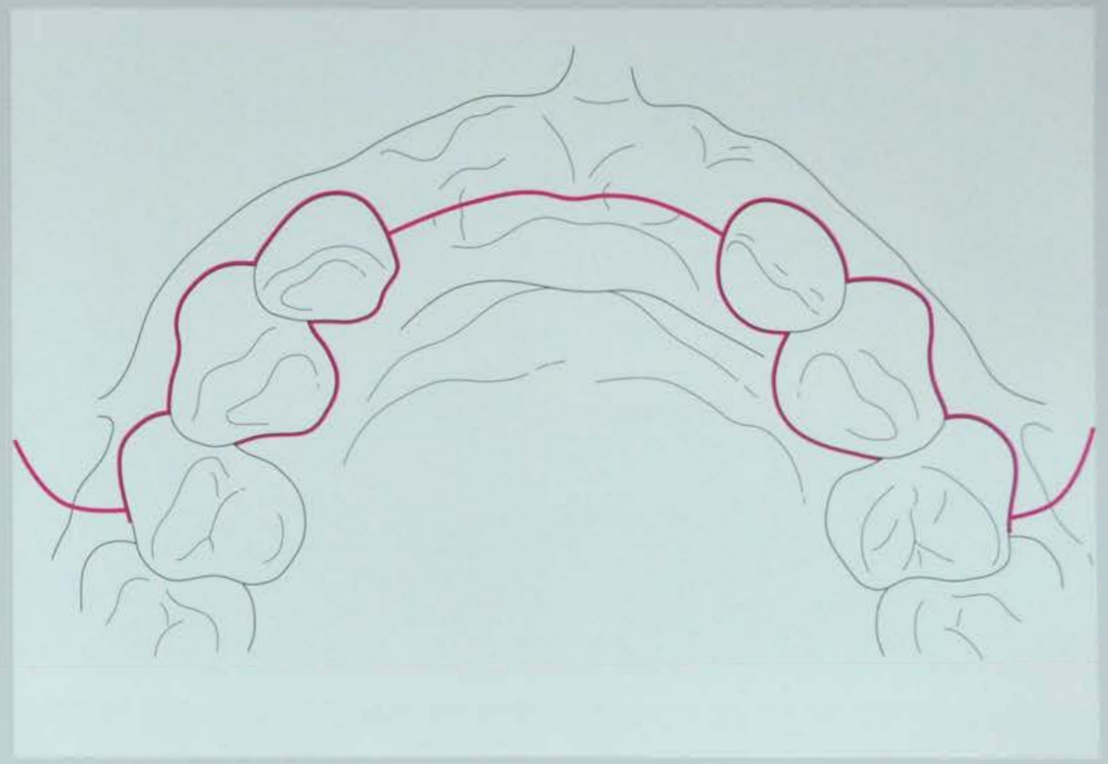
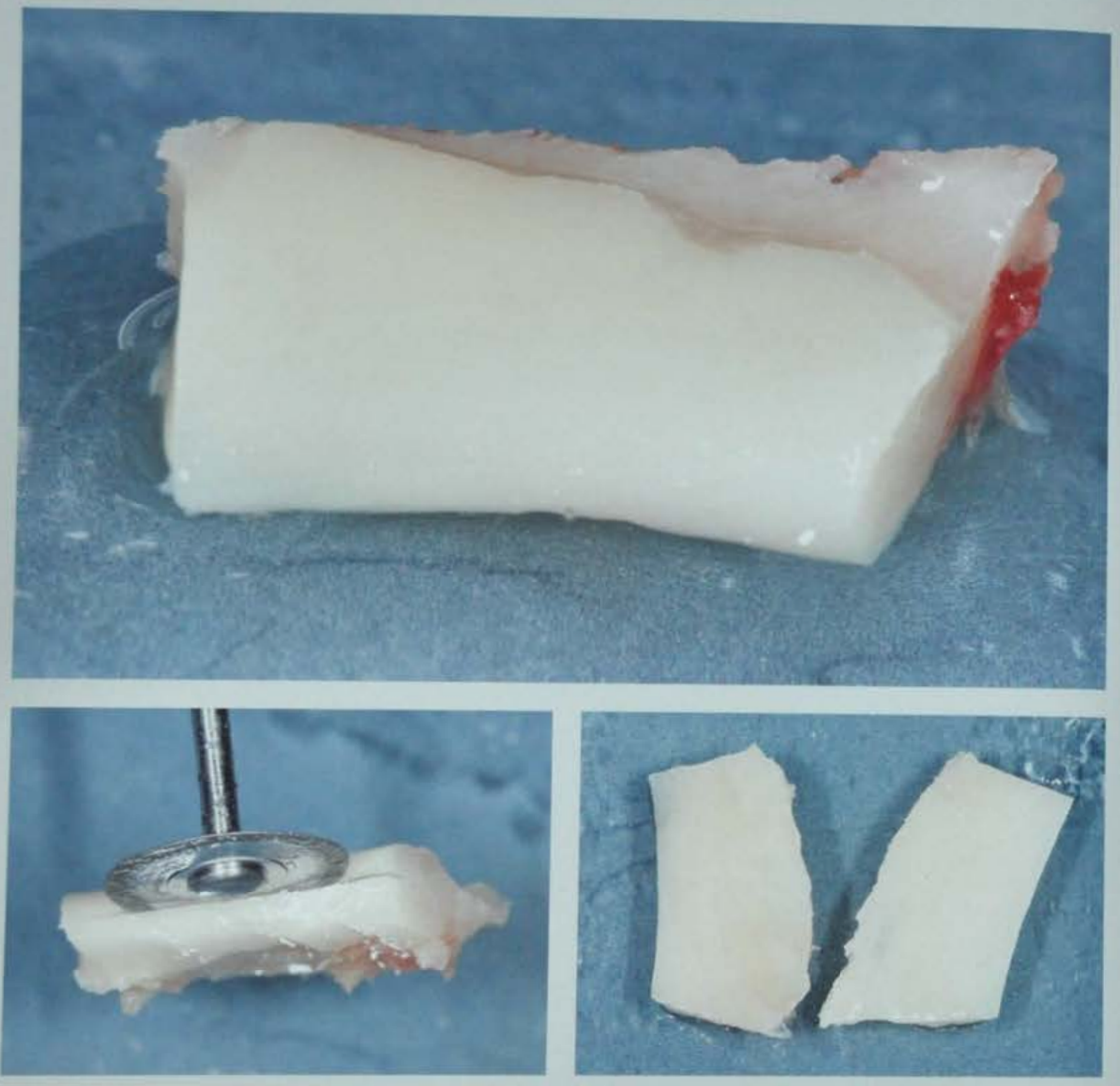


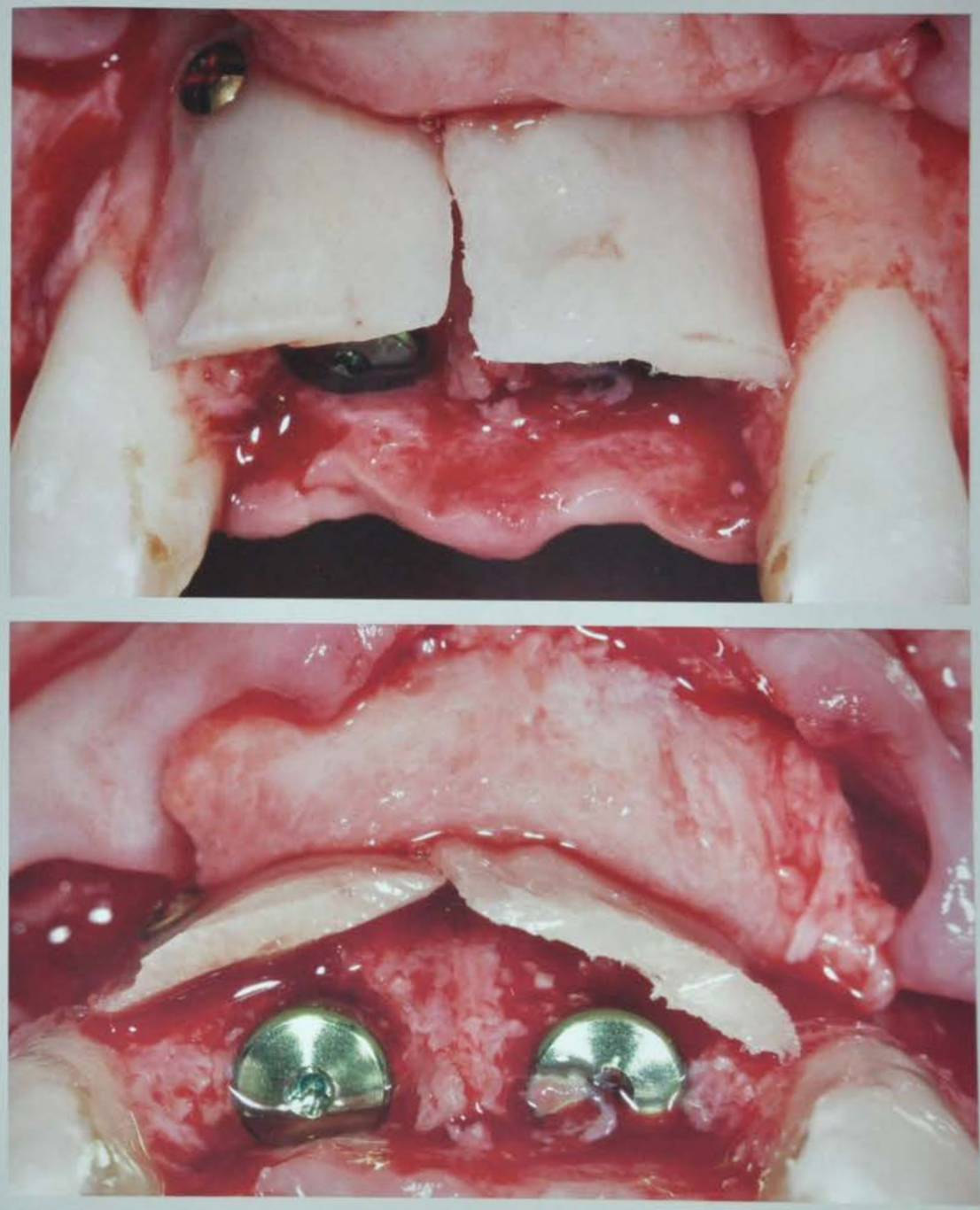
Fig 13-256 Schematic illustration of the site after completion of the incision design. After an alveolar ridge incision extending to the bone is made, a microblade is used to place an intrasulcular incision at the teeth adjacent to the gap. The intrasulcular incision is extended buccally to the first premolars and palatally to the canines. On the buccal side, a vertical releasing incision is performed distal to the first premolar. Reflection of a full-thickness flap on the buccal and palatal sides provides full visualization of the defect. For additional mobility of the buccal flap, the periosteum is slit and the flap is further dissected to create a mucoperiosteal-mucosal flap. It is advisable to perforate the cortical bone in the defect area with small drills at this time to induce sufficient bleeding for later defect reconstruction.

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Figs 13-257 to 13-259 An autogenous bone block is harvested from the angle of the jaw. The bone chips produced during drilling are collected with a bone filter. A diamond disk is used to cut the harvested piece of bone longitudinally outside of the mouth.

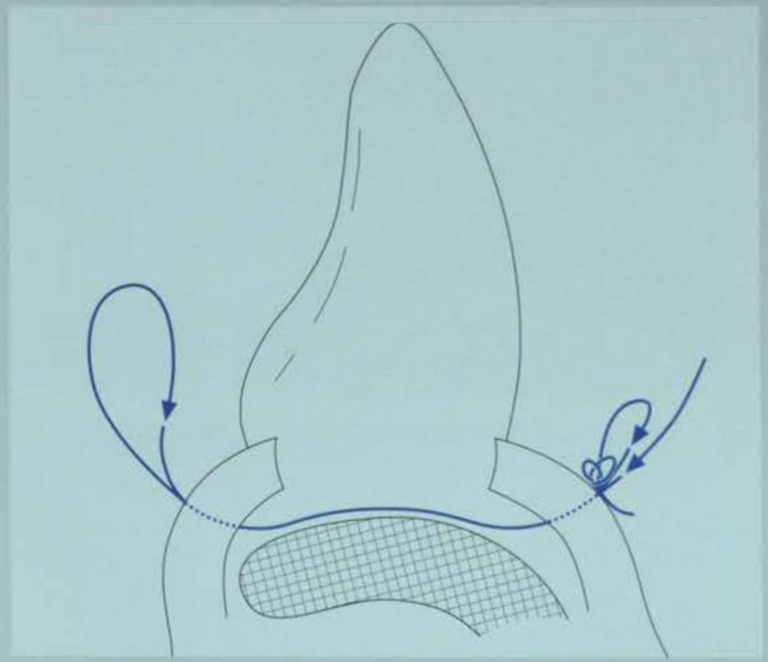
Figs 13-260 and 13-261 The two cortical bone plates are secured to the alveolar ridge with osteosynthesis screws, ensuring that the defect area is adequately covered and stabilized. In this case, reconstruction with simultaneous implant placement is possible because of the configuration of the defect and the position of the osteosynthesis screws. To enable soft tissue augmentation to be performed simultaneously with hard tissue augmentation, a free subepithelial connective tissue graft is harvested from the palate and secured to the buccal flap with a 7-0 Seralene DS-12 suture so that it is fixed over the alveolar ridge buccally and will later lie below the incision line. This ensures closed healing of the augmentation site, even if postoperative wound dehiscence occurs.

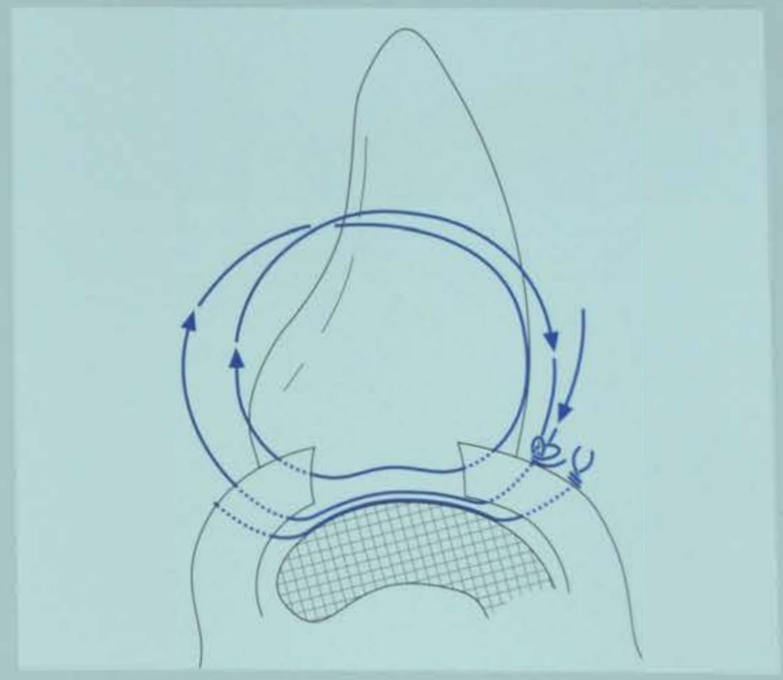


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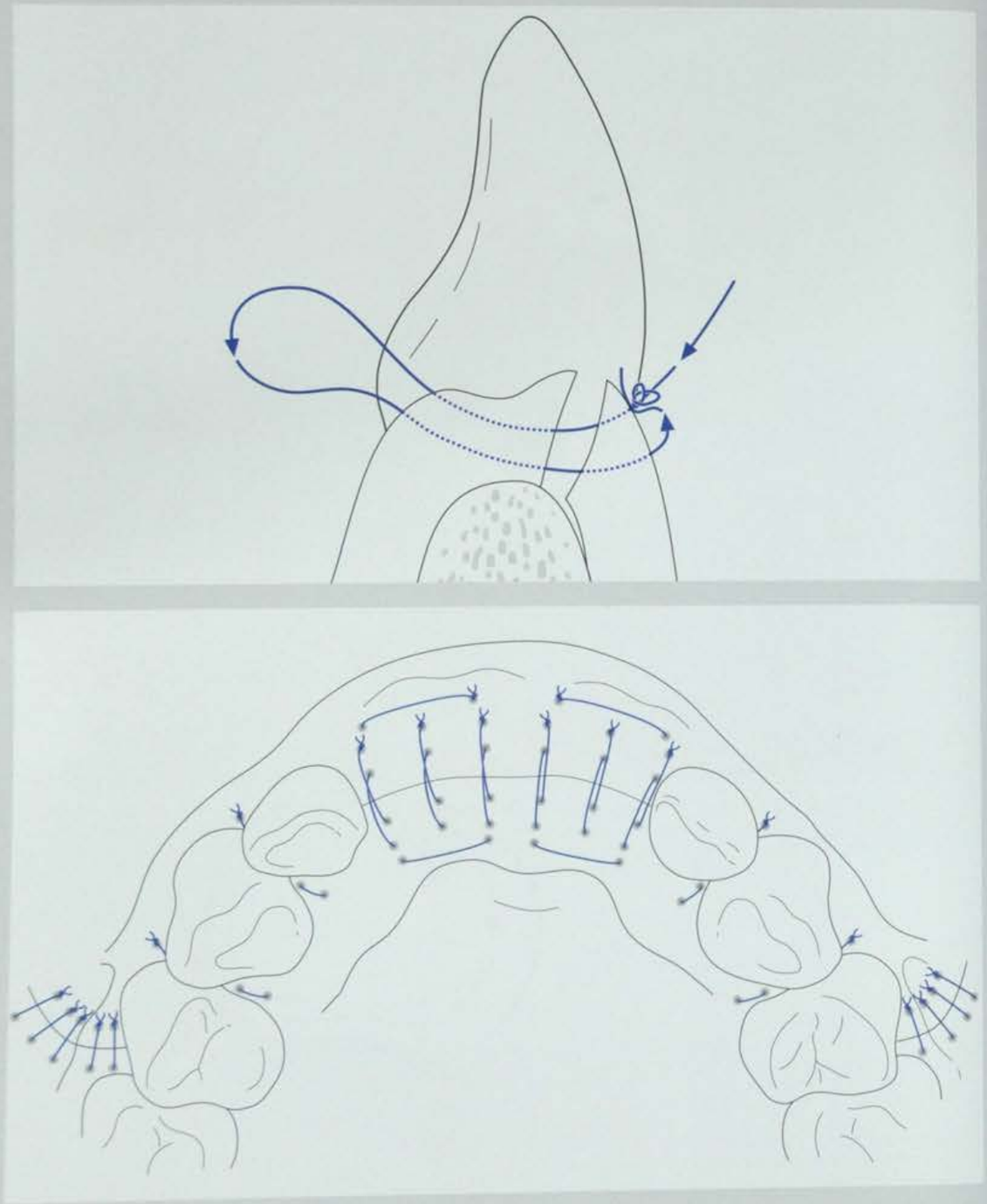
Fig 13-262 A non–cross-linked collagen membrane (Bio-Gide) is trimmed to size according to the anatomical dimensions of the defect and fixed apically to the defect using resorbable pins. The space between the cortical bone plates and the niches and spaces buccal to the two bone plates are filled with a mixture of particulate autogenous bone (collected with the bone filter) and DBBM (Bio-Oss). The collagen membrane is then pulled over the augmentation material and positioned under the palatal flap.



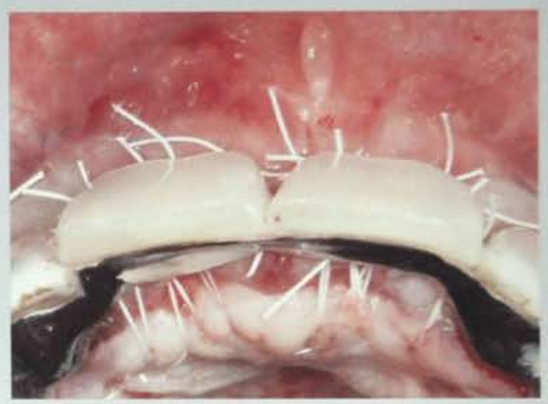


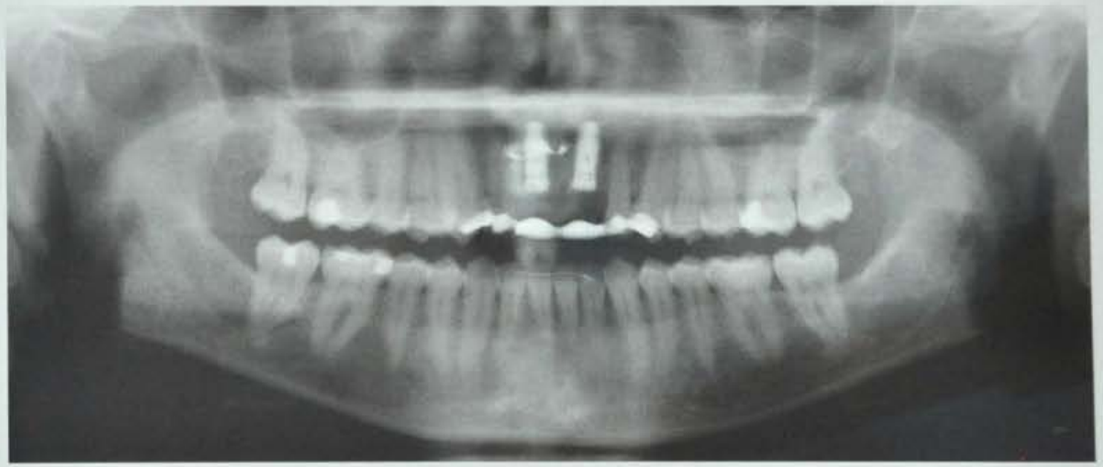
Figs 13-263 and 13-264 The wound is closed with mattress sutures and double-sling sutures (Gore-Tex CV-5).

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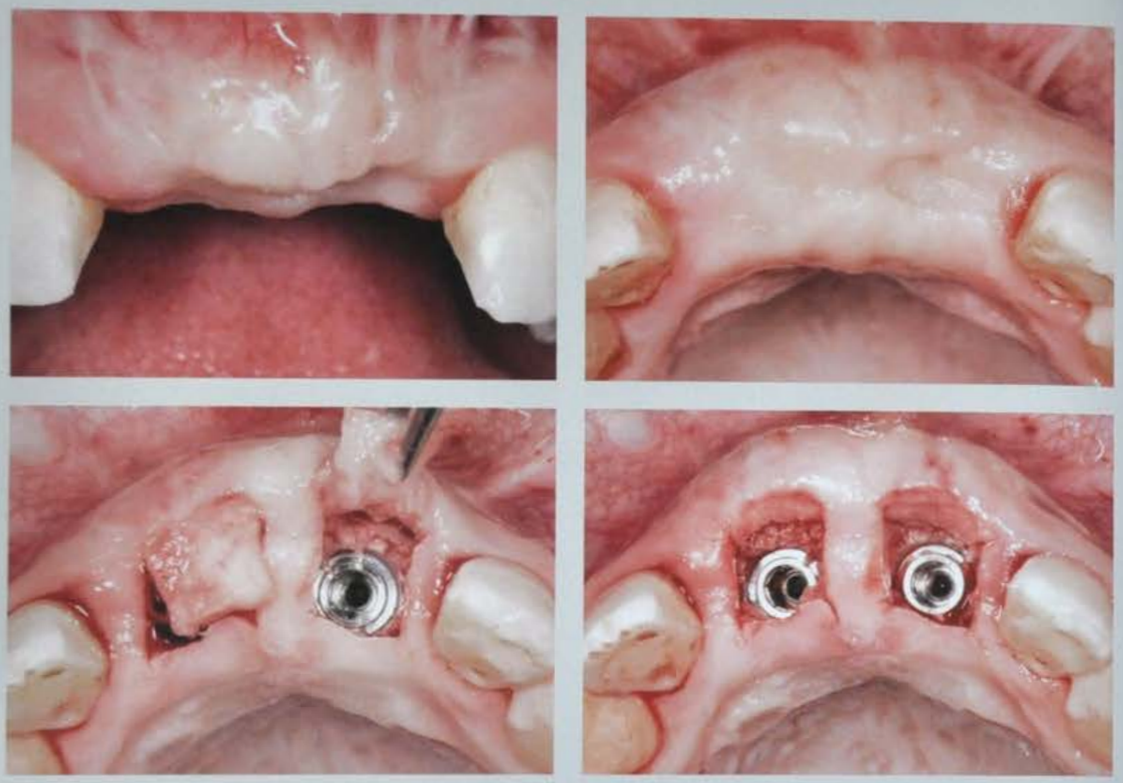




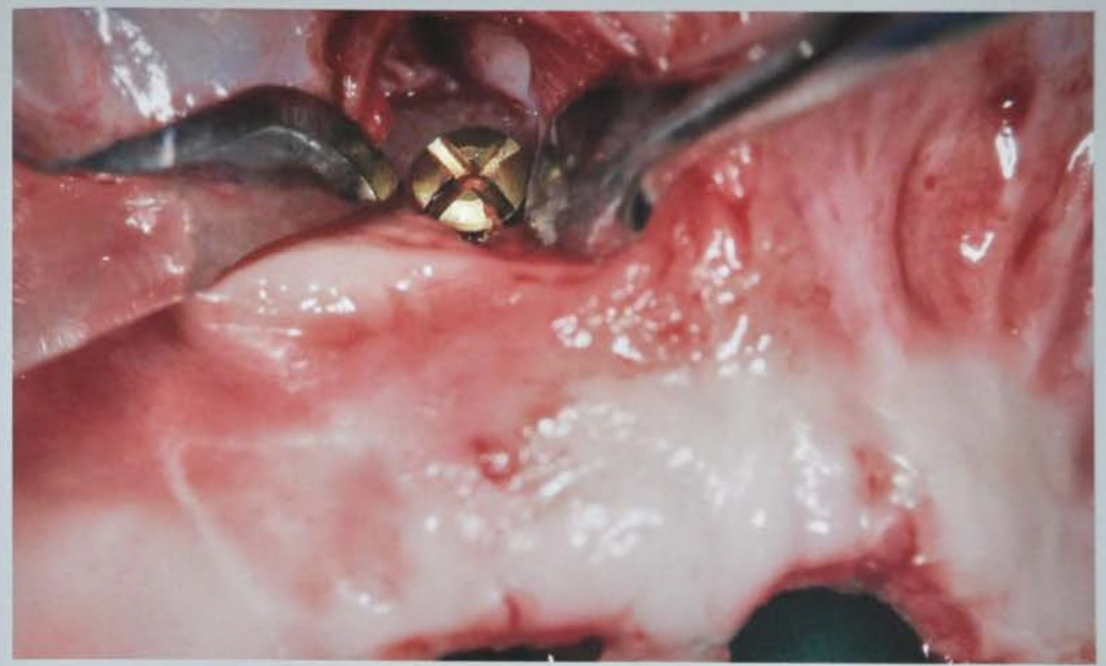


Figs 13-265 to 13-269 Next, the vertical releasing incisions are closed with interrupted sutures, and the mobilized papillae are closed with vertical mattress sutures. It is crucial to ensure that the pontics of the fixed provisional restoration are ground back far enough to ensure that there is sufficient space between the pontic and the surgical site. Figure 13-269 (bottom) shows the immediate postoperative radiograph.

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Figs 13-270 to 13-275 Second-stage implant uncovering surgery is performed via the modified roll flap technique 5 months after implant placement and defect reconstruction. The osteosynthesis screws are removed at this time.





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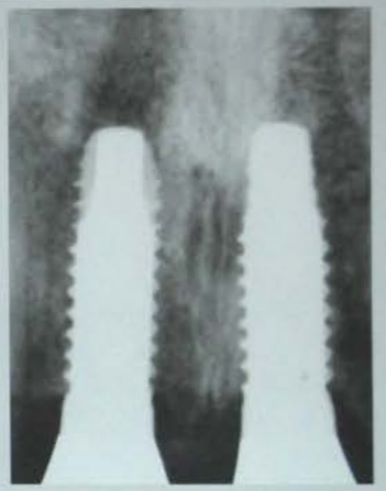


Fig 13-276 Five months after the implants are uncovered, impressions for fabrication of the final restorations can be taken.









Figs 13-277 to 13-281 Results after the completion of treatment. Zirconia abutments with fired ceramic shoulders have been used to enable a certain degree of prosthetic compensation for soft tissue recession that may take place in the future.

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Fig 13-282 Patient after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)



See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 9, Chapter 2: Cortical Bone Plate Method for Simultaneous Implant Placement and Vertical Ridge Augmentation."

13.2.5 Implant Uncovering with the Modified Roll Flap Technique

KEY POINTS

01. Select the technique based on the *buccal soft tissue dimensions*.

02. *De-epithelialize* an area of the alveolar ridge corresponding to the cross section of the tooth to be replaced.

03. *Cut the de-epithelialized area* laterally and palatally down to the bone.

04. Elevate a *full-thickness* buccal pedicle flap.

05. Convert the provisional restoration into an *implant-supported provisional*. The emergence profile of the provisional restoration should very closely resemble that of the definitive implant reconstruction.

06. Elevate and undermine a partial-thickness flap:
- Extend it *buccally* and *apically* beyond the mucogingival junction.
- Extend it *laterally* at least one tooth width beyond the planned augmentation site.
- Completely mobilize the *papillae* of the teeth adjacent to the gap.

07. Roll the *buccal pedicle flap* into the prepared tunnel.

08. Insert an *implant-supported provisional restoration* with an emergence profile that is very similar to that of the definitive implant reconstruction.

09. *Splint* the contact points with flowable composite resin.

10. Use vertical double-crossed sutures to *secure* the flap and the pedicled connective tissue.

11. Apply *gentle pressure* to the wound for several minutes.

12. Give the *patient* complete and comprehensive *postoperative instructions*.

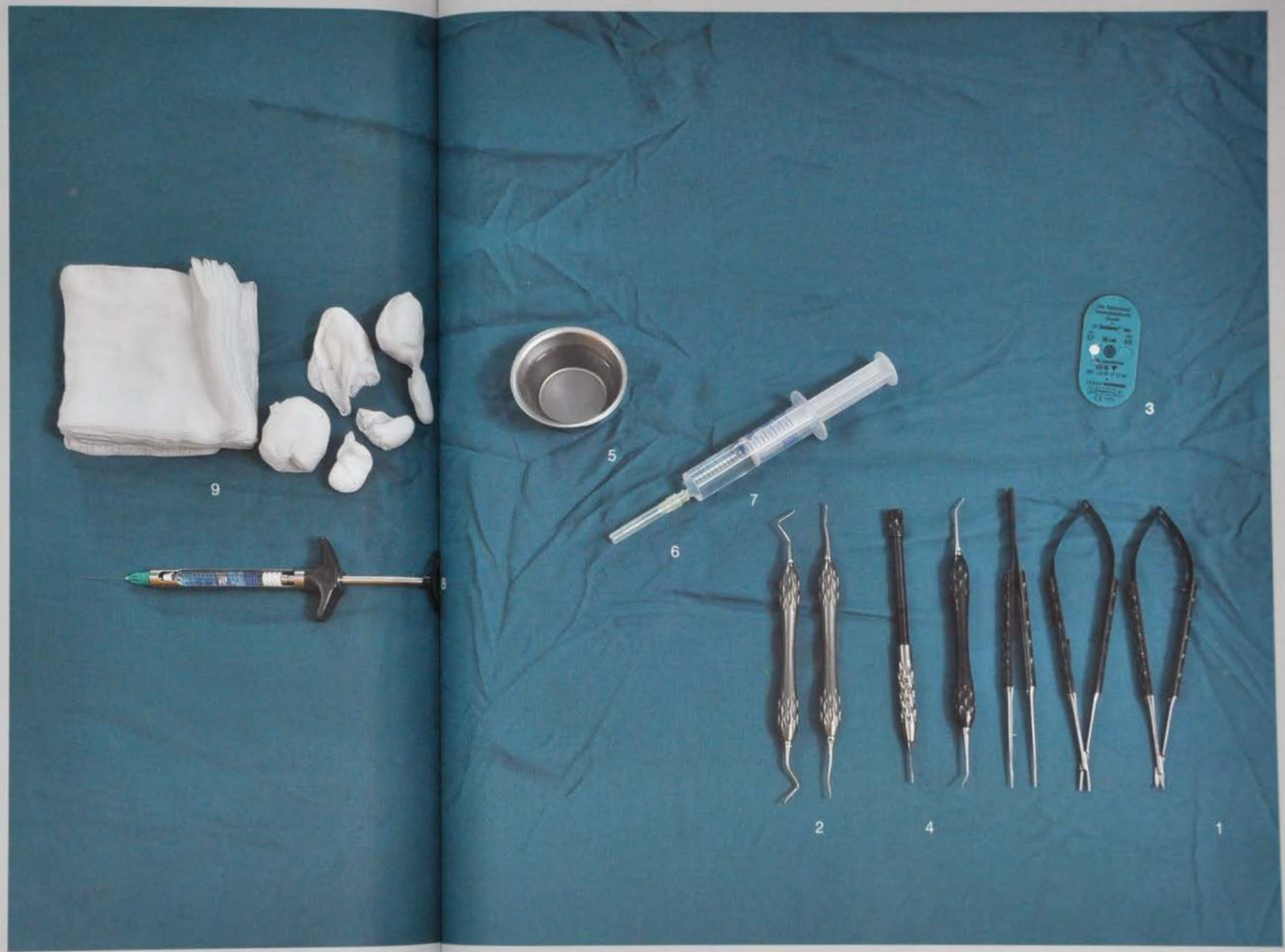
TIME MANAGEMENT



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WORKPLACE PREPARATION CHECKLIST

1. Microsurgical instrument set
2. Tunneling Knives I and II
3. Suture materials: 6-0 Seralene DS-15
4. Keydent microblade
5. Sterile water in a metal dish
6. Blunt cannula
7. 10-mL syringe
8. Local anesthetic
9. Large and small pledgets



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STEP-BY-STEP PROCEDURE



Fig 13-283 A missing maxillary left central incisor is to be replaced with an implant. The edentulous space is classified as Class I. Therefore, implantation with simultaneous defect construction is to be performed by means of the modified double-layer technique in the first stage of implant surgery.







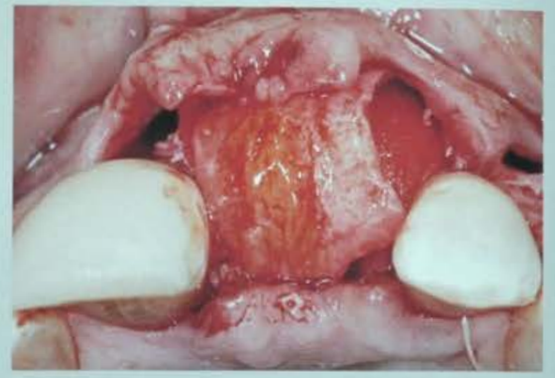




Figs 13-284 to 13-288 After elevation of a full-thickness flap and visualization of the defect area, the implant is placed in the prosthetically correct position. Implant position indexing is performed to ensure that the provisional restoration will have an ideal emergence profile at the time of second-stage implant uncovering surgery. An impression post is screwed into the implant and splinted to the adjacent teeth for this purpose.

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Figs 13-289 to 13-292 The defect is reconstructed via the modified double-layer technique, which incorporates DBBM (Bio-Oss) as well as both a conventional non–cross-linked (Bio-Gide) and a cross-linked (Ossix) collagen membrane. In addition, a free subepithelial connective tissue graft harvested from the palate is inserted into the defect region.





Figs 13-293 to 13-295 After completion of suture closure, the provisional restoration is bonded in place.

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Figs 13-296 to 13-299 The intraoperatively prepared index is used to transfer the intraoral implant position to the cast, making it possible to fabricate an implant-supported provisional restoration before the implant is uncovered.




Figs 13-300 and 13-301 Clinical findings 5 months after implantation and defect reconstruction. Due to the moderate buccal tissue deficit, the modified roll flap technique will be used for second-stage implant uncovering surgery.

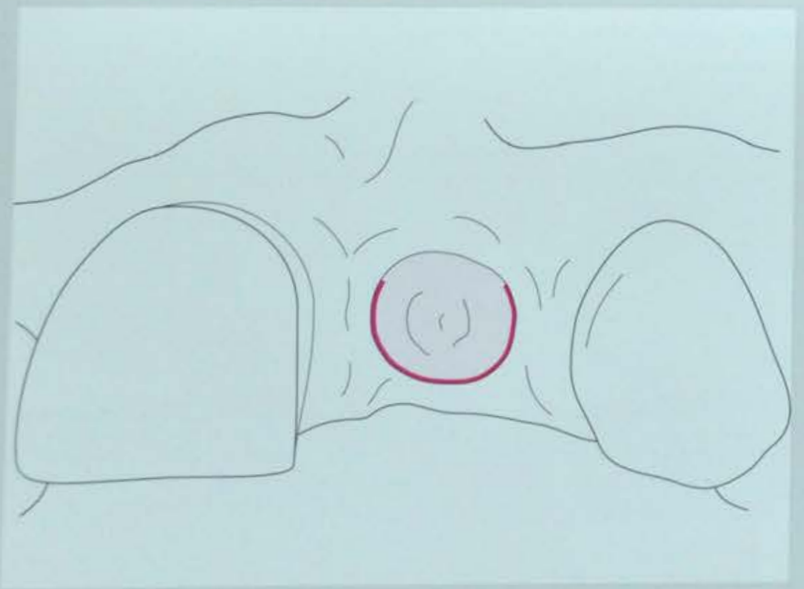




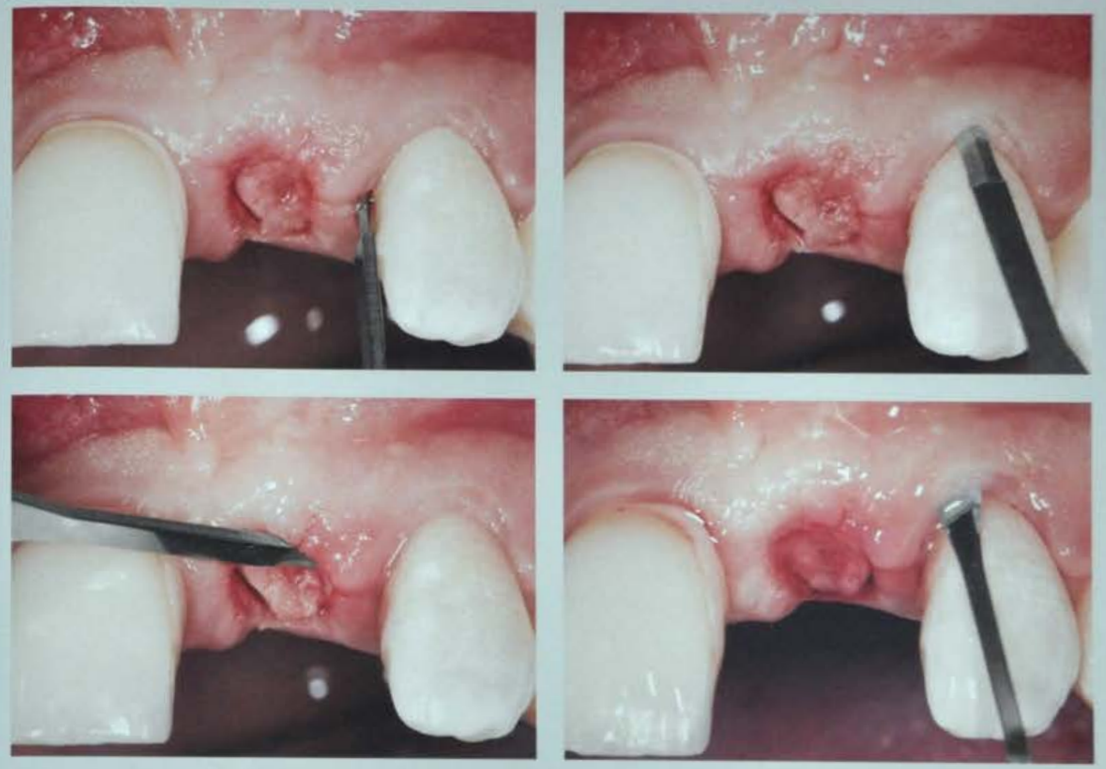

Figs 13-302 to 13-305 First, a microblade is used to de-epithelialize a section of the alveolar ridge, the area of which corresponds to the cross section of the root of the replaced tooth at its point of emergence from the soft tissue.

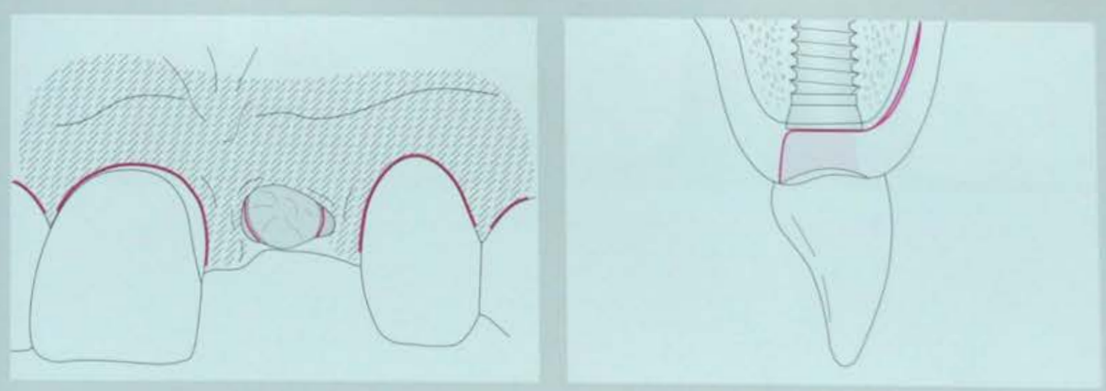
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Figs 13-306 and 13-307 Next, the microblade is used to cut the de-epithelialized area laterally and palatally to expose the underlying bone and implant cover screw. The blade should be held perpendicular to the tissue surface during this process. The buccal aspect is not cut.





Figs 13-308 to 13-313 Starting from an intrasulcular incision around the teeth adjacent to the gap, the microblade and Tunneling Knives are used to dissect and undermine a partial-thickness flap on the buccal aspect. The flap is extended at least one tooth lateral to the defect. The periosteum at the base of the papillae adjacent to the gap is dissected, and the papillae themselves are elevated as a full-thickness flap. To achieve adequate flap mobility, the papillae of the teeth immediately adjacent to the gap must also be sharply dissected over the periosteum and fully incorporated into the flap. Figures 13-312 and 13-313 (bottom) are schematic illustrations of the site after completion of the tunnel preparation.

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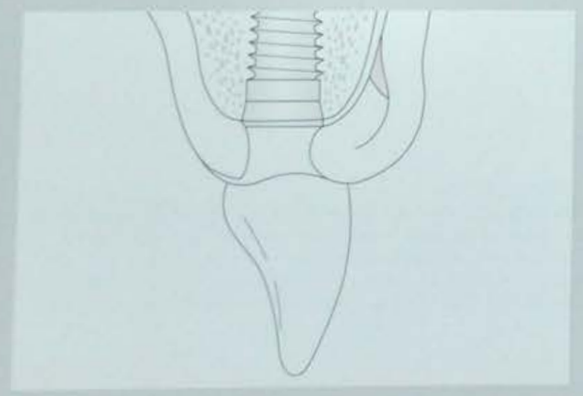




Figs 13-314 and 13-315 The periosteal elevator is used to lift the de-epithelialized buccal pedicle flap from the underlying bone and implant cover screw. The microblade is used to cut the periosteum from the inner aspect to establish a connection to the buccal tunnel.







Figs 13-316 to 13-318 The mobilized flap can now be rolled into the buccal tunnel.





Figs 13-319 and 13-320 A bone profiler is used to remove any bone present coronal to the implant shoulder.



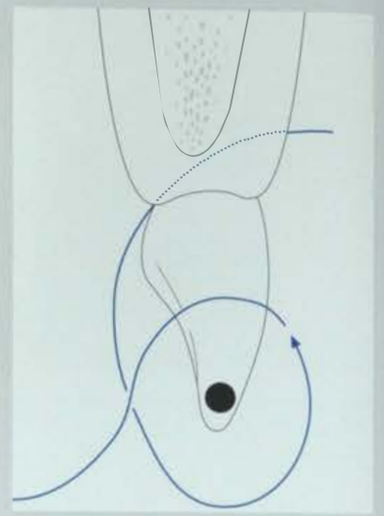




Figs 13-321 to 13-323 The provisional restoration made by indexing at the time of implantation is screwed in place, and the contact points to the teeth adjacent to the gap can be splinted with flowable composite resin without enamel etching.

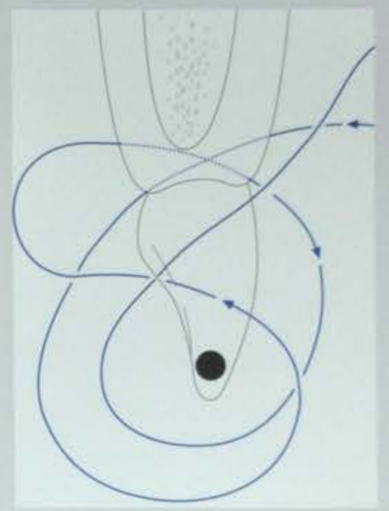
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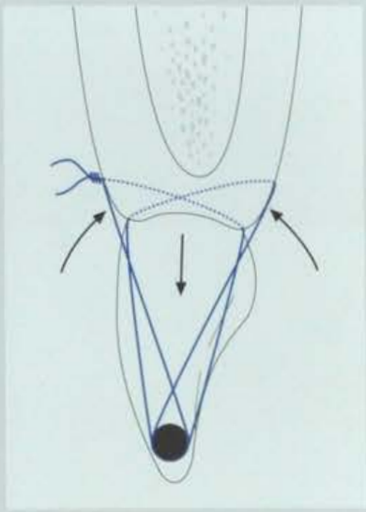




Figs 13-324 and 13-325 Suture closure is accomplished with two vertical double-crossed sutures of 6-0 Seralene DS-15 suture material. First suture: Starting on the buccal side at the level of the mucogingival junction, the needle travels through the base of the papilla, passes beneath the splinted contact point and through the interdental soft tissue, and exits on the palatal side, slightly apical to the tip of the papilla. The needle is then guided over the incisal edges of the teeth and returned to the buccal side. It then glides beneath the splinted contact point, back-first so as not to engage the tissue, and exits on the palatal side.









Figs 13-326 to 13-329 Second suture: From the palatal side, the needle passes through the base of the papilla and emerges slightly apical to the tip of the papilla on the buccal side. Next, the needle is guided back to the palatal side and again glides beneath the splinted contact point, back-first so as not to engage the tissue, and returns to the buccal side. The suture is then tied.

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Fig 13-330 Clinical appearance 1 week after surgery, before suture removal.







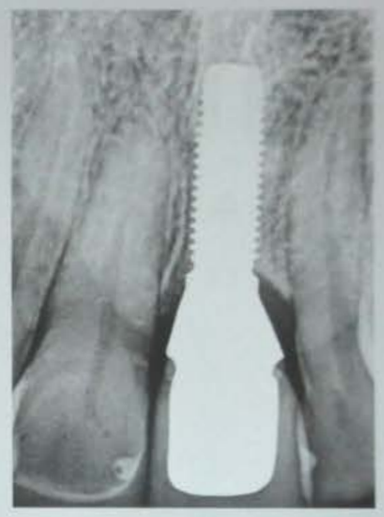
Figs 13-331 to 13-333 Five months after implant uncovering, impressions for the final restoration can be taken. A customized impression post is used to take soft tissue impressions with an adequate degree of precision. The veneer on the adjacent central incisor is removed to obtain an impression of the prepared tooth and the implant.

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Figs 13-334 to 13-337 Results after placement of the ceramic veneer and screw-retained, single-unit, implant-supported crown.







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Fig 13-338 Patient after the completion of treatment. (Dental technician: *Uli Schoberer*, Seehausen, Germany.)

See also the DVD compendium "Plastic-Esthetic Periodontal and Implant Surgery, Volume 10: Implant Uncovering with the Modified Roll Flap Technique."

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SECTION C

COMPLICATIONS

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CHAPTER 14

INTRAOPERATIVE BLEEDING

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Most of the procedures presented in this book can only result in intraoperative bleeding from relatively small terminal vessels. Therefore, it normally is not necessary to tie off or ligate the blood vessels with sutures should any damage occur. The application of pressure to the affected area for a few minutes will generally suffice to stop any significant bleeding. However, there are exceptions to the norm. Major hemorrhage can occur when connective tissue grafts are harvested from the palate or bone grafts are harvested from the mandibular angle.

14.1 Damage to the Greater Palatine Artery When Harvesting Subepithelial Connective Tissue Grafts from the Palate

Damage to the greater palatine artery or one of its major branches is a serious complication that is difficult to control, even for an experienced clinician. When connective tissue grafts are harvested from the palate, it is imperative to always use risk-free procedures and pay close attention to these anatomical structures (see chapter 7).

Damage to the greater palatine artery can lead to massive bleeding. If hemorrhaging occurs, it is important to remain calm and not to panic. Injection of a local anesthetic with an added vasoconstrictor into and around the major palatine artery and the application of pressure to the area generally help to reduce the bleeding, at least enough to improve visualization of the operating field and thus to gain more control over the situation. In most cases, the severe bleeding and poor visibility will make it impossible to locate the damaged blood vessel in the tissue for suture ligation or electrocoagulation. Dissection and slight elevation of a full-thickness flap extending to the major palatine canal in order to ligate the neurovascular bundle after it is drawn out of the canal is more likely to achieve successful hemostasis but could also cause serious complications such as paresthesia and necrosis of the palatal mucosa.

The best way to stop the bleeding is therefore to apply a pressure dressing. The routine preoperative fabrication of surgical stents before harvesting of subepithelial connective tissue grafts from the palate is strongly recommended for this reason (see chapter 6). In the event of major bleeding from the palatal donor site, the surgical stent can quickly be converted into a pressure dressing. A 1.0- to 1.5-cm area overlying the greater palatine foramen is roughened, and adhesive is applied on the fitting surface of the stent. After this, a 1.0- to 1.5-mm thick layer of light-curing flowable composite resin material is applied to the prepared area. In the meantime, an assistant should use a compress to apply pressure to the region of the greater palatine foramen.

The modified surgical stent is tried in and the composite layer adjusted as needed. When the surgical stent is pressed in the correct position, distinct anemia of the mucosa around the greater palatine foramen should be visible. Next, the coronal portions of the palatal surfaces of the maxillary posterior teeth are etched with phosphoric acid, and adhesive is applied. The surgical stent is inserted, positioned, and secured to the etched tooth surfaces with a generous amount of light-curing flowable composite while pressure is maintained (Fig 14-1). Once it is certain that the bleeding has been stopped, the clinician can consider admitting the patient to the hospital for 24 hours' observation.



Fig 14-1 (a to c) Emergency measures in case of damage to the palatine artery or one of its major branches. First, the greater palatine canal is infiltrated with local anesthetic to induce vasoconstriction, and pressure is applied to the area for several minutes with a compress.

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Fig 14-1 (d and e) A layer of composite resin is then applied to the portion of the surgical stent overlying the greater palatine foramen. An assistant continues to apply pressure to the wound during this time.





Fig 14-1 (f and g) The composite buildup must be adjusted as needed to ensure that the stent will be seated in the correct position while exerting sufficient pressure to produce distinct anemia of the mucosa in the greater palatine foramen region.





Fig 14-1 (h and i) Finally, the surgical stent is inserted, positioned, and secured to the etched tooth surfaces with a generous amount of light-curing flowable composite while pressure is maintained.

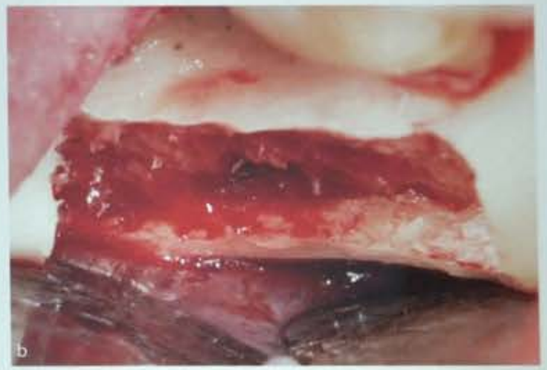
14.2 Excessive Bleeding After Harvesting of Bone Grafts from the Mandibular Angle

The harvesting of autogenous bone grafts from the mandibular angle is a safe procedure with a low rate of complications (see chapter 7). Because these grafts consist mainly of cortical bone, only small areas of cancellous bone are exposed in the donor region. Any major bleeding from bone graft harvesting should absolutely be stopped before suturing to prevent hematoma resulting from postoperative bleeding into the surrounding tissues. A very effective way to do this is to apply an absorbable hemostat agent, such as oxidized regenerated cellulose (Tabotamp), until hemostasis has been achieved (Fig 14-2). The site is then sutured as usual.

Intraoperative bleeding

1. Fabricate a surgical stent preoperatively whenever a connective tissue graft is to be harvested from the palate.
2. If the palatine artery is cut, inject a local anesthetic into the greater palatine canal and apply pressure to the wound to achieve initial hemostasis.
3. Apply composite resin to the surgical stent to create a pressure dressing and adhesively bond the stent to the teeth.
4. After hemostasis has been achieved, decide whether the patient should be admitted to the hospital for monitoring.
5. Stop any major bleeding from autogenous bone graft harvesting from the mandibular angle before suture closure. Absorbable hemostat agents such as oxidized regenerated cellulose are useful in these indications.





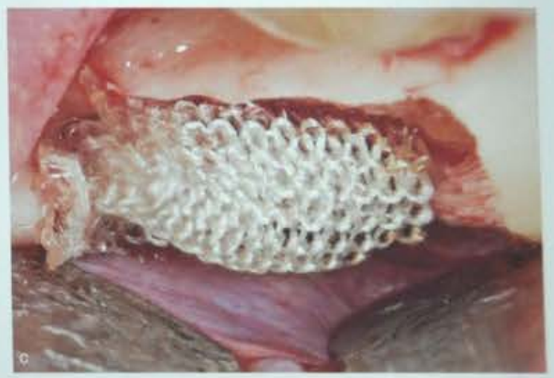


Fig 14-2 (a to c) Any major bleeding from autogenous bone graft harvesting from the mandibular angle should be stopped before suture closure. Oxidized regenerated cellulose (Tabotamp) has proved very effective in these applications.

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CHAPTER 15

FLAP PERFORATION

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Flap perforation is a potential complication that most frequently occurs during partial-thickness flap elevation. The thinner the soft tissue, the more difficult the technical execution of flap elevation. The risk of perforation is greatest at the mucogingival junction. The presence of scar tissue from previous surgery (eg, apicoectomy) further complicates the technical execution of partial-thickness flap elevation. Flap perforation can increase the risk of flap necrosis by impairing local blood flow. Furthermore, the use of a perforated flap to cover a connective tissue graft can have negative consequences for graft integration. Proper instrumentation and technique are thus key elements of successful partial-thickness flap elevation (see chapter 4).

If flap perforation should occur, the main clinical challenge is to complete flap dissection without enlarging the perforation. Therefore, the flap must be completed in a slow and very controlled manner. It is advisable to perform further dissection in the perforation area by pressing the blade to the underlying bone with relatively heavy pressure. After completion of flap elevation, the tear may be left open or closed with sutures, depending on the size of the perforation. If sutures are placed, it is imperative that fine suture material be used to prevent the suture from tearing the flap and enlarging the perforation (Fig 15-1). The surgical procedure itself is completed as originally planned.

Flap perforation

1. Attempt to complete flap dissection without enlarging the perforation.
2. Suture large perforations.
3. Complete the surgical procedure as planned.





b



c

Fig 15-1 (a to c) Flap perforation occurred during gingival recession surgery using the modified tunnel technique. In such cases, it is important to complete flap dissection without enlarging the perforation site. Subsequently, the perforation is closed with interrupted sutures made of microsurgical suture material.

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CHAPTER 16

POSTOPERATIVE BLEEDING

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Postoperative bleeding rarely occurs after plastic-esthetic periodontal and implant surgery if autograft harvesting and suture closure procedures were performed correctly (see chapter 7). When it does occur, patients always consider this to be a serious complication. Proper patient education is therefore a key factor in the success of treatment. Patients must understand that mild bleeding during the first hours after surgery is normal and no cause for concern. Furthermore, they must be told to protect the surgical site and be informed of the need to avoid physical exertion and vasodilators such as caffeine and alcohol during the first postoperative days (see chapter 6).

In the event of severe postoperative bleeding, the patient must contact the dentist immediately so that emergency measures can be initiated without delay. First, it is advisable for the clinician to inject a local anesthetic containing epinephrine into the surgical area to locate the source of bleeding (Fig 16-1). If the sutures are no longer intact, they must be revised or replaced. The patient can then use a compress moistened with sterile saline solution to apply gentle pressure to the surgical site. This will stop the bleeding within 30 minutes in most cases. Afterward, the patient should ice the surgical site and remain in the dentist's office awhile for observation.

If postoperative bleeding should occur after a connective tissue graft or bone graft is harvested from the palate or mandibular angle, respectively, the instructions in chapter 14 should be followed.

Postoperative bleeding

1. Inject a local anesthetic containing epinephrine into the surgical site to locate the source of bleeding, and then check and correct the sutures as needed.
2. Apply pressure to the wound.
3. In case of postoperative bleeding from the palate or mandibular angle after connective tissue or bone graft harvesting, follow the instructions in chapter 14.

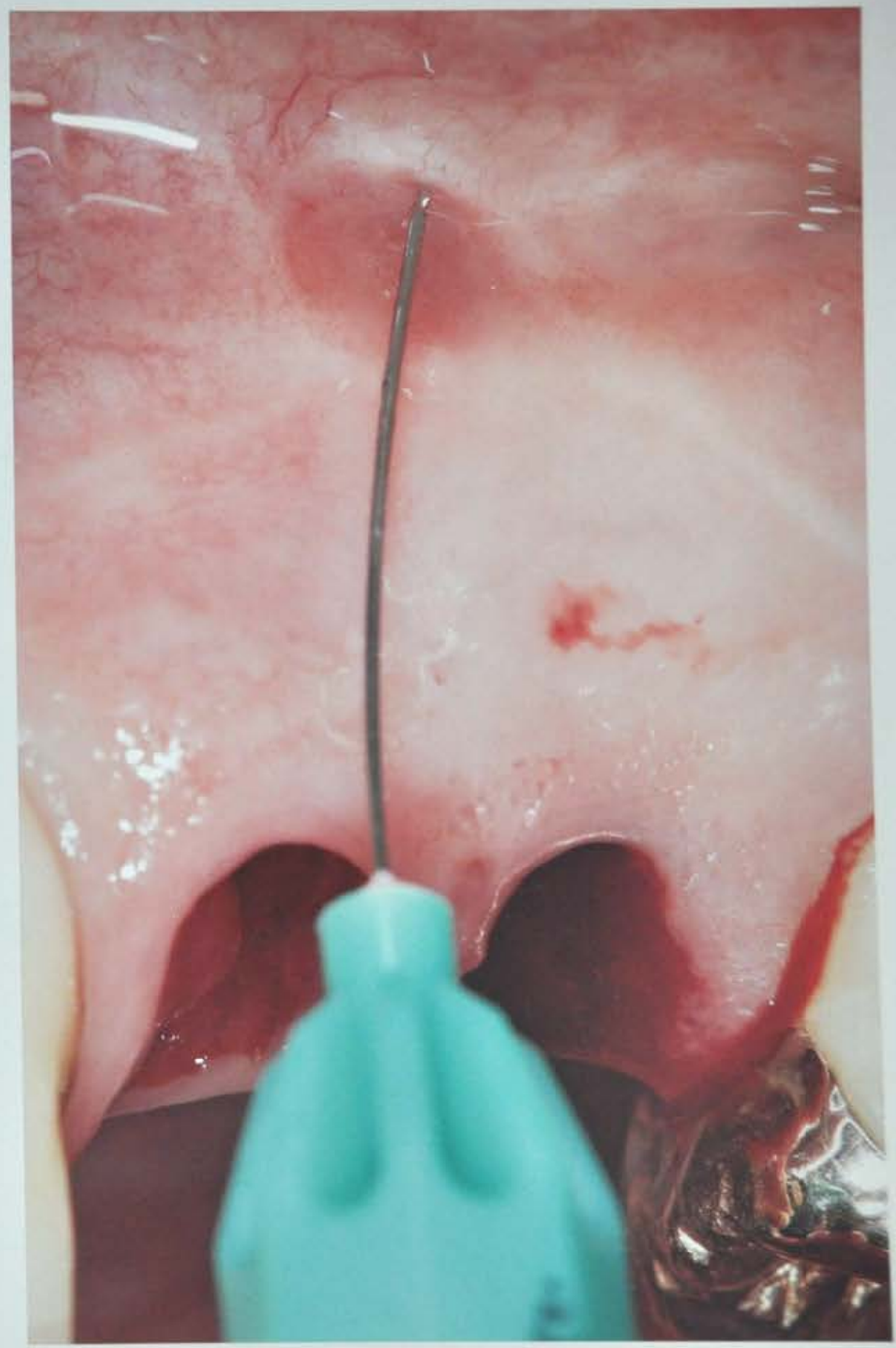


Fig 16-1 If postoperative bleeding occurs, it is advisable to inject a local anesthetic containing epinephrine into the surgical site as the first emergency measure. This usually makes it possible to locate the source of bleeding.

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CHAPTER 17

POSTOPERATIVE INFECTION

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Postoperative infection and impaired wound healing can occur after any surgical procedure, including periodontal and implant surgery. The esthetic and functional consequences for the patient are difficult to impossible to correct. Therefore, preventive measures should be taken to minimize these risks. In this context, it is important to consider the systemic and local factors that affect wound healing (see chapter 3).

After surgery, bacterial colonization of the wound always occurs because of the immigration of pyogenic microorganisms in the course of wound healing. The immune system responds by activating a complex system of immune defense mechanisms, which generally succeed in eliminating the pathogens. Wound infection can occur secondary to impaired wound healing when one or more sites of this complex system are weakened or overwhelmed. This can be caused by increased bacterial colonization of the wound or reduced local or systemic resistance.

In the case of open (secondary intention) wound healing, the response to increased bacterial colonization of the wound is increased wound secretion. In plastic-esthetic periodontal and implant surgery, most of the surgical wounds heal by suture-assisted, primary intention healing. If postoperative wound infection occurs, the wound secretions collect in the closed wound space. The bacteria and degradation products cannot flow out and therefore collect in the surrounding tissues, which frequently results in the spread of infection and abscess. The consequential increase in tissue pressure impairs the blood supply to the region, thus promoting the further spread of infection. Once the wound margins are separated, the secretions can drain, decreasing tissue pressure and allowing wound healing by secondary intention.

17.1 Postoperative Wound Dehiscence

Postoperative wound dehiscence secondary to infection is characterized by the separation of the wound margins and the drainage of secretions out of the wound as a result of increased tissue pressure. This can result in increased pain and swelling in the surgical region. These cases require symptomatic local treatment in which the surgical site is cleaned with 0.1% chlorhexidine solution and topical 1% chlorhexidine gel is applied. This regimen is repeated once daily at the dental practice for several days. The sutures should be left in place until satisfactory healing has occurred.

If the patient shows signs of poor general health, systemic antibiotics should be administered to decrease the risk of abscess. Aminopenicillins (eg, amoxicillin, 500 mg three times daily for 7 days) are prescribed in these cases because of their good soft tissue distribution. Patients allergic to penicillin should receive clindamycin (300 mg three times daily for 7 days) instead (see chapter 6).

If postoperative wound dehiscence occurs, it normally is not possible to achieve the desired esthetic outcome of periodontal plastic surgery. In many cases, it will be necessary to repeat the procedure after the site has healed. Wound dehiscence following implantation and hard tissue augmentation can result in the exposure of barrier membranes. Removal of the implant is indicated in the event of failure of the aforementioned local treatment measures or of exposure of the bone substitute material and implant. In these cases, the surgery can be repeated after complete healing has occurred.

Wound dehiscence can also occur as a primary entity independent of wound infection (Fig 17-1). Potential causes of noninfectious, primary wound dehiscence include a compromised blood supply to the flap, inadequate flap mobility, insufficient sutures, poor suturing techniques, and iatrogenic trauma. Both infectious and noninfectious wound dehiscence have the same clinical consequences.

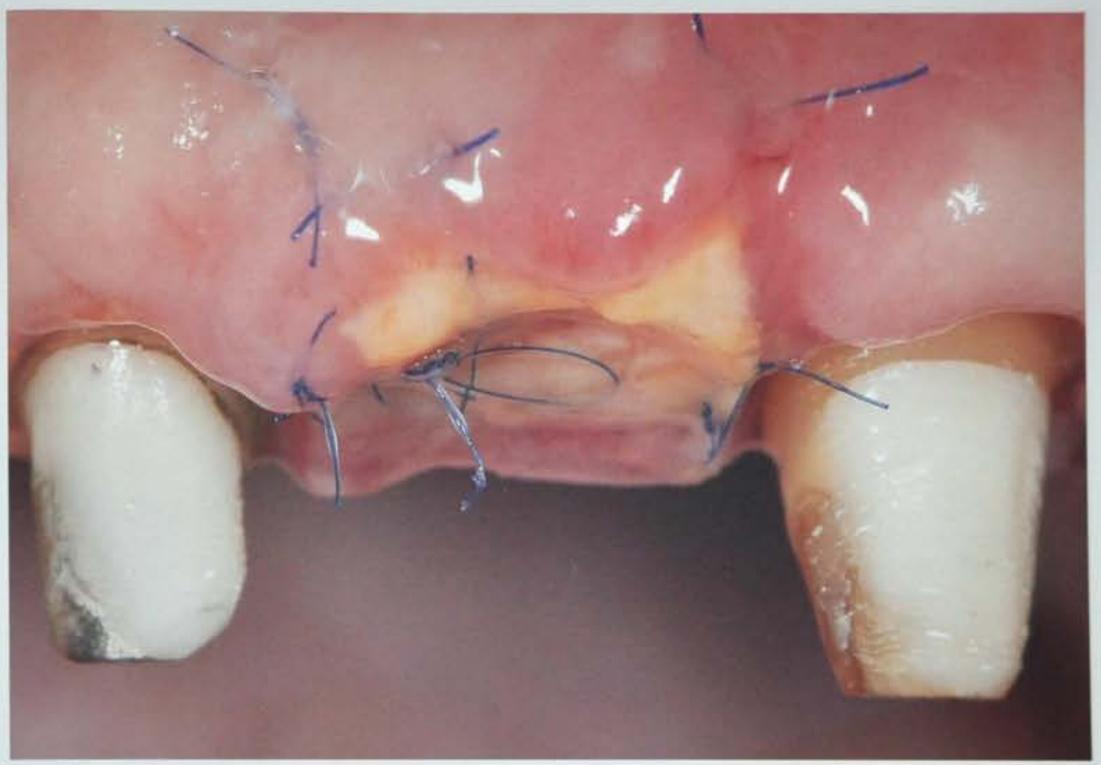


Fig 17-1 Noninfectious wound dehiscence has occurred after alveolar ridge augmentation using an autogenous connective tissue graft. Local treatment consisted of cleaning the surgical site with 0.1% chlorhexidine solution and applying 1% chlorhexidine gel at regular intervals.

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17.2 Abscess Incision and Drainage

The presence of pus oozing from the wound during visual inspection or palpation is a sign of impaired wound healing. In these cases, the dentist should attempt to completely drain the abscess by means of chlorhexidine rinses and careful manual instrumentation (Fig 17-2).

If this does not succeed, incision and drainage of the abscess must be performed. The use of 4% articaine with epinephrine 1:100,000 has proved to be an effective means of anesthetizing inflamed hyperemic regions (see chapter 6). Conduction anesthesia should be performed whenever possible in these cases because the injection of local anesthetic into terminal nerve endings has limited effects because of tissue acidosis. Supplementary injections of local anesthetic tangential to the surrounding tissues overlying the planned incision can also be administered.

Ideally, a No. 15 macroblade should be used to make the incision, which should not be placed over the point of maximum swelling but rather at the deepest point of the abscess. The incision should be long enough to ensure complete drainage and allow for continual drainage. A stab incision usually is not sufficient for this indication. A drainage strip is placed after the wound has been copiously rinsed with chlorhexidine or povidone-iodine solution. The cycles of wound disinfection and strip changes are repeated daily until the acute symptoms have subsided. Seven-day antibiotic treatment (amoxicillin, 500 mg three times daily, or clindamycin, 300 mg three times daily in case of penicillin allergy) may be indicated in severe cases.

Abscesses in certain anatomical locations are a major concern because of their potential to spread. These include abscesses in the canine fossa, which have a potential for intracranial spread, sublingual abscesses, which can spread to the deep floor of the mouth, and parapharyngeal abscesses or phlegmons. Patients with these extremely rare complications of periodontal plastic and implant surgery should be hospitalized and treated by an oral and maxillofacial surgeon. Adjunctive antibiotic treatment is obligatory in these cases.

Wound healing disorders associated with pus manifestation and abscess formation must be expected to have negative consequences and may result in the need for secondary corrective surgery.

Postoperative infection

1. For wound dehiscence: Treat locally with 0.1% chlorhexidine solution and 1% chlorhexidine gel for several days, with or without additional systemic antibiotic treatment for 7 days as needed (amoxicillin, 500 mg 3 times daily, or clindamycin, 300 mg 3 times daily for patients allergic to penicillin).
2. For wound healing disorders with pus manifestation and abscess formation: Drain the abscess thoroughly, irrigate the surgical site with 0.1% chlorhexidine, and place drainage strips; repeat antibacterial wound treatment with chlorhexidine rinses and strip changes each day until complete healing is achieved. For infections with a tendency to spread, add 7-day antibiotic treatment (amoxicillin, 500 mg 3 times daily, or clindamycin, 300 mg 3 times daily for patients allergic to penicillin).



Fig 17-2 Pus is discharging from an infected wound following periodontal plastic surgery for treatment of gingival recession. Chlorhexidine rinses should be used together with careful manual instrumentation in a first attempt to completely drain the abscess via the gingival margin.

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CHAPTER 18

FLAP AND CONNECTIVE TISSUE GRAFT NECROSIS

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Flap necrosis is very rare. Faulty incision planning or flap execution can be added to the general factors that have a negative effect on healing. Full or partial flap necrosis requires immediate sharp dissection of the necrotic tissue with a scalpel or surgical scissors. Any areas of exposed bone should be covered, for example, with chlortetracycline-soaked strips and a periodontal dressing. Secondary surgery, if needed, must be postponed until complete healing is achieved.

Diffusion is the sole mechanism of nutrient supply to free connective tissue grafts during the first postoperative days. Starting around the third postoperative day, revascularization occurs, characterized by successive reconnection of the graft to the surrounding vascular network via the formation of new capillary anastomoses and graft integration (see chapter 7). This is why connective tissue graft necrosis is less common than flap necrosis. In these rare cases of graft necrosis, immediate removal of the necrotic tissue is still crucial. If only parts of the graft are necrotic, only the necrotic areas need to be removed; this can be done with surgical scissors or a scalpel. If the graft is completely necrotic, removal of the entire graft is indicated. It is essential that the patient return for daily monitoring, disinfection of the surgical site with 0.1% chlorhexidine solution, and topical application of 1% chlorhexidine gel. For extensive necrosis, 7-day systemic antibiotic treatment can be considered (amoxicillin, 500 mg three times daily, or clindamycin, 300 mg three times daily for patients allergic to penicillin).

If full or partial necrosis of an autologous connective tissue grafts occurs, achievement of the desired surgical outcome cannot be expected. Secondary surgery normally must be postponed for at least 3 months until complete healing has been achieved (Fig 18-1).

Flap and connective tissue graft necrosis

1. Immediately excise necrotic tissue.
2. Treat the surgical site daily with 0.1% chlorhexidine solution and 1% chlorhexidine gel.
3. For extensive necrosis, add 7-day systemic antibiotic treatment (amoxicillin, 500 mg three times daily, or clindamycin, 300 mg three times daily for patients allergic to penicillin).
4. Postpone corrective surgery until complete healing has been achieved.

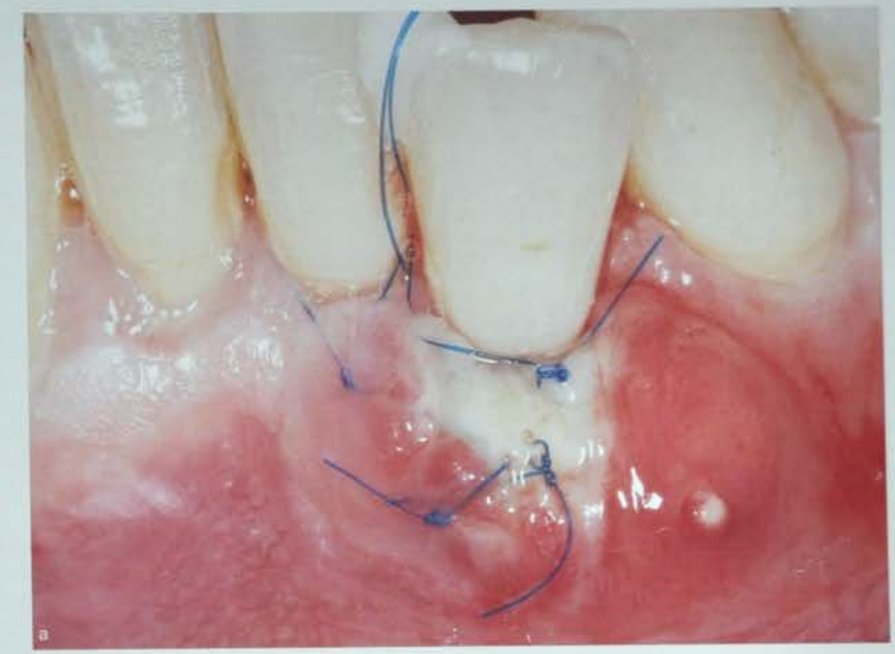




Fig 18-1 (a and b) Partial necrosis of a connective tissue graft after surgical treatment of gingival recession surgery using the modified tunnel technique. After removal of the necrotic tissue, the wound was regularly cleaned and treated with chlorhexidine.

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CHAPTER 19

FAILURES WITH AUTOGENOUS BONE BLOCKS AND CORTICAL BONE PLATES

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19.1 Exposure of Bone Blocks and Cortical Bone Plates

Exposure of autogenous bone blocks and cortical bone plates can have a number of causes, including flap necrosis, wound dehiscence of inflammatory and noninflammatory origin, and mechanical stresses on the surgical site due, for example, to removable prostheses. The exposure of barrier membranes, bone particles, bone substitute materials, bone blocks, bone plates, or fixation screws invariably results in bacterial contamination and the consequent resorption of augmented bone, which can ultimately lead to the failure of the entire augmentation procedure (Fig 19-1).

Bone graft exposure is extremely difficult to treat and has a poor prognosis. It is not possible to repeat the graft procedure unless only a small area is exposed and the soft tissues around the exposed area have completely healed. This generally is not the case until at least 4 weeks after augmentation surgery. Until then, the patient should treat the area around the exposed site with 0.1% chlorhexidine solution or 1% chlorhexidine gel several times a day. Before surgical coverage, the exposed bone must be debrided to remove the bacterially contaminated bone tissue; in many cases, the buccal volume of the bone graft must be reduced to achieve tension-free soft tissue closure. Seven-day systemic antibiotic treatment is also recommended in these cases (amoxicillin, 500 mg three times daily, or clindamycin, 300 mg three times daily for patients allergic to penicillin). Even with treatment, the chances of achieving complete coverage of the graft and, thus, saving at least part of the augmented tissue are still poor. If this treatment attempt fails (and if there is extensive exposure), removal of the entire graft (membrane, bone particles, bone substitute material, and/or fixation screws) is indicated. The augmentation procedure can be repeated after complete healing has been achieved.



Fig 19-1 A membrane has become exposed 2 months after guided bone regeneration with autogenous bone grafting for hard tissue augmentation.

19.2 Mobility, Extensive Resorption, and Necrosis of Cortical Bone Plates

Second-stage implant surgery is normally performed 6 months after hard tissue augmentation. By that time, osseous integration of the graft is usually complete, and the fixation screws can be removed and the implant or implants can be inserted in the prosthetically correct position.

If complete integration of the bone graft to the recipient bed has not yet occurred, mobility of the graft may become evident by the time the fixation screws have been removed or the implant bed has been prepared. Graft mobility can arise for various reasons, including mechanical irritation of the site during healing (eg, due to a removable prosthesis), inadequate primary fixation of the graft to the recipient bed with osteosynthesis screws, and failure to fill the spaces between the recipient bed and the graft with bone particles or bone substitute material or to cover the augmentation site with a membrane during augmentation, both of which could result in the downward growth of connective tissue between the transplant and the recipient bed, resulting in impaired integration of the bone graft. Regardless of the cause, graft mobility makes it necessary to thoroughly remove the connective tissue and particulate augmentation materials enveloped in connective tissue between the graft and the recipient bed, to provoke bleeding, and to restabilize the graft in the recipient bed, ie, to repeat the augmentation procedure. This also means that it will be necessary to wait another 6 months before implant placement.

Even if membrane exposure does not occur, a certain amount of resorption can always be expected when bone block grafts or bone plates are used (see chapter 13). The bulging of the fixation screws beneath the mucosa during the healing period is suggestive of excessive resorption. After the suspicious site is opened on the planned implantation date, it often becomes apparent that entire sections of the fixation screws are not covered by bone. If it is possible to achieve primary stability of the implant in the prosthetically correct position in spite of resorption, guided bone regeneration can be performed for secondary augmentation at that time. If resorption is so extensive that it is not possible to achieve primary stability of the implant or implants, hard tissue augmentation must be repeated and implantation postponed for another 6 months.

If, on the planned day of implant placement, it becomes obvious that the graft is partly or completely unincorporated and necrotic, complete removal of the dead tissue is indicated. Seven-day systemic antibiotic treatment is recommended in these cases (amoxicillin, 500 mg three times daily, or clindamycin, 300 mg three times daily for patients allergic to penicillin). The augmentation procedure can be repeated after complete healing has occurred.

Failures with autogenous bone blocks and cortical bone plates

1. Graft exposure: Remove the exposed graft; the augmentation procedure can be repeated after complete healing has occurred.
2. Graft mobility: Completely remove the graft and the soft tissue between the graft and the recipient bed; in many cases, repeat surgery can be performed simultaneously.
3. Excessive resorption: Perform supplementary augmentation procedures, either simultaneously with implant placement (small defects) or in a second surgery (large defects).
4. Partially or completely unincorporated and necrotic grafts: Remove the affected tissue and prescribe 7-day systemic antibiotic treatment (amoxicillin, 500 mg three times daily, or clindamycin, 300 mg three times daily for patients allergic to penicillin); repeat surgery can be performed after complete healing has occurred.

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CHAPTER 20

IMPLANT LOSS

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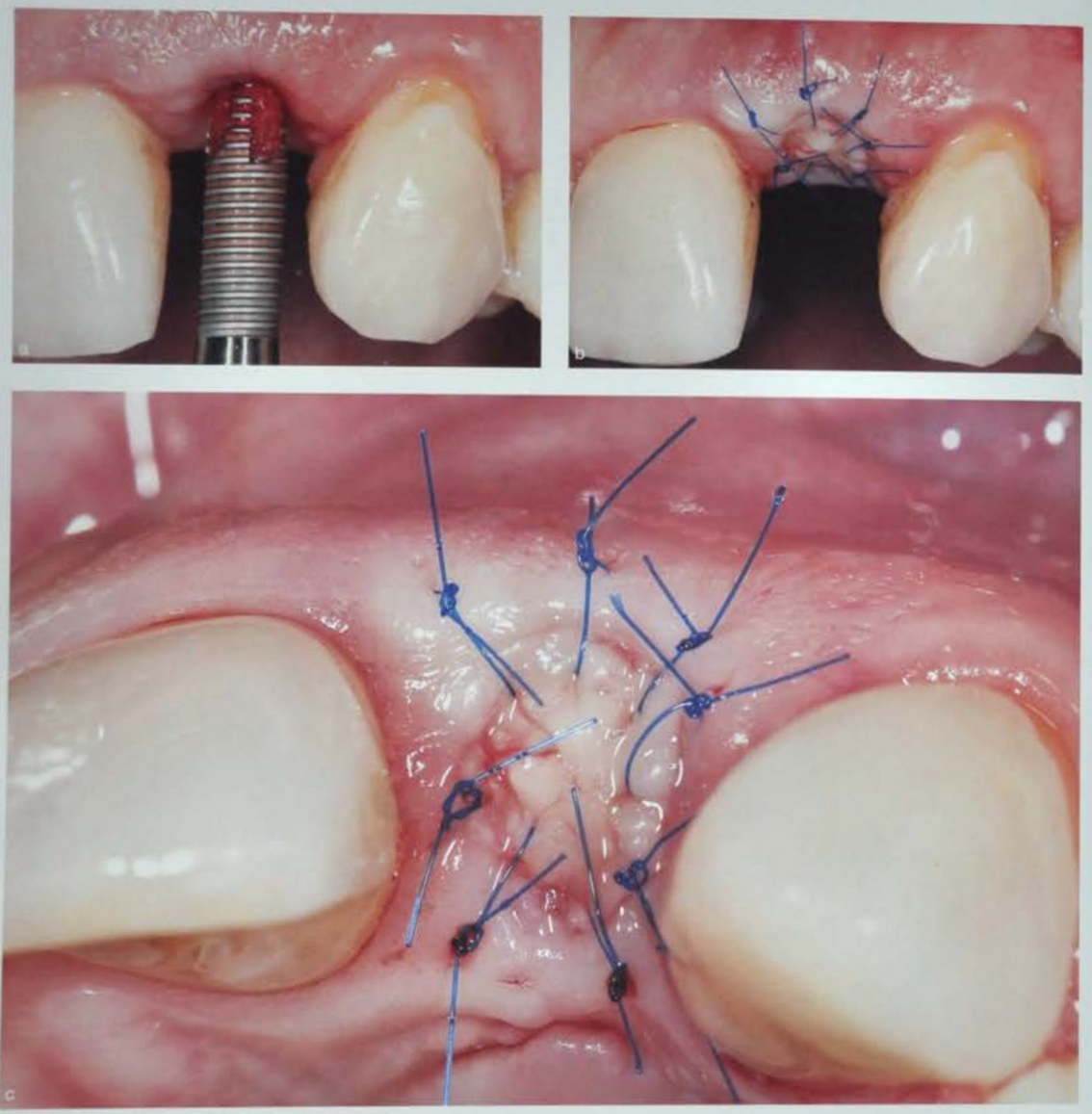


Fig 20-1 (a to c) Explantation of an implant lacking primary osseointegration. Socket seal surgery was performed for ridge preservation. A new implant was placed 6 to 8 weeks later using a two-stage approach.

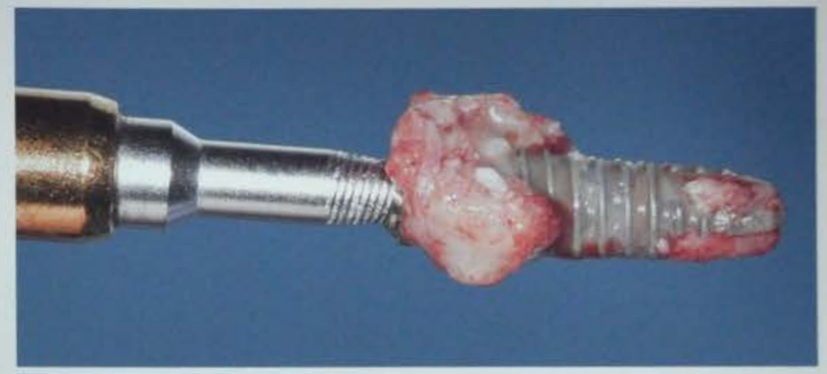


Fig 20-2 Complication associated with the use of an explantation instrument specifically designed for the explantation of partially osseointegrated implants. Instead of loosening at the implant–peri-implant bone junction, the implant detached at the marginal peri-implant bone only, a problem with serious consequences.

The lack of primary osseointegration or secondary loss of osseointegration of implants can occur for various reasons. Infection, peri-implant bone trauma associated with implant bed preparation and implant insertion, micromovement of the implant during the integration period, and early loading of the implant can prevent successful osseointegration.[1] Early implant loss is characterized by loose implants, which can be easily removed (Fig 20-1).

Late implant loss is primarily caused by peri-implant inflammation, mechanical complications, and implant fractures.[2–4] These implants are usually at least partially osseointegrated and, thus, difficult to remove. Very small trepan burs or bone cutters are used in these cases to minimize explantation-related trauma and defect formation. Any connective tissue remaining in the bone must be thoroughly removed.

Explantation instruments specifically designed for this purpose by various manufacturers are of great clinical interest. A ratchet mechanism removes the implant while another mechanism countercuts the threads of the implant shaft, making it possible to securely grip and loosen the implant. The drawback, however, is that the dentist cannot control whether the implant detaches at the junction between the implant and peri-implant bone as planned or from the peri-implant bone only. This can have serious consequences (Fig 20-2).

Explantation without simultaneous augmentation has provided good clinical results in both early and late implant loss. However, when implant loss occurs in the esthetic zone, socket seal surgery should be performed simultaneously with explantation for ridge preservation (see chapter 12). After 6 to 8 weeks of healing, implant therapy can be continued using a multistage approach (see chapter 13).

Implant loss

1. Remove the implant using an atraumatic technique.
2. Do not perform augmentation procedures at the time of explantation; only perform ridge preservation procedures.
3. After 6 to 8 weeks of healing, continue implant therapy using a multistage approach.

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CHAPTER 21

SCARS, TATTOOS, AND EXCESS SOFT TISSUE

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Scars and excess soft tissue that are visible when an individual is smiling can be an esthetic problem, so it is important to prevent the occurrence of these late complications following plastic-esthetic periodontal and implant surgery, especially because successful correction of these problems is very difficult and hard to predict.

Scar formation frequently results from wound dehiscence, which results in secondary wound healing. However, clinical experience has shown that predictable prevention of scars from horizontal incisions is not possible, even in cases with precise incision design and uncomplicated healing. Unlike vertical scar correction, horizontal scar correction is rarely successful. Therefore, horizontal incisions in the esthetic zone should be avoided if at all possible.

An attempt can be made to reduce vertical incision scars with a rough diamond. However, to achieve a good cosmetic result, it is usually necessary to excise the vertical scar tissue with deep wedge incisions and to slightly mobilize and suture the remaining tissue in layers. Precise approximation of the wound margins is crucial.

Tattooing can result from the deposition of metal particles in the soft tissues. A coarse diamond bur can be used to remove superficial deposits but not those in deep tissues. Therefore, it is usually necessary to excise the entire tattooed area. It is important to ensure that the subepithelial connective tissue is completely removed, leaving only the periosteum on the underlying bone. Small tattooed areas can be removed as described for vertical scars and sutured with a microsurgical technique.

In this case, the prognosis for a successful outcome is good. The removal of large areas of mucosa would make it necessary to leave the wound open to heal by secondary intention, leaving the patient with a questionable prognosis for a good cosmetic outcome.

The use of very thick connective tissue grafts, especially for treatment of gingival recession, can result in the formation of *excess tissue* that does not blend harmoniously with the surrounding soft tissues and therefore becomes a cosmetic problem after completion of healing. Relatively simple excision of the excess tissue can be accomplished with a scalpel and/or coarse diamond bur. The wound is then left open to heal by secondary intention. The prognosis for improvement of the cosmetic result is good (Fig 21-1).

Scars, tattoos, and excess soft tissue

1. Horizontal scars: Predictable correction normally is not possible.
2. Vertical scars: Place deep wedge incisions to excise the vertical scar tissue, mobilize the adjacent soft tissue, and suture in layers.
3. Tattooing: Treat small areas of tattooing like vertical incision scars. Excise large tattoos completely and leave the wound open to heal by secondary intention.
4. Excess tissue: Remove with a scalpel and/or coarse diamond bur.





Fig 21-1 (a and b) Excess tissue and scarring developed in the maxillary left region after placement of a coronally positioned flap with subepithelial connective tissue graft for root coverage.

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c



d



e



f



g

Fig 21-1 (c to g) The excess tissue is excised with a scalpel, and the scars are removed with a bud-shaped, coarse diamond bur.

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Fig 21-1 (h and i) Result after the completion of treatment 1 year after surgery.

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CHAPTER 22

BIOLOGIC WIDTH VIOLATION

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Although violation of the biologic width is not a surgical complication per se, it is useful to discuss potential solutions to this problem because of the potential need for periodontal surgical treatment.

If a restoration margin is placed subgingivally, there is a risk that the preparation margin will ultimately lie apical to the floor of the sulcus in the area of epithelial or connective tissue attachment, resulting in a violation of the biologic width (see chapter 1). Violation of the biologic width is a serious complication that can rarely be corrected without major consequences for the patient. Other possible causes, such as plaque-related inflammation, hypersensitivity to dental materials, and deficient or defective design of the restoration, must be excluded from the differential diagnosis.[1,2] First, the patient should be given optimal oral hygiene instruction and professional support. If no improvement is observed, restorations in the affected areas must be removed and replaced by high-quality long-term provisional restorations. If these measures also fail, it can be assumed that the diagnosis of biologic width violation is correct. Radiographs can provide useful additional information.

In these cases, an apically positioned flap could theoretically be used to establish the biologic width, but the procedure requires the removal of tooth-bearing bone. It can be assumed that a minimum of 2 mm between the restoration margin and the crest of bone is needed to establish the biologic width (see chapter 1). Clinical experience has shown that violation of the biologic width usually occurs at interproximal sites, so the additional removal of interproximal alveolar bone would be unavoidable with an apically positioned flap (as opposed to esthetic crown lengthening). The price for eliminating the inflammation would be major esthetic compromises because of the loss of both buccal and, more importantly, interproximal soft tissue. This is precisely why periodontal surgical procedures are rarely used to establish the biologic width in the esthetic zone.

Orthodontic extrusion is the method of choice to reestablish the biologic width in the esthetic zone. Coronal movement of the affected teeth can establish the necessary distance between the restoration margin and the crest of bone without esthetic consequences for the soft tissue margin. However, this requires that orthodontic extrusion be accomplished without coronal migration of the alveolar bone and gingival margin. This is ensured by performing marginal gingival fiber resection and mechanical root instrumentation of the affected teeth once every 2 weeks during the active phase of orthodontic treatment[3–6] (Fig 22-1).

The difference between orthodontic extraction and orthodontic extrusion is that greater and constant force is used in the latter case (see chapter 12). Extrusion is completed once the restoration margin has reached a slightly supragingival position. It may be necessary to shorten the incisal edges of the provisional restoration to account for the extrusion distance. To prevent relapse, active extrusion must be followed by a minimum 6-month stabilization period prior to fabrication of the new restoration (Fig 22-2).

Biologic width violation

1. To establish the diagnosis of biologic width violation, exclude other potential causes of inflammation.
2. Orthodontic extrusion is usually the only acceptable method for reestablishment of the biologic width in the esthetic zone.
3. To prevent relapse, allow a minimum 6-month stabilization period following active extrusion prior to fabrication of the new restoration.

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Fig 22-1 Orthodontic extrusion is the method of choice to reestablish the biologic width in the esthetic zone. To prevent coronal displacement of the alveolar bone and the gingival margin, marginal gingival fiber resection and mechanical root instrumentation of the affected teeth should be performed once every 2 weeks during the active phase of orthodontic treatment.

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Fig 22-2a Clinical example of orthodontic extrusion for treatment of biologic width violation. The initial clinical evaluation reveals severe inflammation of the marginal gingiva around both maxillary central incisors, which had been restored with crowns. Violation of the biologic width is confirmed by a thorough differential diagnosis.





Figs 22-2 (b and c) After completion of orthodontic extrusion, the preparation margins of the long-term provisional restoration are now supragingival and visible, and the marginal gingival is healed and uninflamed. When a new restoration is fabricated, it is preferable if the restoration margins can remain equigingival; if this is not possible, then they should extend only minimally into the sulcus.





Figs 22-2 (d and e) After completion of treatment and prosthetic rehabilitation, the soft tissues are inflammation free and healthy. (Orthodontic treatment: *Jo Schwarz*, Göppingen; dental technician: *Uli Schoberer*, Seehausen, Germany.)

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APPENDIX

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Material list

1. Mamadent Macro Instrument Set
   American Dental Systems, Vaterstetten, Germany
2. Mamadent Micro Instrument Set
   American Dental Systems, Vaterstetten, Germany
3. Mamadent Tunneling Knives I and II
   American Dental Systems, Vaterstetten, Germany
4. Seralene sutures
   Serag Wiessner, Naila, Germany
5. Serafit sutures
   Serag Wiessner, Naila, Germany
6. Gore-Tex sutures
   Gore, Putzbrunn, Germany
7. No. 15 and No. 12D scalpel blades (macroblades)
   Swann Morton, Sheffield, England
8. Keydent microblade
   American Dental Systems, Vaterstetten, Germany
9. Keydent flexible tunneling microblade
   American Dental Systems, Vaterstetten, Germany
10. Bending pliers for tunneling microblade
    American Dental Systems, Vaterstetten, Germany
11. Surgical glass slab
    Becht, Offenburg, Germany
12. Surgical metal dish
    Martin, Tuttlingen, Germany
13. Vari-TipTM Electrotome Set
    Makro Med, Trier, Germany
14. VT1 Desmotome
    Deppeler, Rolle, Switzerland
15. Histoacryl tissue adhesive
    Braun, Melsungen, Germany
16. Pin Set
    Geistlich, Wolhusen, Switzerland
17. Titanium Pins
    Geistlich, Wolhusen, Switzerland
18. Low Profile Neuro osteosynthesis screws, set
    Synthes, Umkirch, Germany
19. Bone filter
    American Dental Systems, Vaterstetten, Germany
20. Bud-shaped diamond bur, coarse
    Brasseler, Lemgo, Germany
21. Round diamond bur with long shaft, small
    Brasseler, Lemgo, Germany
22. Round diamond bur with long shaft, large
    Brasseler, Lemgo, Germany
23. Carbide bur with long shaft
    Brasseler, Lemgo, Germany
24. Round carbide bur
    Brasseler, Lemgo, Germany
25. Lindemann bur
    Brasseler, Lemgo, Germany
26. Diamond bone-cutting disc
    Brasseler, Lemgo, Germany
27. Bio-Gide collagen membrane, 25 x 25 mm
    Geistlich Biomaterials, Wohlhusen, Switzerland
28. Ossix TM Plus cross-linked collagen membrane, 25 x 30 mm
    OraPharma, Warminster, USA
29. Emdogain and PrefGel
    Straumann, Freiburg, USA
30. Bio-Oss bone substitute, 0.25–1 mm
    Geistlich Biomaterials, Wohlhusen, Switzerland

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