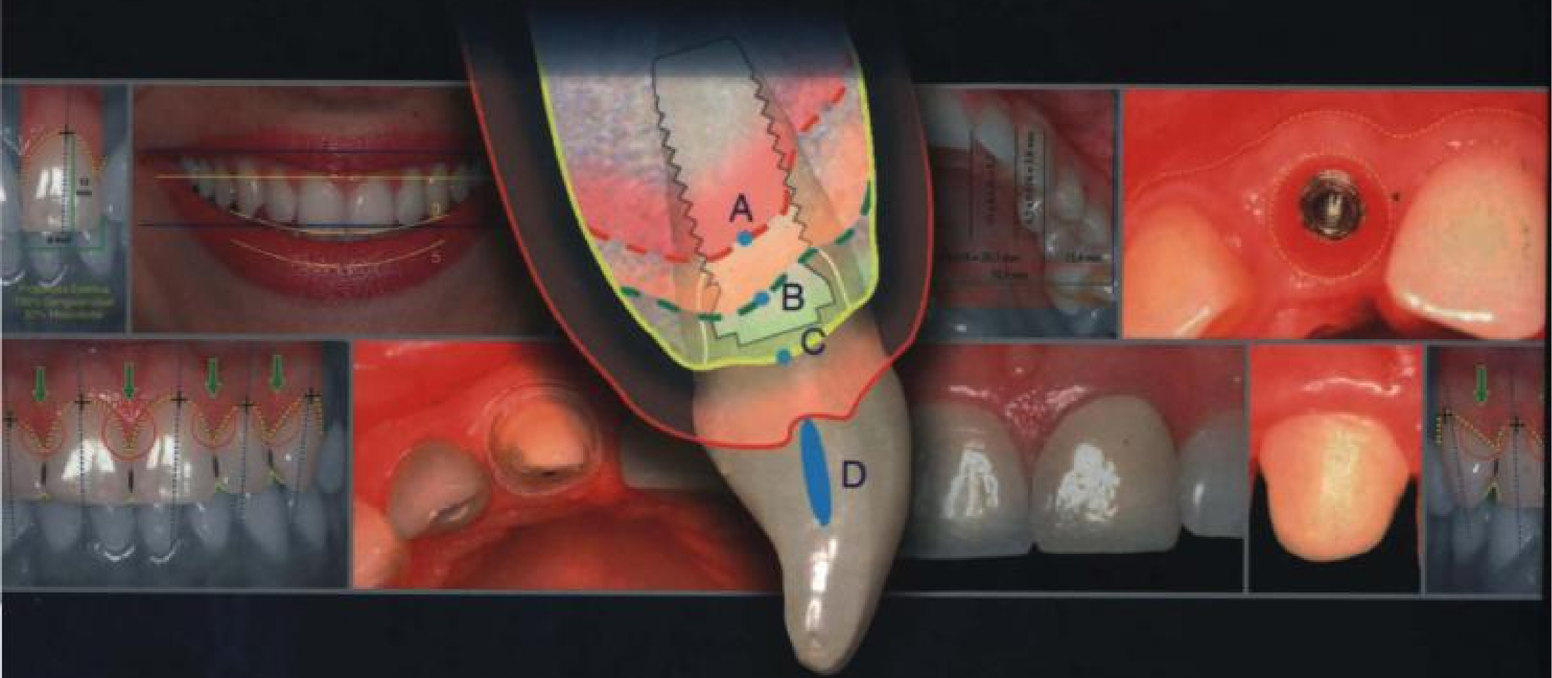
José Bernardes das Neves

Esthetics in Implantology

Strategies for Soft and Hard Tissue Therapy



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ESTHETICS IN IMPLANTOLOGY

Strategies for Soft and Hard Tissue Therapy

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DEDICATION

To my wife, Denise, and my children, André and Isabela, for their love, support and willingness, even in the most difficult moments of our lives.

To my parents, Geraldo and Idalina, for their love, support and moral attitude. My eternal devotion.

To my parents-in-law, Geraldo and Lucy, for supporting my family during my absence.

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To God, for a life blessed by light, divine response to the mysteries that common science does not dare to interpret, for the every day miracles reached.

"It was a tough way, but You, Almighty God, with Your infinite kindness, comprehended my wishes and gave me the courage and will to reach my objectives and follow my journey as well. Now, I must pray to act efficiently in my practice and decisions. I am very thankfully to You God for what I became, and will become."

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Finally, to all my colleagues that contributed to this work, my sincere acknowledgements.

PREFACE

This book is organized in ten chapters that cover anatomical, functional, and clinical bases of osseointegration and its relationship with soft and hard tissue therapy. Also, it demonstrates the importance of multi and interdisciplinary treatment during osseointegration procedures. Clinical success seen in cases presented here was only possible due to optimization of biological, functional and esthetic parameters guided by a multidisciplinary treatment.

Esthetics in Implantology – strategy for soft and hard tissue therapy is, undoubtedly, strongly recommended for clinical activities. It has an objective and didactic approach, being a reference for undergraduate, postgraduate, and professionals working with implantology and connected areas. It is the result of tremendous effort of the author and collaborators. I wish to express my congratulations to this invaluable taskforce, also highlighting its fundamental role a new leadership in the Brazilian Dentistry.

I also wish to express my congratulations to the editors for an excellent work with illustrations and text preparation.

It is a great honor for me to preface this book. Dr. José Bernardes das Neves is one of the most qualified and dedicated colleagues I know, being also my friend and a brilliant pupil of Implantology Course (Master Degree Level) at the Sagrado Coração University, Bauru, USC, Brazil.

Dr. Carlos Eduardo Francischone
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Sagrado Coração University, Bauru, USC, Brazil.

FOREWORD

Prof. Dr. P - I Branemark, March 2007

This book concentrates on the anatomical an coluristic details in the topography of the hard and soft tissues of the intra and estra oral characteristics of patients who have lost a minor or maior part of their maxillofacial personality. Accordidng it emphasizes the necessity of careful analyzis of decisive characteristics of the three dimensional attention to detail when providing teeth and tissues to the edentulous patient in attemps to restore the functional anatomy of the totally or partially deranged hard an soft tissue of the oral invalid.

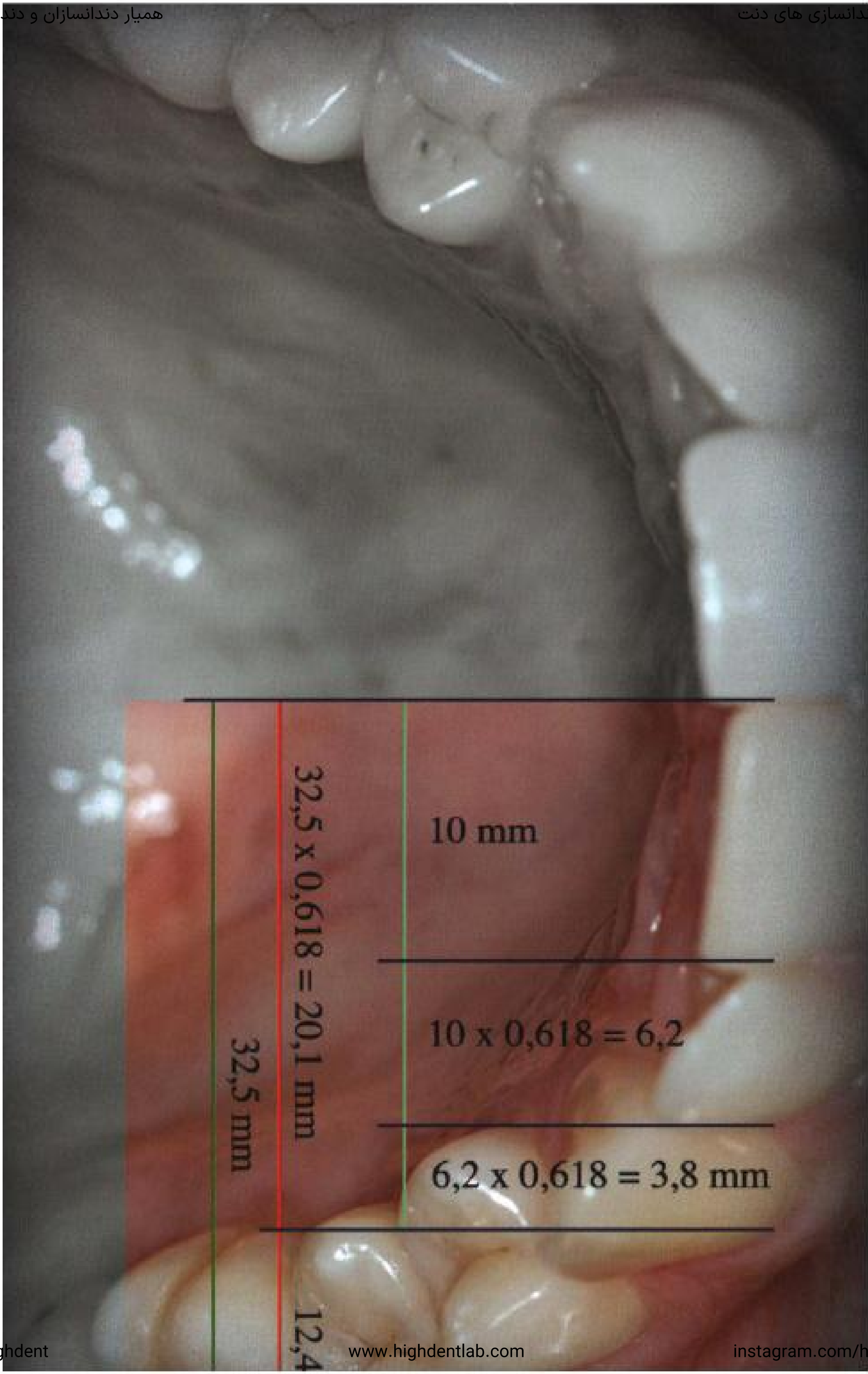
Even minor details can have a significant influence on the quality of both local and total restoration of the patient. The decisive facts in sucess or failure in the final efforts requires attention to details in selection of material and procedure but equally important is a sensitive interaction between doctor and patient. The author of this book has documented a remarkable capacity to achieve return or oral and maxillofacial structure and function as close normal as possible.

CONTENTS

1

ESTHETICS

JOSÉ BERNARDES DAS NEVES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6,2 x 0,618 = 3,8 mm
32,5 x 0,618 = 20,1 mm
32,5 mm
12,4

Esthetics

INTRODUCTION

Esthetics (from the Greek word "aisthetikós") is the science that deals with beauty and philosophical theory of art. Beauty (from the Latin word "bellus") is a property in things, making us love them, emanating spiritual pleasure, produced by nature imitation or by spiritual intuition. It is the ideal beauty.

According to the Aurelio Dictionary of Portuguese Language, esthetic means "the study of conditions and effects of artistic creation"; is the study of beauty, regarding to its inherent concept or about multiple sensations that it evokes in man.

Esthetics is fundamental in modern dentistry, a challenge that most professionals can not ignore, because the esthetic concepts have received significant changes over the years.[14] Since it is not a simple issue, esthetics does not limit itself to shade selection and some rudimentary concepts of tooth arrangement derived from complete denture lessons.

A smile can transmit several ideas and emotions. We have catalogued more than 50 types of smile patterns, each one with specific meanings: fear, misery, courage, love affair, shame, gratitude, and joyless. A pleasant smile has been the final objective to improve lifelike appearance and self-steam. A smile can have different meanings in several cultures and social environments.[21,22] Society rules its own beauty patterns, being highly subjective and influenced by media: outdoors, movies, television programs, etc.

The esthetical concept for human beings is very subjective and related to harmony, beauty, and several factors. Social, psychological, cultural, and even age and time factors have generated different kinds of esthetical concepts.[10]

More and more patients seek dental treatment to improve esthetics since a pleasant smile is important for relationships. The smile is the most important of facial expressions to show feelings and sensations,[1,8,15,18] predominantly found in the oral cavity and ocular regions.

An intra-oral element analyzed separately has no esthetic appeal. However, a positive result can be obtained when all elements integrate harmoniously. Thus, the smile evokes a pleasant sensation with well acceptable esthetics.[7]

Facial Analysis – Frontal View

Horizontal proportions

In a frontal view, horizontal dimensions establish proportions related to the facial, sagittal or lateral components.

To achieve ideal proportions, width of alar base must be similar to intercantal distance, while the inter commissure width must be close to the interpupillary line.

The interpupillary line is the starting point to evaluate level of gingival margins, incisal border positions, and orientation of the maxillary plane. Also, it is part of the occlusal plane (Fig. 1.1).

Vertical proportions

Upper third of face

Hair line to glabella line

The upper third of the face is the least important for restorative procedures but is highly variable, depending upon the hair style. For a harmonious result, the height of the front must be one-third of the total facial height, having the same height of the middle and lower third of the face.

Middle third of face

Nasion line to subnasal line

At this time, it is important to evaluate the face in the general context: right half of face, the horizontal distance from one corner of the lip to the other, and the left half of face.

Inferior third of face

Subnasal to mentonian point

From a restorative view, this aspect is important for the diagnosis and treatment planning. Vertical distance here must be evaluated with the facial musculature relaxed and at rest (Fig. 1.2).

Facial analysis – lateral view

This must be done considering the line from the glabella to the superior border of the lip, and from this point to the soft tissue pogonion (Fig. 1.3).

Normal profile

When the above cited references form straight lines.

Convex profile

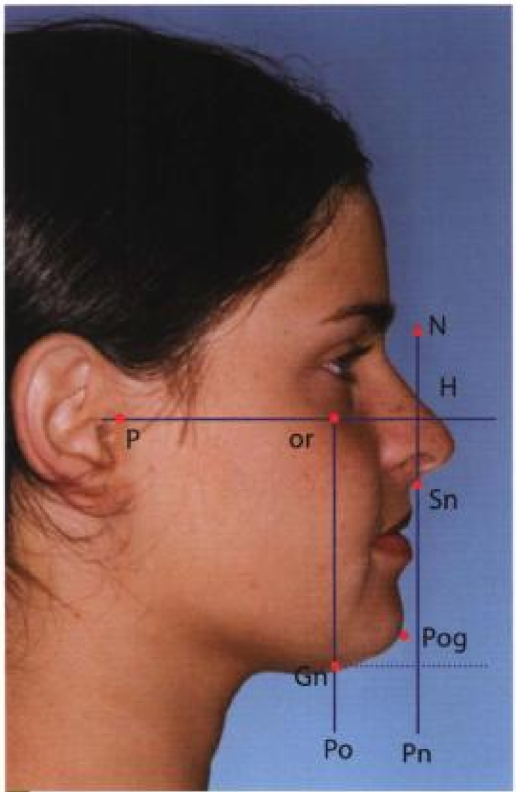
When both reference lines form an angle that indicates backward chin position.

Concave profile

When both reference lines form

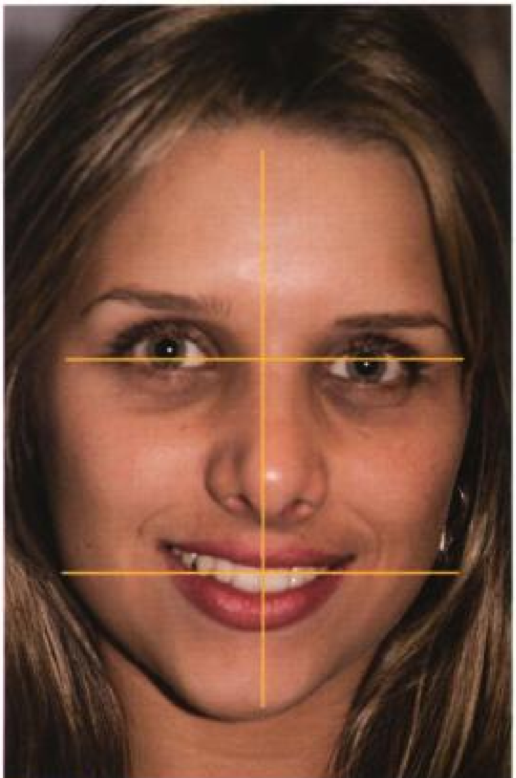
Fig. 1.1 – Frontal view of facial asymmetries. **A.** The left half of the face was composed in both sides. **B.** The right half of the face was now composed. **C.** Actual photography revealing lateral dimensions and their proportions (inner corner of the eyes/interalar distance and interpupillary distance/corner of the mouth).

Fig. 1.2 – Vertical dimension of upper, middle and lower third of the face. Observe golden proportion between greater (chin/commissure) and smaller dimensions (commissure/subnasal).



1.3

Fig. 1.3 – Profile types according to the Schwarz's method. Frankfort orbital plane (H); (Po) orbital perpendicular; (Pn) nasal perpendicular; Gn: gonion; Pog: pogonion, Sn: subnasal, Or: infra-orbital (Adapted from Rakosi et al.[26])



1.4

Fig. 1.4 – The interpupillary and commissure lines form a valuable reference in the horizontal plane. The median line is perpendicular to these horizontal lines.

an angle that indicates forward chin position.

Interpupillary line

The incisal plane of upper teeth and the gingival margin contours must be parallel to the interpupillary line. The eyebrow and the commissure lines are co-participants to establish the actual horizontal plane.

The interpupillary line helps clinicians to evaluate the incisal plane, the level of gingival margins and maxillary inclination.[3]

These lines do not need to be "strictly" parallel to each other. Otherwise, it is necessary to evaluate if they not conflict with the overall horizontal facial perspective[3] (Fig. 1.4).

Median line

Both upper central incisors are separated by an imaginary line called median line. It can be determined from various aspects, including: center of the philtrum, center of the interpupillary distance, median line of lower central incisors, as well as the center of the distance between interalar nose and labial frenum. However, all these references must be taken into account because facial asymmetry can be identified.

This line is the most important to be determined during smile: it provides arch symmetry[4]. Besides, it helps to identify tooth axis and its mesiolateral discrepancies.

SMILE COMPONENTS

Anatomy

The orbicular region includes the upper lip, corner of the mouth and the anterior portion of the cheeks. The nasolabial sulcus runs lateral to the nose toward the corner of the mouth. The philtrum is a vertical depression extending from the nasal septum to the vermilion of the upper lip[1] (Fig. 1.5)

Lip line

Factors that determine lip position are facial musculature, its contraction state, (tonus) and dento-alveolar morphology.[1] Burnstone[9] stated that "the upper central incisors can not be positioned ahead of the upper lip rest position because this breaks labial seal, generating overjet and esthetic unbalance".

The curvature of the upper lip

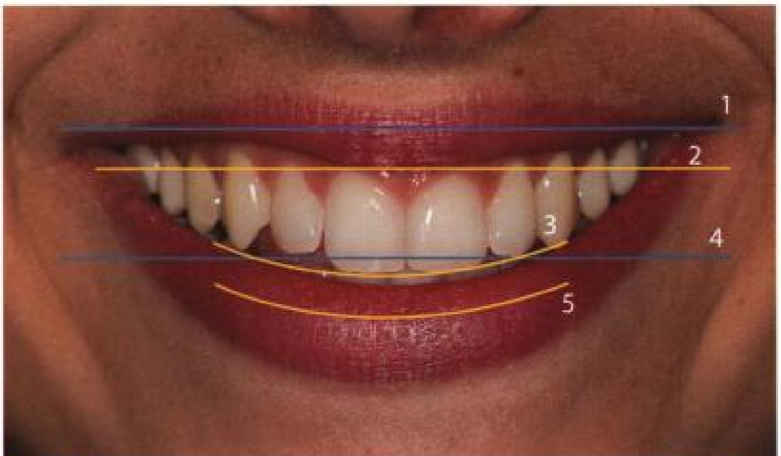


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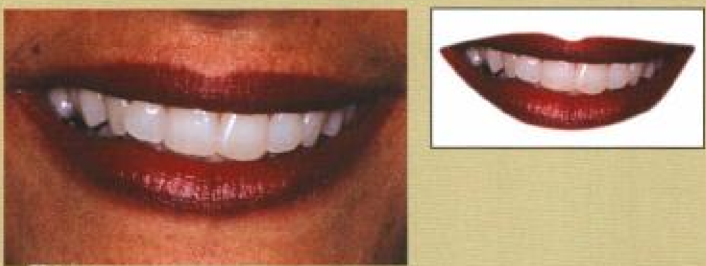
Fig.1.5 – Anatomic structures of the smile and ascending position of upper lip characterizing a pleasant esthetic smile.
1) commissure line,
2) smile line,
3) incisal border line,
4) oclusal plane line,
5) lower lip line.

1.6

1.7



1.8

Fig. 1.6 – Patients display all gingival tissues

Fig.1.7 – Patients display only interproximal papillae.

Fig. 1.8 – Patients display only teeth.

must follow an ascending path from midline to lateral facial position. When this occurs straight or downward, the smile quality is seriously compromised.[1] The incisal borders of upper anterior teeth must be parallel to the inferior lip. This is an important factor in the esthetic reference.

The lip line is noticeable when teeth are visible, exposing only interdental gingival tissue.[2]

The upper lip line is important to evaluate the length of the upper central incisor at rest or during smile, and the vertical position of gingival margins during motion.

The lower lip line provides bucco-lingual position of upper incisal borders and the curvature of the incisal plane.[3]

Smile line

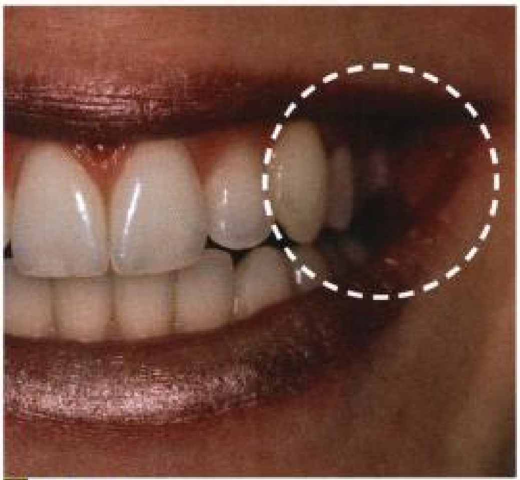
The smile line is one the most important factors that contribute to a pleasant smile.[10] There are three smile patterns, being impossible to convey detailed specific visual characteristics for each type.

High smile line

It provides visualization of the whole cervical to incisal length of upper anterior teeth, and a continuous band of gingival tissue, being observed in 10.57% of individuals (Fig. 1.6).

Medium smile line

It is the most common; tooth exposure ranges from 75% to 100%. Only interproximal gingival tissue is visible. It is seen in 68.94% of individuals.



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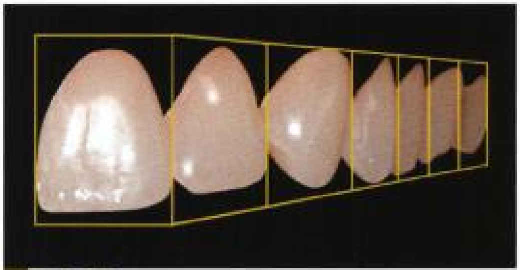


1.9B

Fig. 1.9A – Buccal corridor. Observe dark space between oral mucosa and upper teeth. This region should never be invaded.

Fig. 1.9B – Levin's grid showing dental proportions of incisor and canine teeth.

Low smile line

It shows less than 75% of upper anterior teeth. Around 20.48% of individuals present with this smile pattern[1] (Fig. 1.8).

Buccal corridor

It is a dark space generated during smiling, between the buccal surfaces of teeth and oral mucosa comprising the corner of the mouth and cheeks.[3,4]

An artificial and unpleasant smile results when this space is invaded (Fig. 1.9).

Lower lip line

The relationship between upper incisal borders and inferior lip is important to determine its length.

When consonants F and V are pronounced, the incisal borders must touch at the vermilion of the lower lip.[30]

This helps to determine the buccal inclination of incisal third in the upper central incisors, which must coincide with the closing path of the lower lip.[3]

DENTAL ESTHETICS

Tooth size

Tooth size is not only relevant in dental esthetics but also in facial esthetics. Teeth must harmonize with facial parameters to achieve optimal esthetics.

A practical tip is to consider the same cervical to incisal dimension for incisors and canine teeth[5] (Fig. 1.10A to C).

Shape

Basically, teeth can be grouped into three forms: squared, rounded and tapered. In some cases, it resembles facial morphology.

Squared teeth have well developed, evenly distributed vertical ridges. Both marginal and central ridges are equilibrated dividing labial surface in thirds.

Tapered teeth have a central depression with well developed lateral

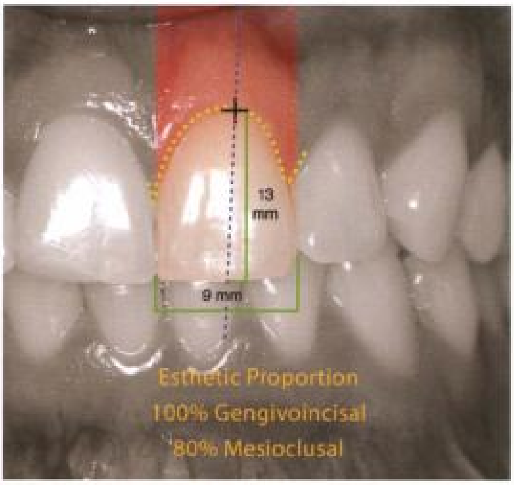


Fig. 1.10A – Upper left central incisor. Observe height, gingival contour, golden proportion, and gingival zenith.

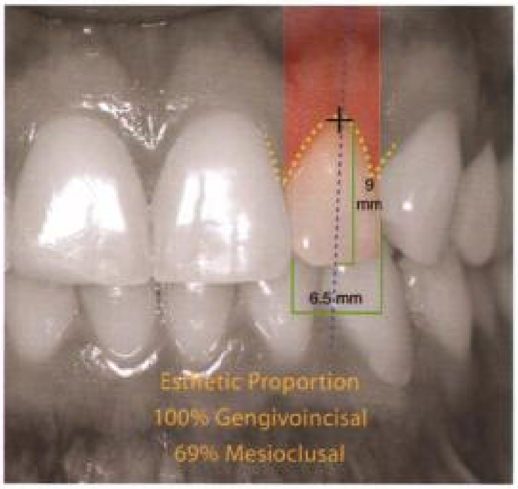


Fig. 1.10B – Upper left lateral incisor. Observe height, gingival contour, golden proportion, and gingival zenith.

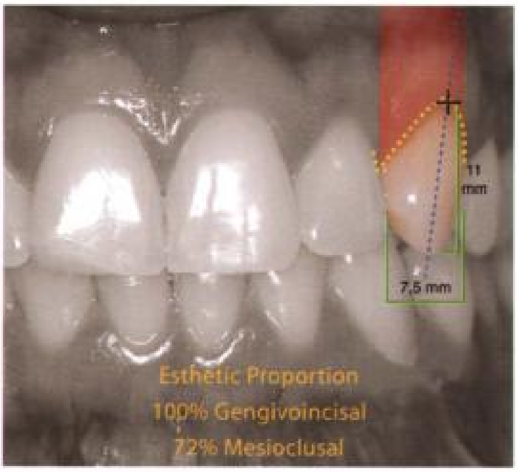


Fig. 1.10C – Upper left canine. Observe height, gingival contour, golden proportion, and gingival zenith.

ridges. On the other hand, rounded teeth have a thick, well pronounced central ridge and residual lateral ridges. An incisal aspect reveals that marginal ridges are directed toward lingual in round teeth[5] (Fig. 1.11).

Frush and Fischer[27] considered gender, age and personality as adjunctive tools for esthetic dentistry. Bortheiry[28] emphasized rounded teeth in female and squareed teeth for male individuals, being tapered teeth the most common in both sexes. Lombardi[29] stated that the wear pattern of incisal borders reflects patient's age (Fig. 1.12); on the other hand, upper lateral incisors with well rounded or defined angles reflect female and male patterns. Finally, canine teeth with convergent axis and small dimensions reveal delicate personality, whereas those with more divergent axes represent vigorous persons.

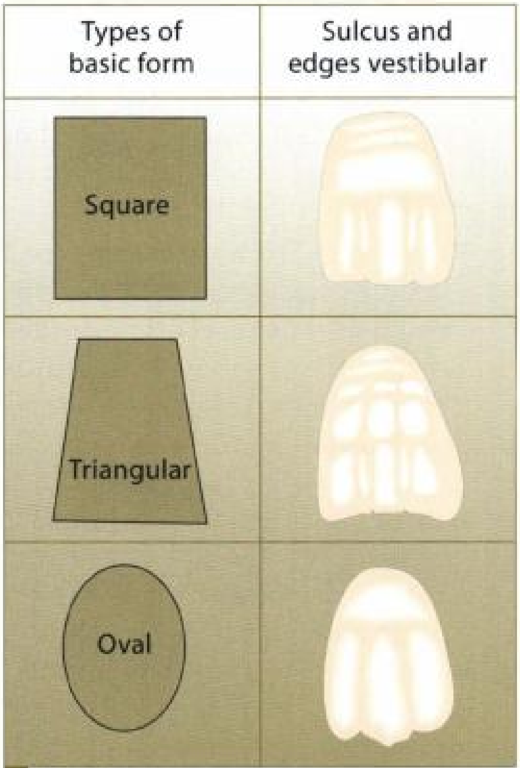
Texture

It is one of the most important factors to obtaining pleasant esthetic restorations since it confers natural appearance to teeth[4,5].

The surface of natural teeth scatters and reflects light in all directions, resulting in optical illusions regarding tooth color and shape. Hence, its has fundamental role in esthetics[25] (Figs. 1.13A and B).

Position and arrangement

A smile evokes more pleasant sensations when teeth are adequately positioned and arranged. Poorly positioned teeth do not only compromised arch form, but also interfere with relative and ap-



1.11

Fig. 1.11 – Basic tooth forms and correspondent surface textures.

1.12

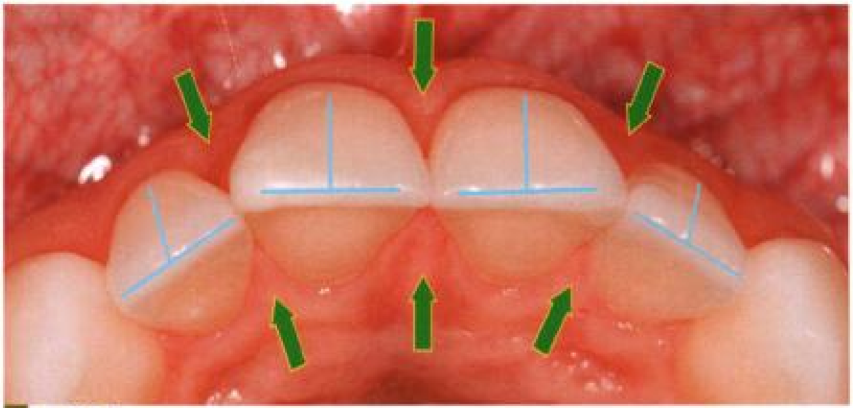
Fig.1.12 – Observe mamellons in the younger teeth (1). Note wear of incisal borders in the old teeth (2).

1.13A

Fig. 1.13A – Illusion effects. Bright surfaces appear to be larger, but in fact both have the same dimensions.

1.13B

Fig. 1.13B – Optical effects regarding tooth width. Although tooth on the left has more length and appears to be the narrowest of all three, both have the same width.



1.14

Fig. 1.14 – Incisal view of upper teeth. Tooth angulation and inclination defining interproximal papillae.

parent tooth proportions. However, many individuals do not have well aligned teeth but still exhibit beautiful and pleasant smiles.

Axial inclination

Inclination of long axis of teeth must be analyzed in a vertical plane, both in mesio-distal and bucco-lingual directions.[4]

Upper central incisors have long axis parallel or slightly distal to the midline. This inclination is more accentuated in lateral incisors.

On the other hand, canines may present parallel or distal inclination.

In the lower central incisor teeth, the long axis is parallel to the midline or has little mesial inclination, being this more accentuated in canines than in lateral inferior teeth (Figs.1.10A to C).[4]

Proportions

Tooth proportions have a central role in the smile esthetics. This relationship depends on tooth width, length, arrangement and format in both arches, as well as smile configuration.

A smile is considered satisfactory in frontal view when each tooth has approximately 60% the size of the adjacent teeth.[24] According to this formula, the ideal central incisor/canine ratio is 0.618 to 1 (Figs. 1.15 to 1.17).

It is important to highlight that teeth must not be interpreted as units, because non proportional elements also display an attractive smile.[5]

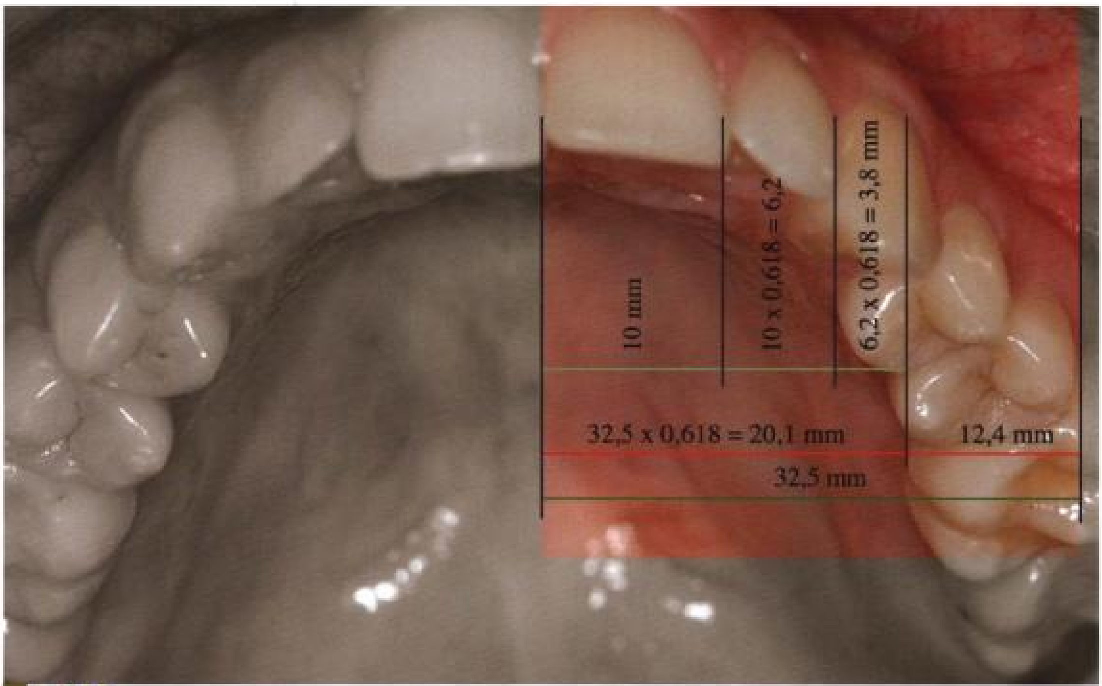
Proximal contacts

The proximal contact areas define tooth individuality and influence width to length ratio.[11]

In the posterior area, contact points are dislocated to the buccal region. In the anterior region, the contact point area is located at the incisal third between two adjacent upper central incisors; it progress cervically between upper central and lateral incisors, being located at the medial third between upper lateral and canine teeth (Fig. 1.18).[4,17]

EMBRASURES

Embrasures are V-like spaces between proximal surfaces of two ad-

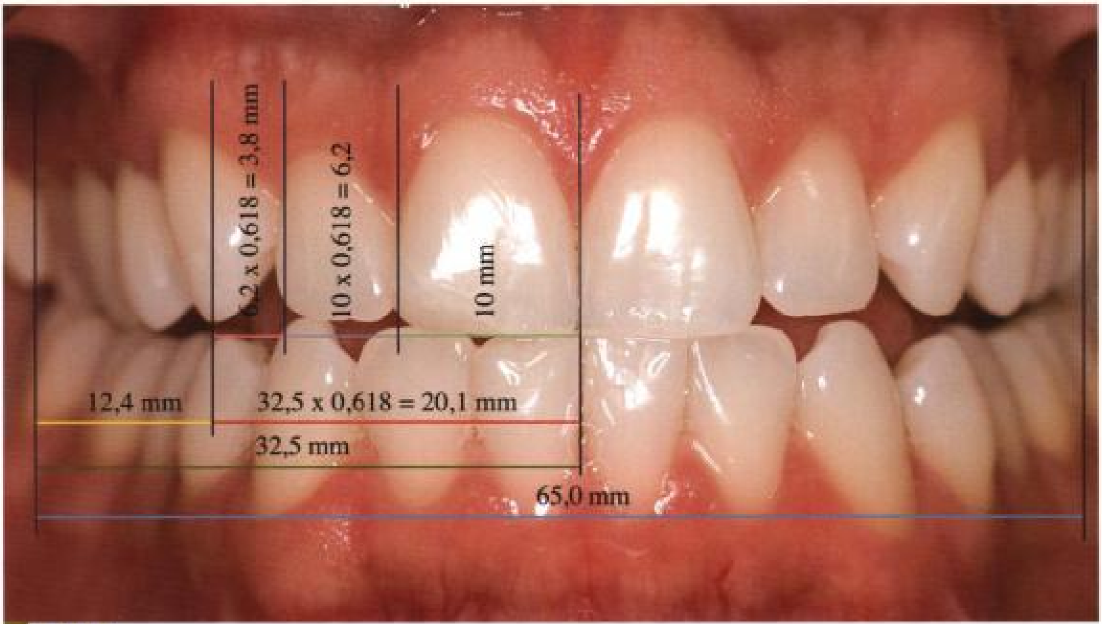


1.15

Fig. 1.15 – The actual width of upper central incisor (10mm), that corresponds to 1.1618 in the golden proportion, is multiplied by 0.618 to obtain the actual width of upper lateral incisor (6.2mm), that corresponds to 1.0 in the golden proportion; the apparent width of the canine (3.8mm) is obtained by multiplying the width of lateral incisor (6.2mm) by 0.618. Thus, a grid in golden proportion is established taken into account half the smile length (Adapted from Mondelli[10], p.134).

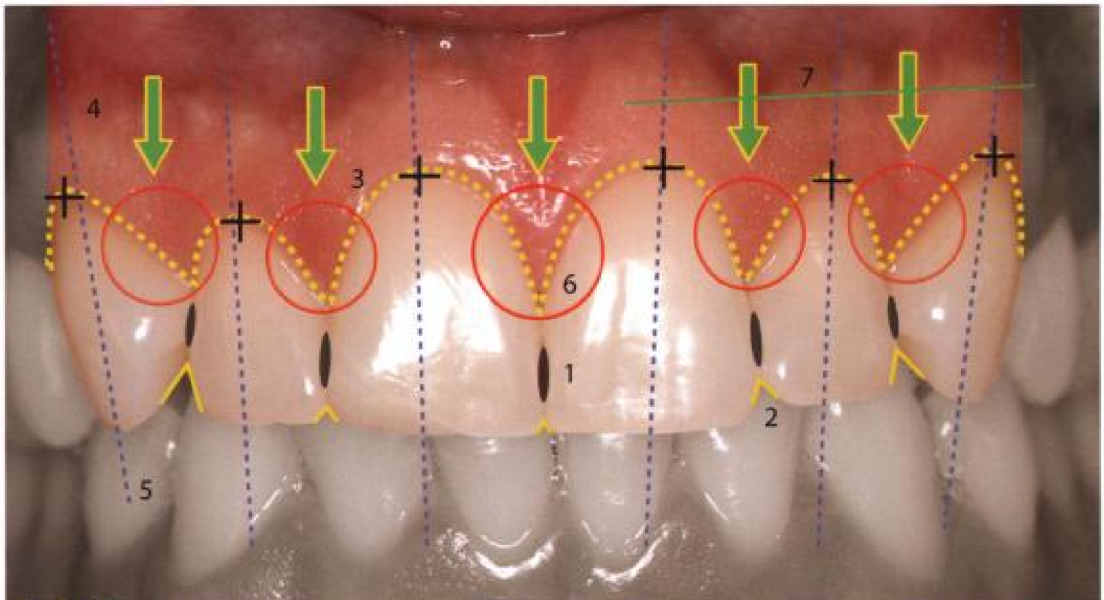
1.16

Fig. 1.16 – Levin's grid construction. The smile length is taken with a caliper rule and divided by two (32.5mm). This measure is multiplied by 0.618 to obtain half of the esthetic anterior segment (20.1mm) and this value by 0.618 to obtain the width of buccal corridor (12.4mm). (Adapted from Mondelli[10], p.134).



1.17

Fig. 1.17 – The actual width of upper central incisor (10mm), that corresponds to 1.1618 in the golden proportion, is multiplied by 0.618 to obtain the actual width of upper lateral incisor (6.2mm), that corresponds to 1.0 in the golden proportion; the apparent width of the canine (3.8mm) is obtained by multiplying the width of later incisor (6.2mm) by 0.618. Thus, a grid in golden proportion is established taken into account half the smile length (Adapted from Mondelli[10], p.134).



1.18

Fig. 1.18 – Diagram indicating location of interproximal tooth contact points (1), embrasures (2), gingival contours (3), gingival zenith (4), axis of anterior teeth (5), and gingival papillae (6). The level of papilla between central and lateral incisors is more apical, being the upper central and canine papillae at the same level (7).

jacent teeth. They can be classified in incisal, cervical, and occlusal embrasures (Fig. 1.18).

Incisal embrasures

In the anterior teeth, the incisal embrasure corresponds to one-quarter of the distance between the crest of the papilla and the incisal borders. The remaining three-quarters accounts for the proximal contact area. The same aspect has one-third of the distance between central and lateral incisors. Also, incisal embrasures are wide between lateral and canine distance, representing half the distance between the crest of the papilla and the incisal borders.

On the other hand, there is no rule for incisal embrasures in posterior teeth, since the canine is considered a transition tooth in the arch segments. Generally speaking, the incisal embrasure between canine and premolar teeth must be equal or larger than that found between lateral and canine teeth (Fig. 1.18).

The incisal embrasure form and amplitude can be altered by time and modify tooth appearance (Fig. 1.18). In this way, width to length ratios are modified: narrower embrasures implies larger teeth, whereas wider embrasures results in narrower teeth.

Cervical embrasures

The cervical embrasures depend upon the proximal contact surfaces and accommodate the interproximal papilla. In the anterior teeth, cervical embrasures are narrower. In the posterior teeth, cervical embrasures are wider (Fig. 1.18).

Occlusal embrasures

These are related to cusp trajectories during eccentric mandibular movements. The buccal embrasures are transition areas between buccal and proximal surfaces. The lingual embrasures are transition areas between lingual and proximal surfaces. Lingual embrasures are wider than buccal embrasures.

The contact between adjacent teeth, the cemento-enamel junction, and the width of interdental surfaces determine shape and size of gingival papilla. Papillary tissue has a pyramidal configuration, with the base being an imaginary horizontal line joining cemento-enamel junctions. In the premolar and molar regions, gingival papilla has a more rounded appearance.[1]

GINGIVAL ARCHITECTURE

When healthy, gingival tissues completely fill the cervical embrasures. The marginal gingival contour has a triangular configuration, with its apical portion located distal to the center of the tooth. This point is called gingival zenith (Figs. 1.10, 1.12 and 1.18). It lies distal in the central incisors and canine teeth, being more centered along the tooth axis of the lateral incisors.[1-4] An imaginary line can be drawn at the height of gingival contours, parallel to the interpupillary line and the maxillary plane. This line serves as reference to the smile esthetics.

Variations in the gingival contour between two adjacent upper central incisors impart visible alterations in width, length, and tooth

Real measures of anterior teeth.

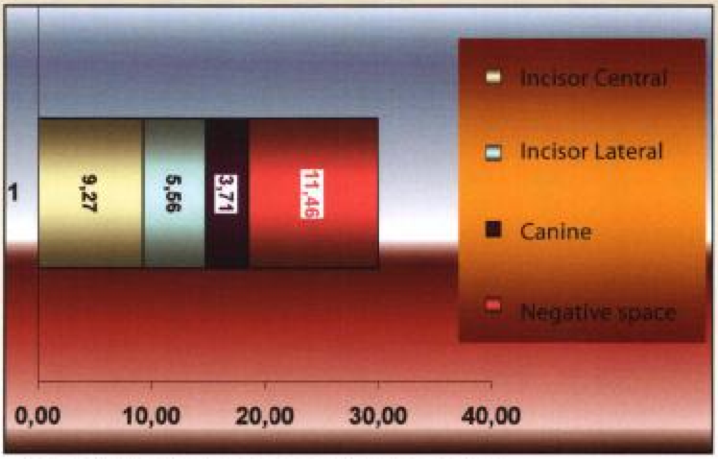
Insert width of smile

60,00	Width	Height
Width half smile	30,00	
Width tip C and IC	16,54	
Incisor central	9,27	11,59
Canine	3,71	10,30
Negative space	11,46	

Insert width of IC

8,03	Width	Height
Smile width	51,97	
Width of tip C and IC	16,06	
Incisor central	8,03	10,04
Canine	3,21	8,92
Negative space	9,93	

C = Canine, IC = Incisor Central



Gentle, Dr. José Leitão. Computerized proportion

1.19

position. Also, maxillary spatial orientation is lost[11].

Ideally, the height of the gingival contour in the upper central and canine teeth is greater than in the lateral incisors, with the first two having the same contour levels.

COMPUTERIZED PROPORTION

It is now possible to determine width to length ratios of anterior teeth through a software computer, as seen in Fig. 1.19.

GOLDEN PROPORTION

It is a subconscious register that evokes comfort, beauty, and pleasant perception of beauty, mathematically defined as 1.0 to 0.618 ratio (Fig. 1.20A to C).

This is verified when proportion of the smaller to the greater is the same as the proportion of the greater to the whole. The golden proportion can be found in the most beautiful smiles, faces, and bodies. Nature rarely is an absolute science, but this phenomenon comprehends a higher biological plane (Figs. 1.21 to 1.23)[6]. The golden proportion is a valuable tool for objective interpretation of facial and dental esthetics. Also, it facilitates communication among dental professionals[1].

Levin[31] created grids in the golden proportion, which relate the width of the space occupied by central incisors and half the total width of the smile (Figs. 1.24)[1,4]. However, tt is important to note that even without these "divine numbers", persons

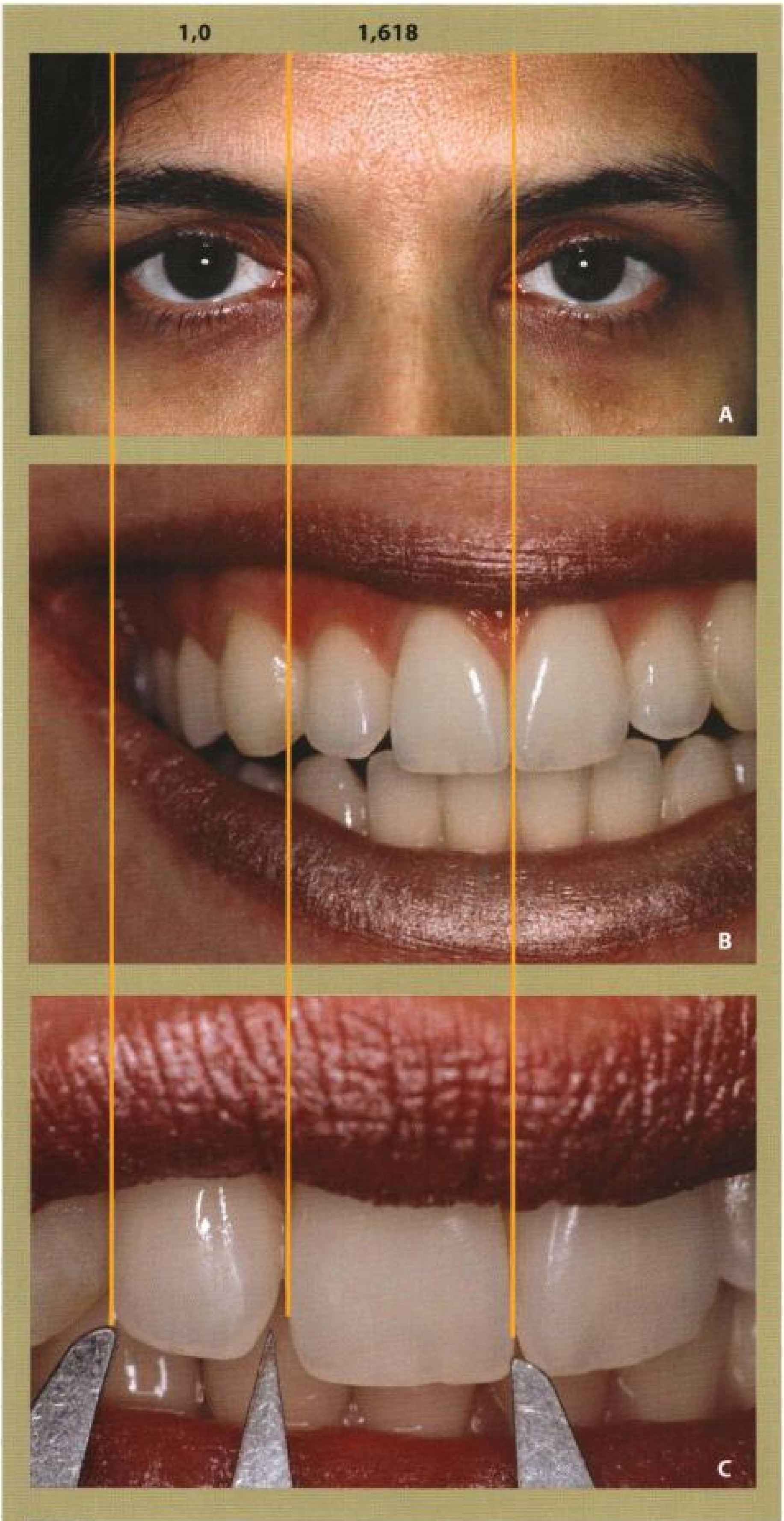


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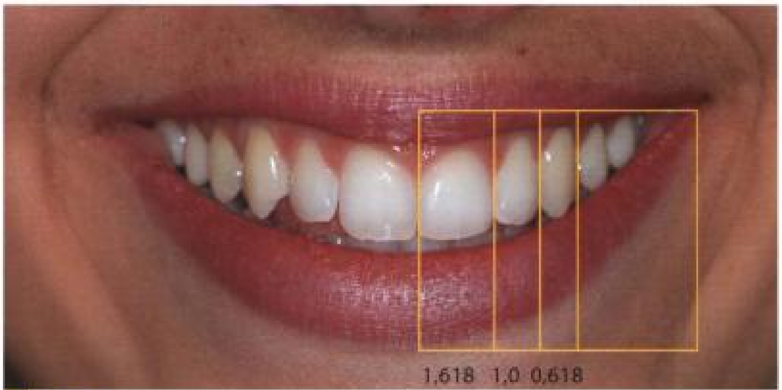
Fig. 1.20A – Relationship between interocular width and golden proportion. B and C. Golden proportion of teeth. Vertical lines are in golden proportion with their correspondent numeric values.

1.21

1.22



1.23

1.24

Fig. 1.21 – Golden proportion between upper (1.0) and lower lip (1.618).

Fig. 1.22 – Golden proportion between interalar base/commissure (1.0) and commisure/chin (1.618).

Fig. 1.23 – Golden proportion of anterior teeth.

Fig. 1.24 – Levin's grid[31] in golden proportion for anterior teeth.

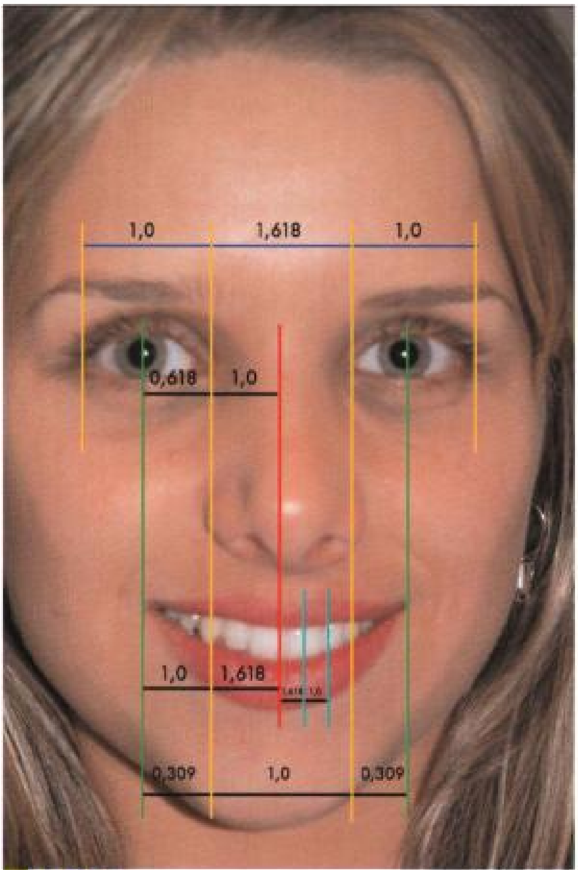
can have very pleasant appearances (Fig. 1.25).

THE PERFECT SMILE

According to the beauty pattern accepted in the Western countries, the following characteristics can be cited (Fig. 1.26):

- the upper lip lies at the gingival margin of central incisors, with a discrete superior curvature;
- only interproximal gingival tissue should be visible on smiling;
- the six anterior teeth and the buccal surfaces of premolars must be evident;
- the lower lip line must follow the incisal border lines;
- a well design buccal corridor;
- the commissure line must be parallel to the interpupillary line;
- the median line coincides with a balanced smile.[1,2]

Individual variations on smile depends upon quantity and quality of gingival tissues, amount of lip sup-



1.25

1.26

Fig. 1.25 – Patient's frontal view. Observe several golden proportions that can be found.

Fig. 1.26 – An esthetic pleasant smile.

port and tooth angulation, and harmonious integration between teeth and facial components.

The upper central incisor position controls the median line, provides lip support, and the composition of smile line. The upper lateral incisor reflects "personality" being subordinated to the central incisor. Finally, the canine teeth must be positioned to complete the ascendant smile curve. It controls the width of the buccal corridor, supports anterior region of the arch, and controls the labial angle when the patient smiles.[2]

However, according to Dong et al.[12], many patients hide their smiles even after having all dental esthetic problems corrected. Thus, specific exercises to improve smile esthetics are recommended. These measures must follow a strict program to maintain musculature tonus[12,19,20].

The smile anatomy is an integral part in dentistry. A thorough examination of surrounding elements is fundamental to understand the role of dental and facial components in esthetics. To create beautiful smiles, clinicians must provide adequate lip curvature after evaluating the vermilion borders, philtrum volume, and the nasolabial sulcus[7].

The key to a successful esthetic treatment resides in the harmony between facial and intra-oral components.

Box 1-1 – Fundamentals of esthetics.

Fundamentals of esthetics

1. Gengival health
2. Interdental contact
3. Tooth axis
4. Gengival zenith
5. Gengival levels
6. Interdental contact level
7. Tooth relative dimensions
8. Basic characteristics of dental forms
9. Dental characterization
10. Surface texture
11. Shade
12. Incisal border configuration
13. Smile symmetry
14. Lower lip line
15. Facial symmetry

Subjective criteria (integrated with esthetcs)

- Variations on dental forms
- Tooth positioning and arrangement
- Crown height
- Negative space

(Adapted from Magne & Belser, 2002)

"Dentistry is an area that preserves and restores the most beautiful movement of human beings: the smile".

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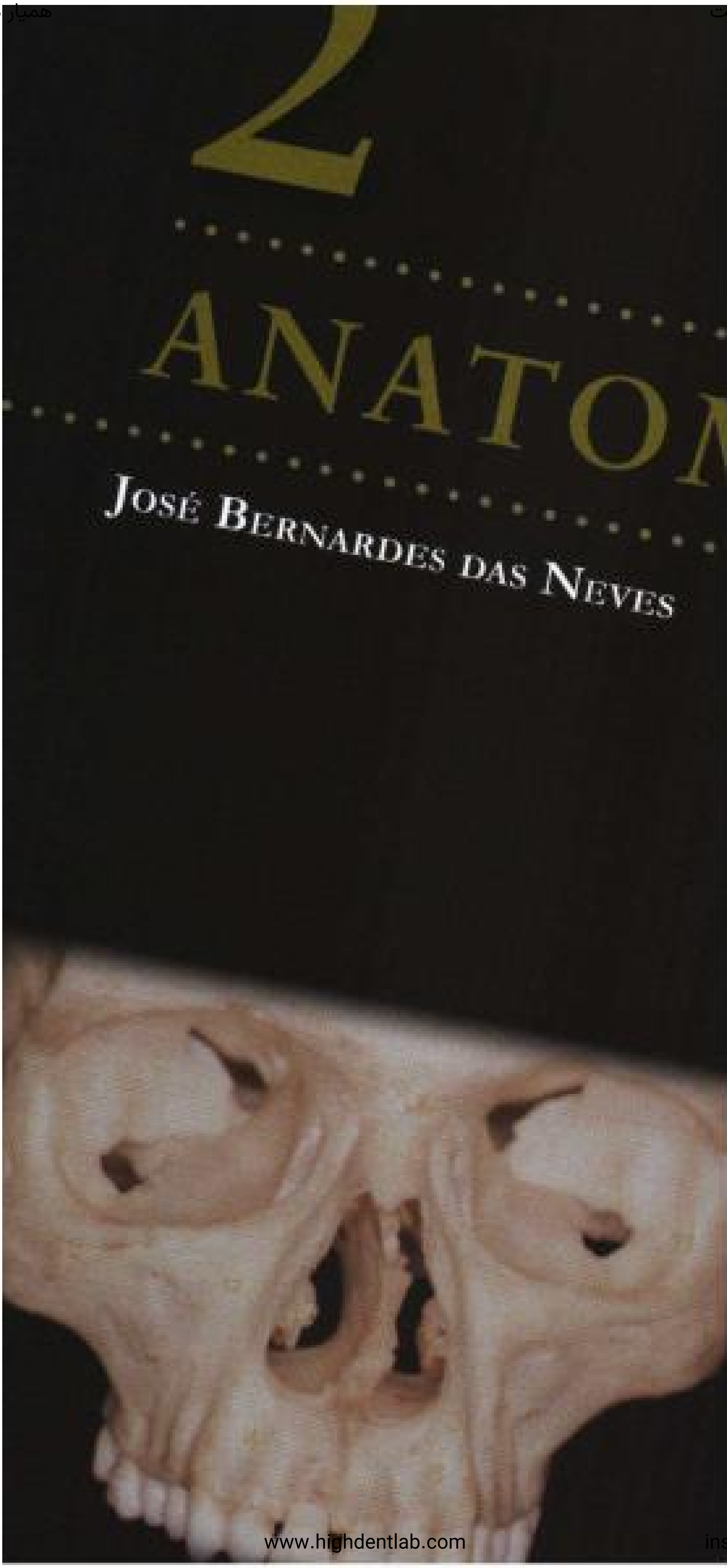
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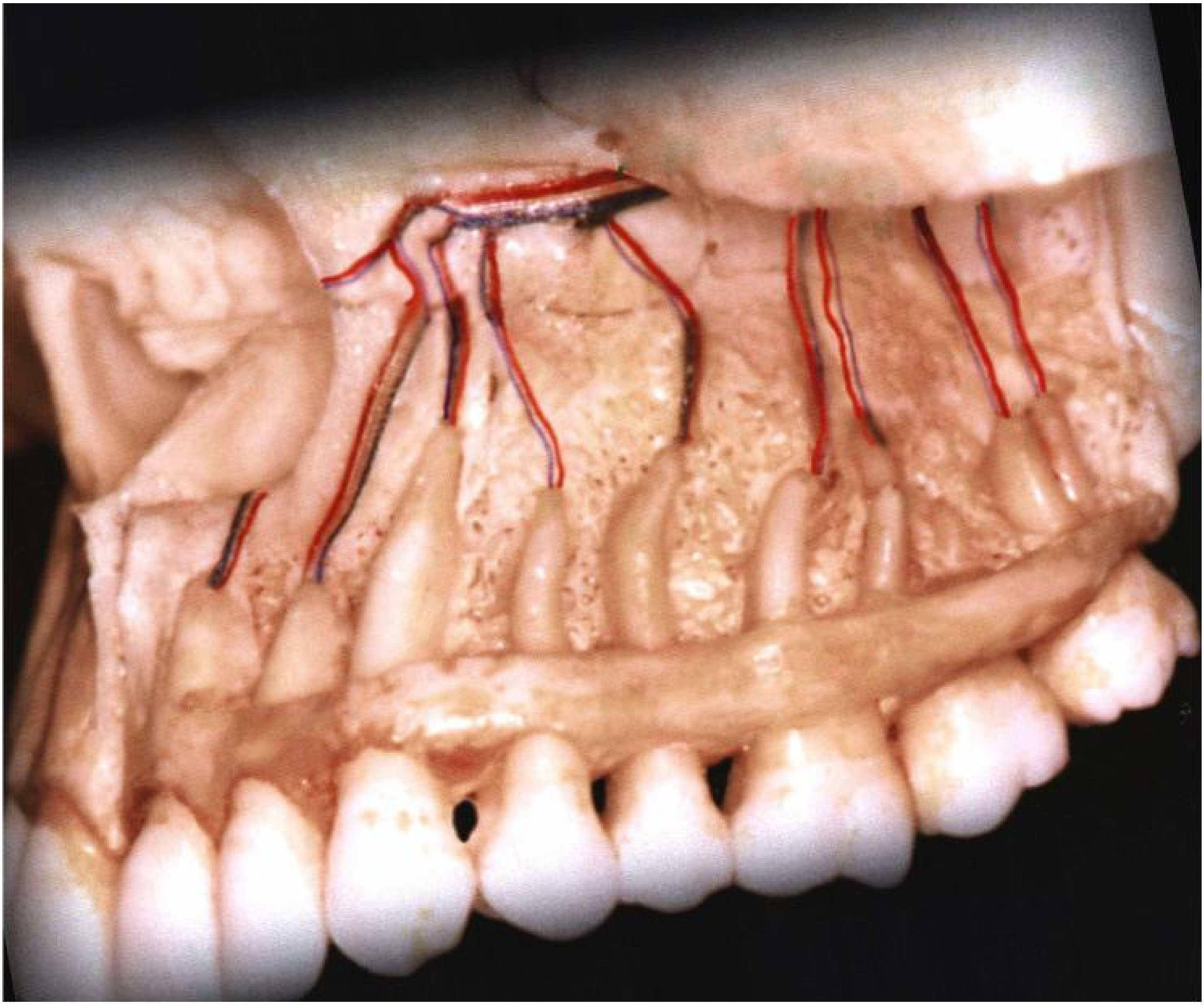


Anatomy

ANATOMY

The knowledge of anatomic structures in the oral cavity is important not only for implantology and oral surgery, but also in every dental discipline. This chapter gives an overview of cranial and facial bones, its related musculature, blood supply, and innervation.

CRANIAL AND FACIAL BONES

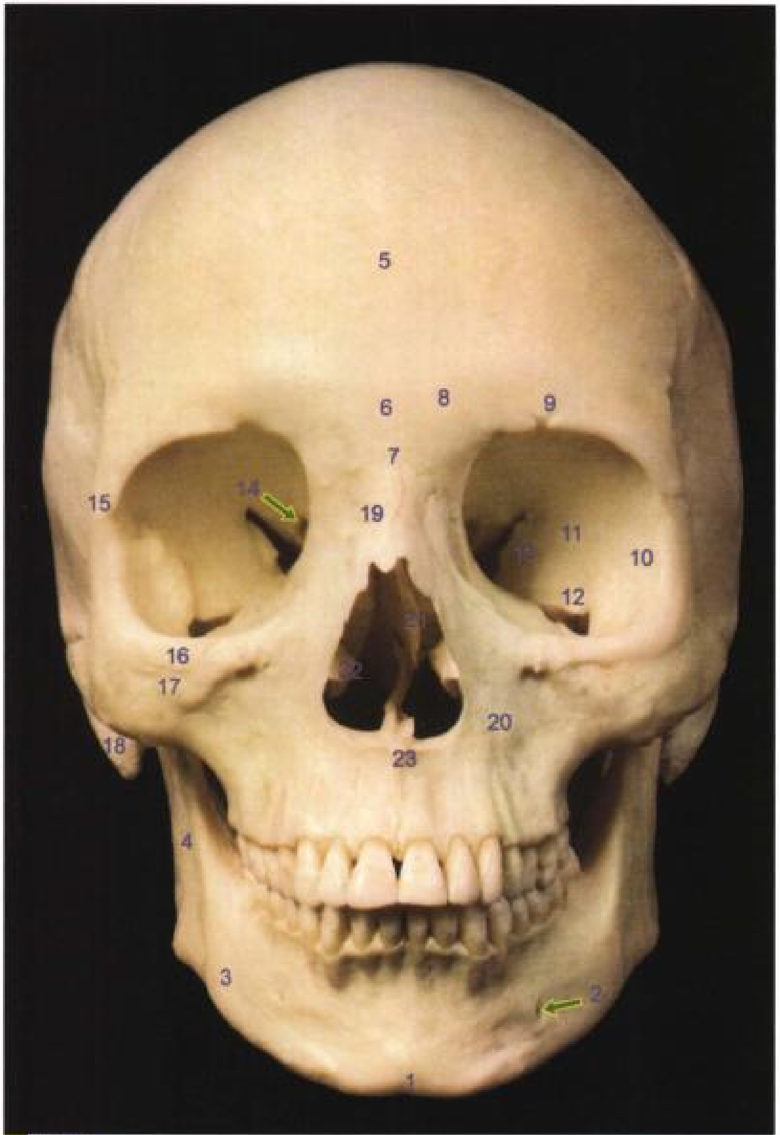
The cranial bones protect the human brain from external injuries, are responsible by the facial skeleton, and act like growth centers during facial development. The human skull is divided in neural and facial parts. The neural part comprehends the base, vault or calvarium. The following bones can found in this region:

- frontal bone
- sphenoid bone
- ethmoidal bone
- occipital bone (close related to the vertebral column)
- temporal bone (lateral area)
- parietal bone (anterior -superior-lateral region)

The sphenoid and ethmoid bones are located in the skull and are important structurally for facial harmony. On the other hand, the following bones have a more relevant participation in the facial region:

- mandibular bone
- maxillary bone
- vomer
- nasal
- lacrimal
- zygomatic
- inferior turbinates
- palatal bone

We will demonstrate the location of neural and facial bones from several views to facilitate reader's comprehension.



2.1

Fig. 2.1 – Skull – frontal view.

1. Mental tubercle
2. Mental foramen
3. Mandible (body)
4. Mandible (ramus)
5. Frontal bone
6. Glabella
7. Nasion
8. Superciliary arch
9. Supra-orbital foramen
10. Zygomatic bone
11. Greater wing of sphenoid
12. Inferior orbital fissure
13. Superior orbital fissure
14. Optic canal
15. Frontozygomatic suture
16. Infra-orbital rim
17. Zygomaticomaxillary suture
18. Mastoid process
19. Nasal bones
20. Maxilla
21. Nasal septum
22. Inferior nasal turbinate
23. Anterior nasal spine

Frontal view

The area above the eyes and the cranial portion is comprised by the frontal bone. The ocular cavity is found here, with lacrimal bone situated medially. At the lateral orbital wall is possible to identify the medial portion of the ethmoidal bone, the greater and lesser wings of the sphenoid bone, with the orbital superior fissure running through them. The roof of the orbital cavity is formed by the frontal bone, laterally by the zygomatic bone, and inferiorly by the zygomatic and maxillary bones. The region below the eyes is formed by the zygomatic bone, also known as the "cheek" bone.

The nasal bone has a septum that comprehends the vomer and the ethmoidal bone. The inferior turbinates run inferior and laterally in the nasal cavity. Part of the parietal and temporal bones is seen, as well as the greater wing of sphenoid (Fig. 2.2).

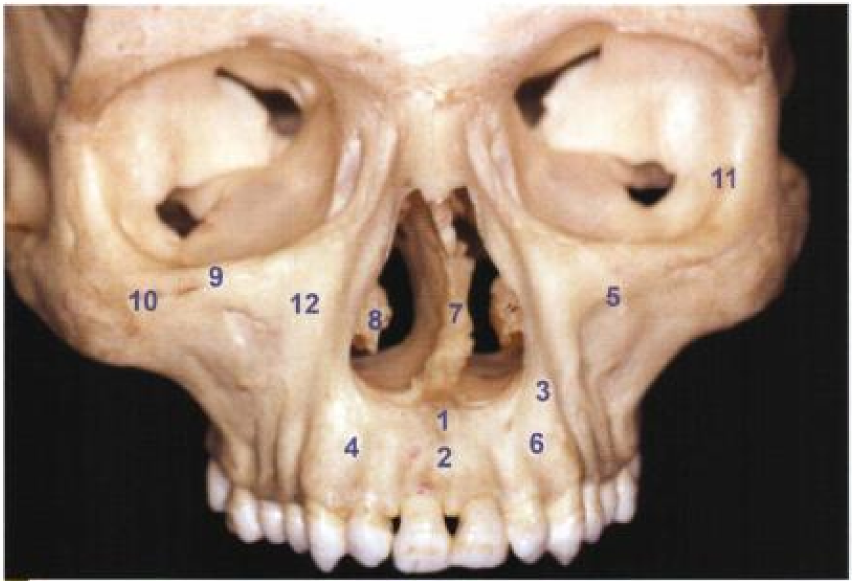
Lateral view

We now can see the frontal, zygomatic, maxillary, mandibular, nasal, lacrimal, part of the ethmoidal, greater wing of sphenoid, temporal, mastoid, as well as parietal and occipital bones. Also, sutures that join different regions of the skull are seen (Fig. 2.3).

Basal view

The region of hard palate is formed by maxillary palatal process and the palatal process of palatal bones. Behind and downward of the palatal bone, a small portion of vomer bone can be seen, followed by the sphenoid bone and the sphen-occipital synchondrosis (junction of sphenoid and occipital bones). Part of the zygomatic and the temporal

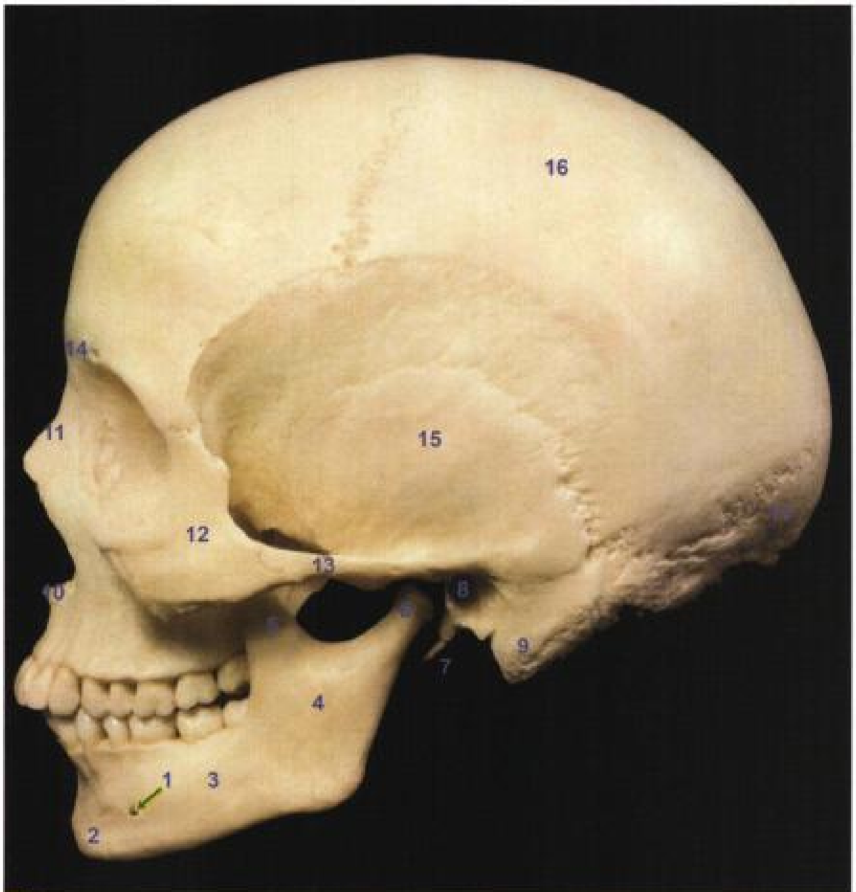
1. Anterior nasal spine
2. Intermaxillary suture
3. Canine eminence
4. Canine fossa
5. Infra-orbital foramen
6. Alveolar process
7. Nasal septum
8. Inferior nasal turbinate
9. Infra-orbital rim
10. Zygomaticomaxillary suture
11. Zygomatic bone
12. Maxillary frontal process



2.2

Fig. 2.2 – Frontal view of the facial skeleton depicting the maxillary bone. Observe excessive bone quantity and quality at the alveolar ridges.

1. Mental foramen
2. mental tubercle
3. Mandible (body)
4. Mandible (ramus)
5. Coronoid process
6. Condylar process
7. Styloid process
8. External acoustic meatus
9. Mastoid process
10. Anterior nasal spine
11. Nasal bone
12. Zygomatic bone
13. Zygomatic arch
14. Supra-orbital foramen
15. Squamous part of temporal bone
16. Parietal bone
17. Occipital bone



2.3

Fig. 2.3 – Skull – lateral view

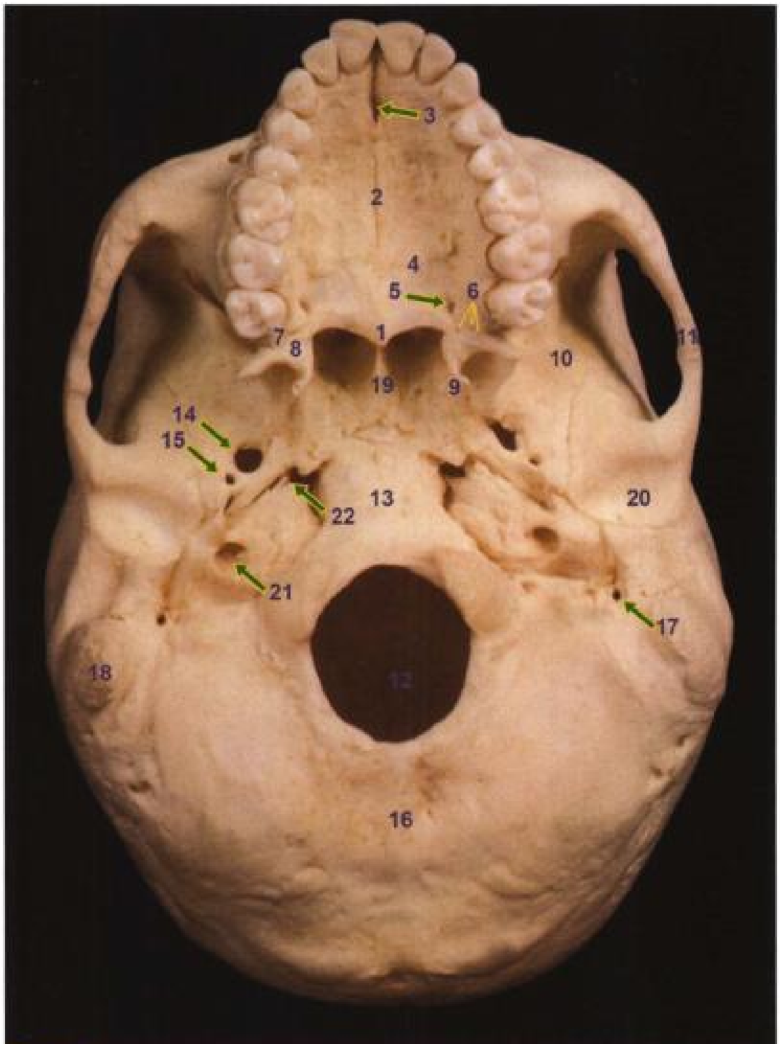
bones can be seen, with a little portion of frontal bone.

Anatomic landmarks observed include the incisive foramen, and the greater and lesser palatal foramens. The pterygoid hamulus is located behind the palatal foramina. Thus, important vessels and nerves cross the pterygoid hamulus, such as the median palatal artery, transverse palatine or sphenopalatine artery.

At the same region we can observe the pterygoid process of the sphenoid, with its medial and lateral boundaries and the pterygoid fossa between them. The foramen rotundum is found laterally in this area. The middle meningeal artery runs behind the rotundum foramen, inside the spinosum foramen. The internal carotid artery lies in the carotid canal, behind the spinosum foramen. Following a posterior-medial direction, one can observe the styloid and mastoid processes, and the stylomastoid foramen, where nerve bundles run to provide facial movements. The jugular fossa and the occipital condyles are found lateral to this area surrounding the greater foramen (Fig. 2.4).

Interior view

The frontal bone constitutes the anterior part of the skull. However, there is a small area in the midline occupied by the ethmoidal bone, where the crista galli and the cribi-



1. Posterior nasal spine
2. Median palatal suture
3. Incisive foramen
4. Transverse palatal suture
5. Greater palatine foramen
6. Lesser palatine foramen
7. Maxillary tuberosity
8. Pyramidal process of palatine bone
9. Pterygoid hamulus
10. Infratemporal crest
11. Zygomatic arch
12. Foramen magnum
13. Pharyngeal tubercle
14. Foramen ovale
15. Foramen spinosum
16. External occipital crest
17. Stylomastoid foramen
18. Mastoid process
19. Vomer
20. Mandibular fossa
21. Carotid canal
22. Lacerum canal

Fig. 2.4 – Skull – basal view

form foramen can be found (dura mater insertions and the pathway of ophtalmic nerve). The greater and lesser wings of the sphenoid bone are immediately behind this region. The parietal, temporal, and occipital bones are located in the posterior-lateral area.

The lesser wing of the sphenoid lies anteriorly in the frontal bone at the anterior cranial vault, which houses the frontal lobes of the brain. At the body of sphenoid, there is a depression called hypophyseal fossa, encompassing the pituitary gland. The round and oval foramen are found in the sphenoid and dental innervation pass through these areas.

Following a posterior direction, one can observe the spinosum foramen, and just beneath, the foramen lacerum. In the posterior region there is a great aperture called foramen magnum in the occipital bone. Laterally, the jugular foramen and the internal acoustic meatus can be seen.

Downward the internal acoustic meatus, we can observe the petrous portion of temporal bone. The middle cranial vault is localized between the acoustic auditory meatus and the lesser wing of the sphenoid with their respective temporal cerebral lobes.

In the posterior region, between the occipital bone and the acoustic auditory meatus, lies the posterior cranial vault, with the occipital cerebral lobes.

MAXILLA

The maxillary bone has a central body, the maxillary sinus and four apophyses: zygomatic, frontal, palatal, and alveolar. It can be compared to a five-sided pyramid with the base forming the nasal cavity, and the apex encompassing the zygoma apophysis. The three sides of the pyramid are: superior or orbital (floor of the orbital cavity), anterior-lateral or malar (skull of the face and the cheeks), and the posterior- lateral or infratemporal (infratemporal fossa). The inferior border encompasses the alveolus, which contains the teeth (Figs. 2.5 to 2.9, 2.11).

Maxilla - lateral view

The alveolar, zygomatic, and frontal processes can be observed. The anterior nasal spine lies anteriorly to the floor of the nasal cavity. The alveolar eminences can be found at the premolar region. The infra-orbital foramen is located above the canine fossa.

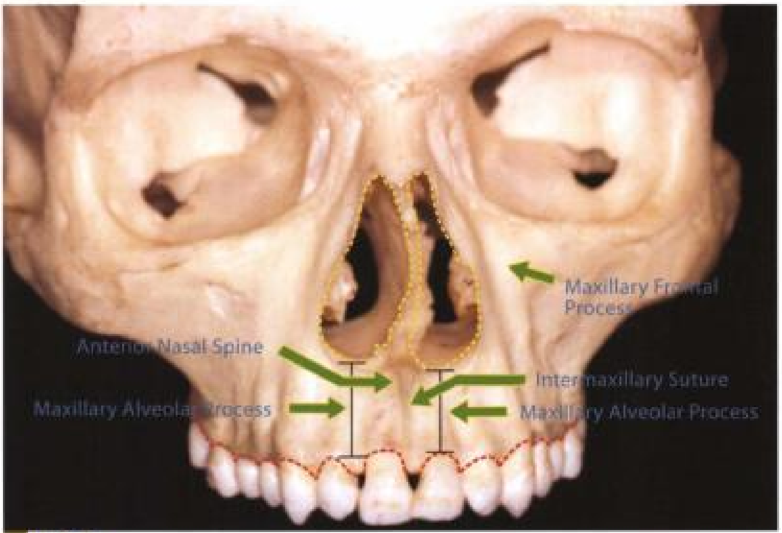
The posterior region is called the maxillary tuberosity. Vessels and nerves that provide nutrition and sensory information to the upper molars and part of the maxillary sinus pass through this region. The tuberosity is also a growth center; lack of space for the third molar and Angle's Class III malocclusion can arise due to insufficient growth at this area.

Maxilla – inferior view

There is the midline suture at the palatal aspect, the incisive foramen and the transverse palatal suture. The midline suture is responsible by the lateral palatal growth.

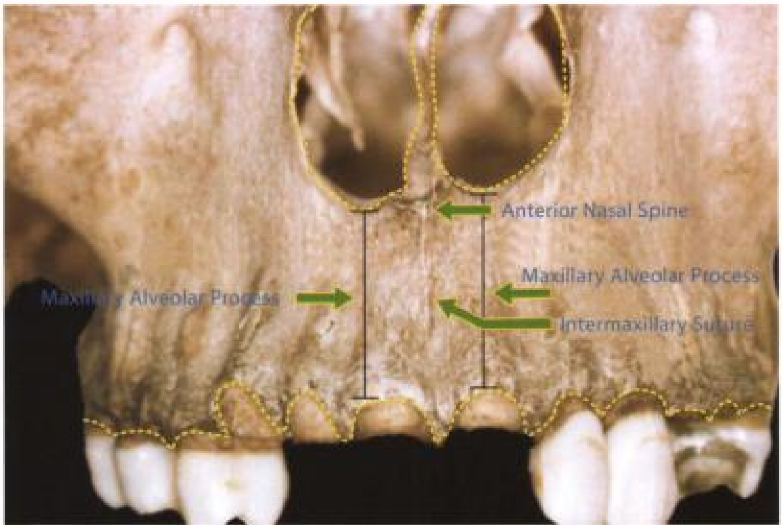
Maxilla – medial view

The medial or nasal surface of the maxilla encompasses a wide and irregular aperture, known as the sinus ostia, which gives passage to the maxillary sinus. At the end of this



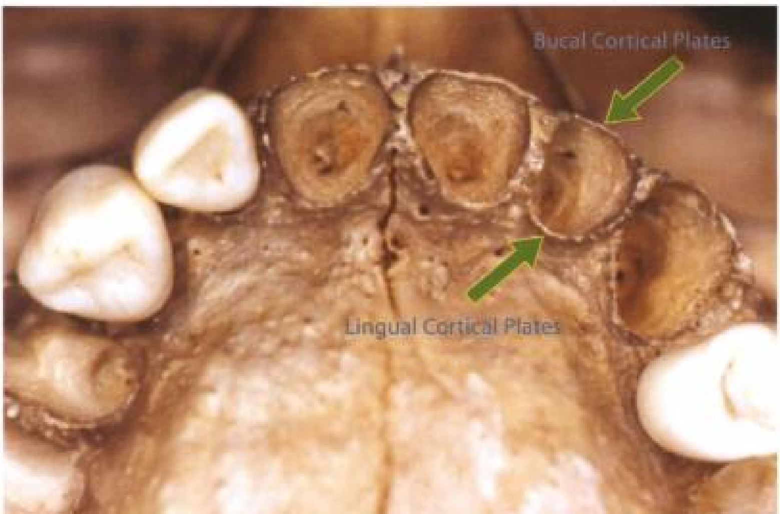
2.5

Fig. 2.5 – Maxillary bone and teeth – anterior view. Observe the bone quantity and quality of alveolar process. (Maxillary frontal process, Anterior nasal spine, Intermaxillary suture, Maxillary alveolar process.)



2.6

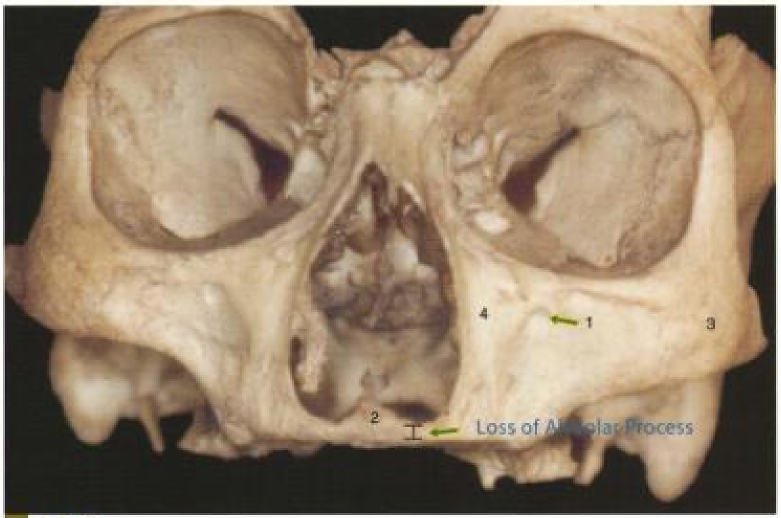
Fig. 2.6 – Cranial bones – anterior view. Note absence of anterior teeth and integrity of alveolar process. (Anterior nasal spine, Intermaxillary suture, Maxillary alveolar process.)



2.7

Fig. 2.7 – Maxillary bone - inferior view. Observe the alveolar process without teeth, with delicate buccal and lingual cortical plates.

1. Infra-orbital foramen
2. Anterior nasal spine
3. Zygomatic bone
4. Maxillary frontal process



2.8

Fig. 2.8 – Cranial skeleton of an edentulous patient – frontal view. Observe the lack of alveolar process with an accompanying thin cortical bone plate. The zygoma and the orbit did not suffer resorption along time.

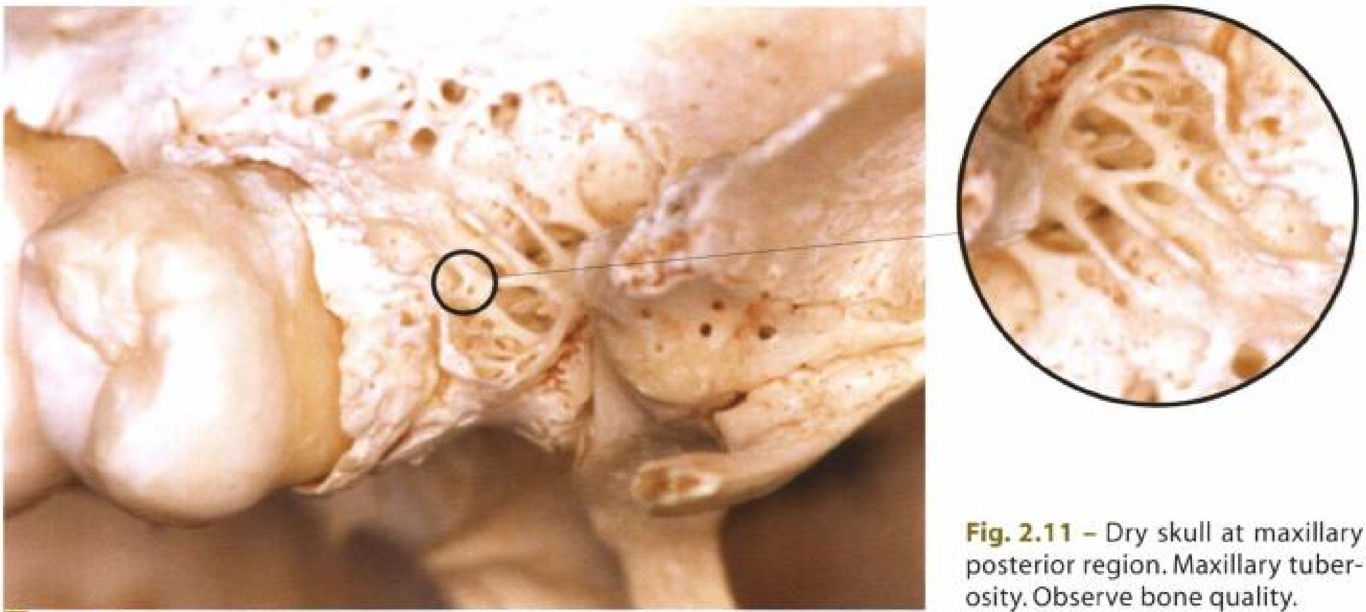
2.9

Fig. 2.9 – Maxillary bone of an edentulous patient – inferior view. Observe the lack of alveolar process due to bone resorption. The incisive foramen coincides with the alveolar crest and the horizontal portion of palatine bone.

1. Incisive foramen
2. Median palatine suture
3. Transverse palatine suture
4. Greater palatal artery
5. Lesser palatal arteries
6. Posterior nasal spine

2.10

Fig. 2.10 – Maxilla – inferior view.



2.11

Fig. 2.11 – Dry skull at maxillary posterior region. Maxillary tuberosity. Observe bone quality.

2.12

Fig. 2.12 – Maxilla – medial view.

1. Anterior nasal spine
2. Alveolar process
3. Palatine process
4. Incisive foramen

area, there is a rough bone articulating with the vertical plate of palatine bone (Fig.2-12). The pterygomaxillary sulcus can be found vertically, in the middle of the posterior border of maxilla. It ends at the angle formed between the posterior border of palatal apophysis and the medial surface of maxillary bone. The superior area of the nasal border has one or two posterior depressions to accommodate the ethmoidal cells. Next, the lacrimal sulcus is found. The sulcus is limited anteriorly by the posterior border of frontal apophysis, and posteriorly by a prominent osseous spine, that projects itself from the anterior border of maxillary aperture. Anterior and at the inferior extremity of the lacrimal sulcus, there is a horizontal crest (crista conchalis) which serves as anchorage for the inferior turbinate.

The orbital border is triangular and slightly inclined latero-anteriorly. Its medial border articulates with the lacrimal bone anteriorly, and with the lamina papyracea of ethmoid bone posteriorly. The posterior angle of palatal bone integrates the orbital floor through its apophysis.

Posteriorly, the orbital face is separated from the infratemporal face by a rhomboidal border that forms the inferior limit of the inferior orbital fissure. Close to this area, there is a sulcus that runs oblique across the floor of the orbit: the infra-orbital sulcus (that contains infra-orbital nerves and vessels). The lateral border of the sulcus forms a projection that covers it partially, until the point where the sulcus forms the infra-orbital canal. The infra-orbital canals converge downward, crossing at 1 or 2cm anteriorly to the upper central incisors. The canal and the infra-orbital foramen deviate laterally, with the canal forming a convex arch at the base of the zygoma apophysis. This can have clinical importance during anesthesia of the infra-orbital nerves. The infra-orbital canal forms a protuberance in the maxillary sinus and can be absent in persons with wide maxillary sinus.

The zygomatic apophysis of the maxillary bone is the apex of the pyramidal body. It articulates with the zygomatic bone suture. Its anterior face represents an extension of the anterior-lateral surface of the maxilla, and its posterior concave surface continues with the infra-temporal convex surface of the maxillary bone.

The frontal apophysis is an osseous lamina, where the anterior border integrates the formation of the superior border of the piriform aperture and extends superiorly, articulating with the nasal bone. The posterior border of the frontal apophysis begins at the anterior-medial angle of the orbital face and contacts the lacrimal bone. It is a thick border that articulates with the frontal bone.

The inferior maxillary border contains the alveolar apophysis or alveolar bone, comprising two parallel bony laminas, forming a protuberance known as alveolar tubercle, with a large medullar space. The lateral part follows an anterior-posterior direction, while the medial part continues with the palatal apophysis and the nasal border of the maxillary bone. The space between these walls is the alveolus that holds teeth in position. In the premolar region, the interdental septum is parallel to alveolar lamina. In the molar region, palatal and vestibular roots are divided, which in turn are separated by a secondary frontal septum.

The palatal apophysis arises from maxillary bone as a lamina, between maxilla and the alveolar apophysis. It is narrower in the anterior-posterior direction, joining the horizontal lamina of palatal bone at the transverse palatal suture. Between the posterior edge of palatal apophysis and the medial wall of maxilla, there is an osseous protuberance where the pterygomaxillary sulcus ends. This is the site of the palatal foramen, where the palatal vessels and nerves run anteriorly. The limit between the palatal and alveolar surfaces is visible only at the posterior border, where the bones form a straight angle.

The buccal region of palatal apophysis is rough and irregular, whereas the nasal one is smooth and concave. Along its middle portion, there is a ridge due to the nasal crest, which is divided in two parts: the anterior portion is higher than the posterior, and articulates with the septal cartilage, while the posterior portion articulates with the nasal border of the nasal septum. There is an abrupt transition between these portions, with a canal running downward and anteriorly (incisive canal) to the palatal area of the maxillary body, carrying the nasopalatine vessels and nerves, and the remnants of the foramina of Stenson. Occasionally, two additional canals are present in the midline; they are termed the foramina of Scarpa, and when present carry the nasopalatine nerves, with the left foramen passing through the anterior segment of the incisive canal, and the right foramen through the posterior segment of the canal. This aspect is important during local anesthesia procedures.

The incisive canal limits both parts of pre-maxilla and the maxillary bone. Sometimes, traces of fusion between pre-maxilla and palatal surface of maxilla can be observed through the nasal aperture of the incisive canal. However, signals of the incisive suture can be more easily detected on the buccal surface of palatal apophysis. This suture begins at the incisive foramen and extends to the medial border of the canine alveolus.

Oral cavity

The oral cavity is partially limited by facial bones. Its lateral and anterior walls are formed by the internal surface of the alveolus joined at the midline. Lingual surfaces of teeth integrate these walls. The internal mandibular surface (above the mylohyoid line) delimitates part of the oral cavity.

The roof of the oral cavity is formed by the hard palate, which is composed of palatal surfaces and horizontal plates of the palatine bones. These bones articulate among them through a cross suture. The palatal median suture divides right and left halves of the hard palate, whereas the transverse suture divides maxillary and palatal bones.

The posterior nasal spine projects itself at the end of the hard palate. Near to the posterior border of the hard palate is the pterygopalatine canal, which ends in the pterygopalatine foramen, carrying the palatine nerves and the descending palatal artery. Bone area behind this foramen presents crests with accessory palatine canals, which gives rise to the posterior palatal nerves that supply soft palate and tonsils.

In the anterior region, the incisive fossa is found at midline and behind the incisor teeth. The incisive suture is observed between the upper lateral incisor and the canine, in young skulls, and part of the incisive fossa, through the canine alveolus.

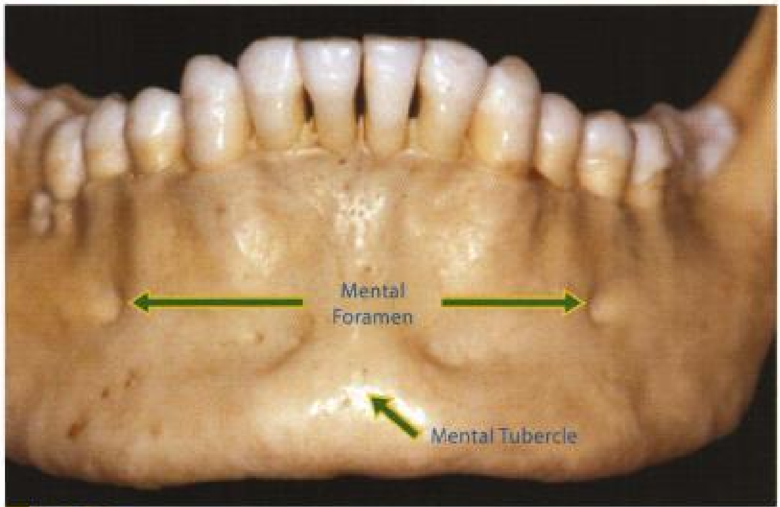
Mandibular bone

The mandibular bone has a horseshoe configuration, being divided in body, ramus, and alveolar process. The alveolar bone is located at the body; the coronal apophysis (muscular) can be found at the most anterior and superior part, whereas the condylar apophysis (articular) can be found at the most posterior and anterior part of the ramus. The posterior border of the ramus and the inferior border of the body form the gonion (mandibular angle) (Fig. 2.13, 2.14, 2.15).

Latero-anterior view

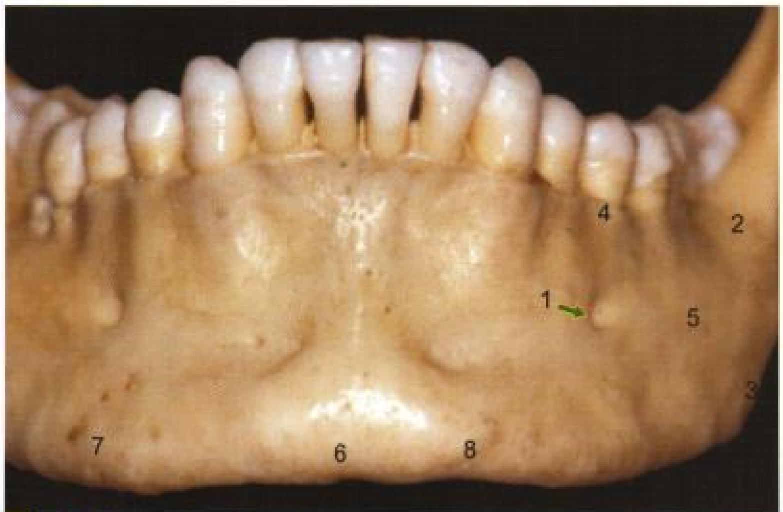
The body is reinforced at its inferior border, which is round, smooth and thick. The mental protuberance is located at the anterior surface of the body of the mandible close to the midline. It has a triangular shape, with a depressed center and raised borders, forming the mental tubercle.. The mental fossa can be found above the mental tubercle, with two or three small orifices that give passage to blood vessels. Below the second pre-molar tooth, on either side, is the mental foramen, the emergence point of blood supply and innervation for the lower lip. This foramen can be found midway between alveolar process and mandibular body, in a vertical direction. In adult individuals, the foramen is situated between the inferior border of the mandible and the alveolar crest, found sometimes close to the inferior border. The canal that gives rise to the mental foramen runs anteriorly and upward to the external surface of the mandible. For this, the margin of the orifice is sharp only at its anterior-inferior circumference.

Following the inferior border, the mandibular angle is found, with the ramus located upward. The ramus plane is located lateral to the alveo-



2.13

Fig. 2.13 – Mandible –anterior view. Observe the mental tubercle and foramina.



2.14

1. Mental foramen
2. External oblique line
3. Mandibular angle
4. Alveolar process
5. Mandibular body
6. Mental Protuberance
7. Mandibular base
8. Mental tubercle

Fig. 2.14 – Mandible – frontal view.

2.15

Fig. 2.15 – Mandible. Observe localization of mental foramen.

lar process at the molar region. The anterior border of the ramus does not find the posterior border of the alveolar process, but forms a faint ridge, called the oblique line, which runs backward and upward from each mental tubercle. This line is robust and progressively disappears near the inferior border, at the first pre-molar region. The oblique line can be identified in the radiograph as a radiopaque line at the posterior mandibular region.

At the posterior region, the bone is marked by rough, oblique ridges on each side, for the attachment of masseter laterally, and the medial pterygoid muscles internally.

At the mandibular ramus, there are two processes, condylar and coronoid, separated by a semilunar depression, the mandibular notch. The condyles are responsible for the temporomandibular joint, along with the articular disk and the temporal bones. The axes of both condyles form an obtuse angle (150 to 160 degrees) at the horizontal plane. The condyle is joined to the ramus by a constricted portion known as the neck. The mandibular notch continues upward and forward until the lateral portion of the condyloid process. Medial to this crest and at the inner portion there is a depression, the pterygoid fossa, where part of the lateral pterygoid muscle is inserted. The coronoid process is anterior to the mandibular neck, where the temporal muscle inserts.

Medial view

From this perspective, the mandibular foramen can be observed, being responsible for the vascularization and innervation of teeth and lower lip. In the third molar region, there is a triangular area that, in well-developed situations, reaches the inferior border of the mandible at the mental region, running between the digastric fossa and the mental spine. This line (mylohyoid line) gives origin to the mylohyoid muscle. As this muscle comprises the floor of the oral cavity, any bony part above this line is part of the oral cavity, and any part below this line constitutes de lateral surface of the submandibular space.

The sublingual and submandibular fossa can be found above and below this line, respectively, with their respective glands.

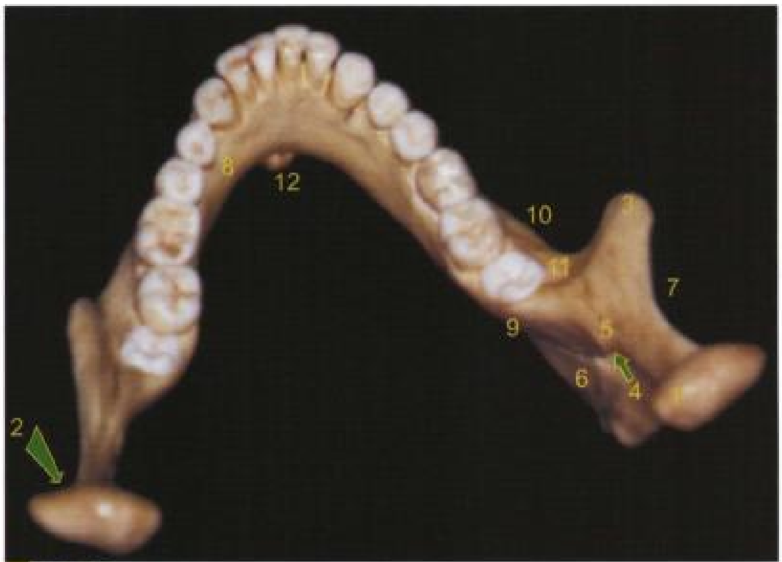
The coronoid process has a ridge that begins near its apex and runs downward and forward to the inner side of the last molar tooth. This ridge bifurcates to form the retromolar area.

Posterior view

Next to the mandibular body and at the inner surface, there is a round, shallow and rough depression, extending to the inferior border at the mental region. This serves as attachment for the digastric muscle. Above the digastric fossa, there is the mental spine for the insertion of geniohyoid (superiorly) and genioglossus (inferiorly) muscles. In the inner surface of the mandibular ramus, there is a structure known as lingula mandibulae, that covers the opening of the mandibular canal, and gives attachment to the sphenomandibular ligament. From the posterior-inferior circumference of the mandibular foramen there is a shallow and narrow sulcus, the mylohyoid sulcus, running downward and forward, housing the mylohyoid nerve (Fig. 2.16).

The mandibular canal, carrying the inferior alveolar nerve and vessels, has its origin in the mandibular foramen. It curves downward and forward in the ramus, following a straight path in the mandibular body. At the first pre-molar region, the mandibular canal divides into the mental canal (running lateral, superior and posterior, to end at the mental foramen) and the narrow incisive canal, which continues until the midline.

The alveolar surface comprehends the inner and outer compact bony plates, joined by interdental radicular septa. The outer plate is free distally to the second molar region, and specially, at the third molar region. The oblique line here fuses with the external line, creating an illusion that the alveolar process is thicker at the distal molar regions (Fig. 2.17, 2.18, 2.19, 2.20).



2.16

Fig. 2.16 – Mandible – postero-lateral view.

1. Condyle head
2. Condyle neck
3. Coronoid process
4. Mandibular foramen
5. Lingula mandibulae
6. Ramus – posterior border
7. Mandibular notch
8. Mylohyoid line
9. Internal oblique line
10. External oblique line
11. Retromolar area
12. Mental spine

2.17

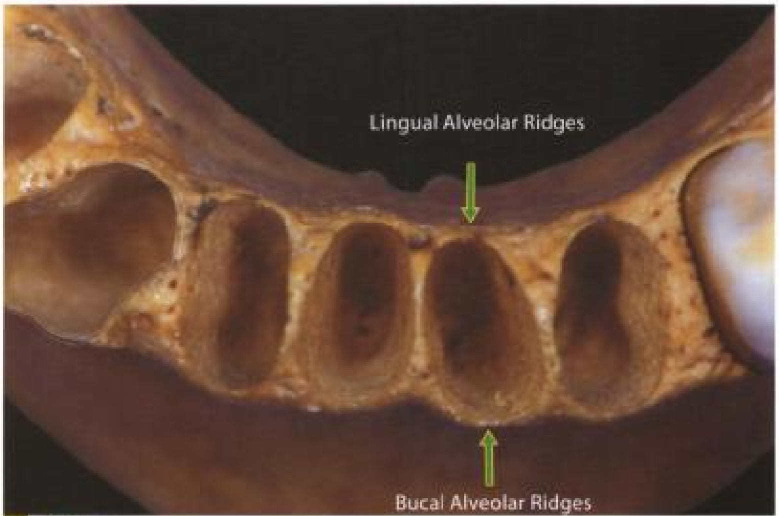
Fig. 2.17 – Mandible – frontal view. Observe alveolar process without teeth.

Conclusion

This anatomic review highlighted important structures during radiographic analysis and surgical planning.

Nasal cavity and Paranasal sinuses

The nose and the nasal cavity represent complex relationships be-



2.18

Fig. 2.18 – Anterior mandibular ridge - occlusal view. Observe the thickness of buccal and lingual alveolar ridges.

2.19

Fig. 2.19 – Occlusal view of edentulous mandible. Note resorption of alveolar process and the knife-edge pattern. Observe prominence of mental spine.

2.20

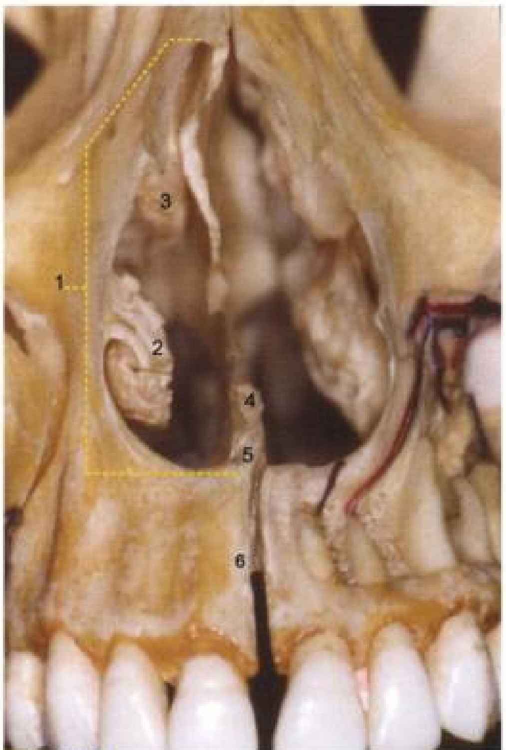
Fig. 2.20 – Lateral view of edentulous mandible: observe vertical and horizontal bone resorption pattern.

tween soft and hard tissues. The outer nasal surface is formed by the nasal bones superiorly and the anterior nasal spine inferiorly. The lateral surfaces are called the ala of the nose. The nose is internally divided by the septum cartilaginous (Fig. 2.21).

Internal view

Initially, the nasal septum and lateral walls of the nasal cavity are seen, revealing three nasal turbinates. The septum is formed by the vomer, a portion of the ethmoid bone and by fibrocartilage. The floor of the nasal cavity is formed by the hard palate, the palatine process of the maxillary bone and the horizontal plate of the palatine bone.

The two upper thirds of the lateral walls of the nasal cavity are formed by the ethmoid. They are called superior and middle turbinate (superior and middle nasal concha). On the other hand, the inferior third is formed by the maxilla and the ethmoid, constituting



2.21

Fig. 2.21 – Nasal cavity – internal view.

1. Nasal aperture
2. Inferior nasal turbinate
3. Middle nasal turbinate
4. Nasal septum
5. Anterior nasal spine
6. Intermaxillary suture

the inferior turbinate (inferior nasal conchae).

Along the nasal septum we will reach the posterior nasal apertures. Its posterior-superior portion is formed by the sphenoid that joins the ethmoid at the sphenoethmoidal process.

Paranasal sinuses

The nasal cavity receives several orifices from other cavities or housings of different types and forms, known as the paranasal sinuses.

The sinuses have four walls: ethmoidal, frontal, maxillary, and sphenoidal.

The area in the lateral wall below each turbinate is called meatus. The inferior meatus is located below the middle nasal concha, where the meatus semilunaris can be found. The superior meatus, below the superior nasal concha, is the smallest.

Frontal sinuses

The frontal sinuses vary greatly in size. They are located above the orbital cavity and behind the superciliary arches, often extending beyond the sagital midline. The sinuses open at the hiatus semilunaris. Infections on this area can cause pain and discomfort above the eyes.

Sphenoidal sinuses

These sinuses are localized in the body of the sphenoid, below the pituitary fossa and at the level of the middle cranial fossa. They extend beyond the sagital midline and open at the most superior and posterior portion of the nasal cavity (sphenoethmoidal process). Infections on this area lead to pressure and congestion, generating diffuse pain.

Ethmoidal sinuses

These are called air ethmoidal cells, since they are divided in small several compartments, namely anterior, middle, and posterior cells. The anterior cells are in the middle turbinates and open in the hiatus semilunaris. The posterior cells are in the superior turbinates and open in the superior meatus. Nasal congestion in this area can be difficult to treat.

Maxillary sinus

It is the largest of the all facial sinuses. It opens at the posterior- inferior ending of the hiatus semilunaris through one or two apertures near of the roof portion, and are thereby unfavorable for sinus drainage (Fig. 2.22 to 2.25). The sinus ostia have no relationship with the upright position of human beings. Its location can be explained by the development of maxillary sinus. The bulkiest inferior portion of the maxillary body houses the buds of the deciduous teeth, forcing maxillary pneumatization to occur below the floor of the orbit. While maxillary bone grows and the teeth are dislodged downward, the sinus expands inferiorly but its origin persists as a communication with the nasal fossa. There is an accessory aperture at the middle meatus, slightly more favorable for sinus drainage. However, it locates near and just below to the normal aperture.

The maxillary sinus occupies the entire maxillary region. It is described as a triangular pyramid, with the base represented by the lat-

1. Alveolar process
2. Prominent dental roots – floor of the maxillary sinus
3. Pterygopalatine fossa
4. Acessory ostium – maxillary sinus
5. Main ostium – maxillary sinus
6. Medial wall of maxillary sinus
7. Sinusal recess
8. Sinusal septum
9. Infra-orbital canal,
10. Orbit
11. Inferior orbital wall

2.22

Fig. 2.22 – Right maxillary sinus, sagital view, middle level. (Adapted from Navarro J, Cavidade do Nariz e Seios Paranasais, p.79).

eral and vertical nasal walls, and the apex toward the zygoma apophysis of the maxillary bone. The three faces of the pyramid face upward, backward, and forward. Also, the superior wall or the roof of the maxillary sinus still forms the orbital floor. The posterior wall is limited by the maxillary tuberosity, while the anterior wall is excavated by the canine fossa. The depth of the canine fossa and the size of the maxillary sinus are inversely proportional. Sometimes, sickle-like osseous crests can be found at the floor or the lateral wall of the sinus, dividing it into several compartments. Presence of such septa can interfere during extraction of residual roots lost into the sinus. When the maxillary sinus has medium size, its floor is at the level of the nasal floor or just below it.

The medial wall of the maxillary sinus, which divides the sinus from the nasal fossa, has in general a slight concavity toward the sinus. This wall has a double mucosal layer at the anterior and posterior apertures, as well as forward and backward of the palatal surface.

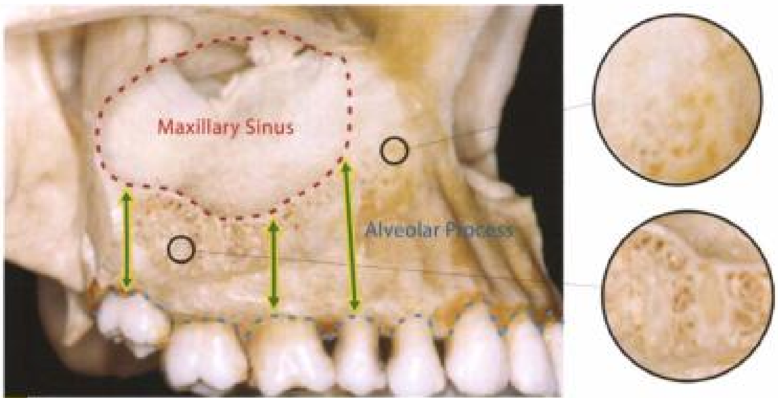
At birth, the maxillary sinus is the size of a pea. With development, it expands and occupies the entire maxillary cavity. In young adults, the sinus extends anterior and posterior from the distal part of the upper canine to the third molar region. Following a superior- inferior path, it extends from the floor of the orbital cavity to the root apex of the posterior teeth. The size and shape of the maxillary sinus varies greatly. The sinus expansion results first in the thinning of its walls and later in the creation of small or large recesses. The smaller of these expansions can be found at the posterior-superior angle, sometimes invading the orbital apophysis of the palatal bone.

The inferior expansion of the maxillary sinus to the alveolar bone results in a close relationship between the sinus and the roots of superior teeth. In extreme cases, the si-

1. Vestibular alveolar process
2. Palatine alveolar process
3. Inter-radicular septum.

2.23

Fig. 2.23 – Axial view. Observe at the second molar region prominent dental roots at the floor of the maxillary sinus.



2.24

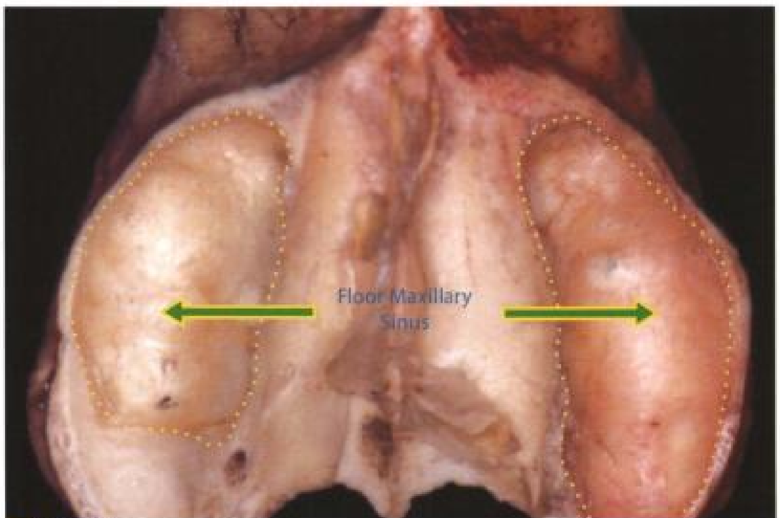
Fig. 2.24 – Maxillary lateral view. Localization of the osseous cavity that houses the maxillary sinus. Note variations on bone quality, as well as the height of the alveolar process in the presence of teeth.

nus expands to the bone between the roots (Fig. 2.23 and 2.24). Bone above the root apices can be absent and, in this situation, the periapical tissue contacts sinus membrane. Implications of this scenario are obvious.

Sinus expansion also can remove the bone walls involving the narrower canals that conduct alveolar nerves, the anterior and posterior walls of the sinus, including the infra-orbital canal wall during nasal infections.

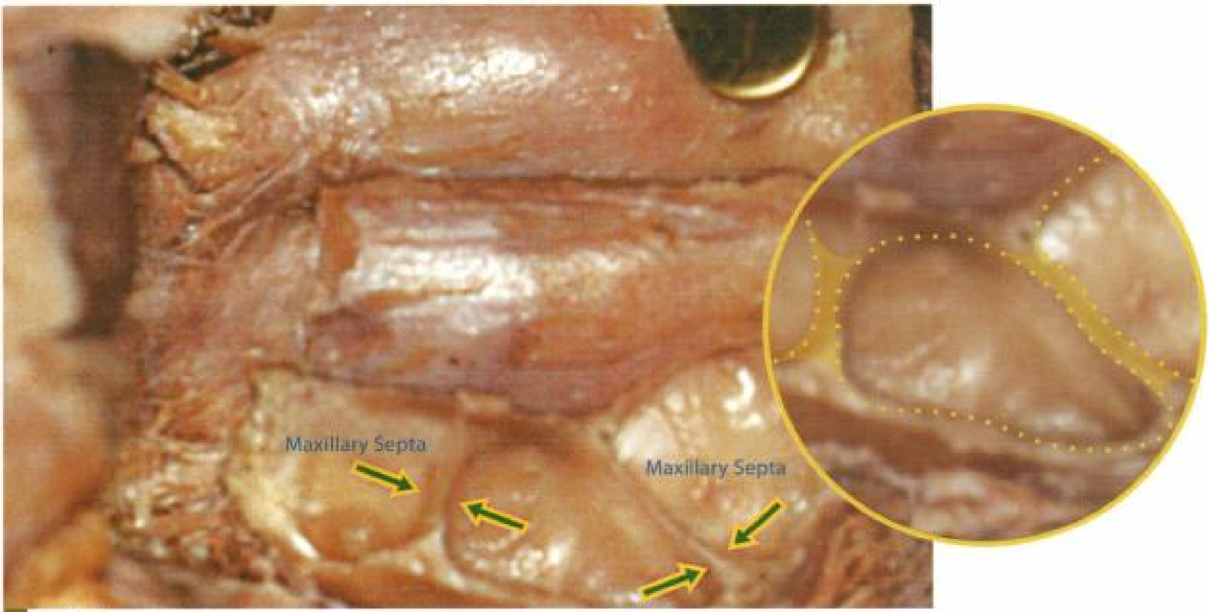
Both right and left sinuses have no symmetry, with sometimes well developed and atrophied situations (Fig. 2.25 and 2.26).

After tooth loss, the sinus can expand to regions where part of the mechanical functions is negligible. Such prolongations are explained because they represent a "replacement" of bone with little functionality.



2.25

Fig. 2.25 – Sinus cavities – superior view. Asymmetry of both sides is evident.



2.26

Fig. 2.26 – Maxillary sinus – superior view. Observe distribution of maxillary septa.

MUSCLES RELATED TO DENTISTRY

Masticatory muscles

The masticatory muscles are: temporal, masseter, medial pterygoid, and lateral pterygoid.

Masseter

It is the most powerful masticatory muscle. It originates at the zygomatic arch and inserts at the mandibular angle. When contracted, it elevates and closes the mandibular bone.

Temporalis

It originates at the temporal fossa, with fibers divided in anterior and posterior portions. The anterior fibers run vertically and the posterior horizontally, both attached to the coronoid process of the mandible. Sometimes, they can insert at the anterior border of mandibular ramus. Also, it is a closing muscle.

Medial pterygoid

It has two origins, with the deep head arising from the medial surface of the lateral pterygoid plate and the superficial head originating from the maxillary tuberosity and the pyramidal process of the palatine bone. The fibers run in a vertical, posterior and laterally direction, to insert along the medial surface of the mandibular angle. The medial pterygoid is responsible for pull and mandibular closure.

Lateral pterygoid

This muscle has two origins: the inferior portion originates at outer surface of the lateral pterygoid plate and the superior portion at the infratemporal surface of the greater wing of sphenoid. Its fibers run in a horizontal and posterior direction, with some fibers attached to the temporomandibular capsule and at the anterior region of the articular disk. The main fibers insert anterior and mesially to the condylar neck. This muscle is responsible for mandibular protrusion and depression during disc movement.

Hyoid muscles

These are responsible for mandibular retrusion and mouth opening. According to their location, those attached from the mandible to the hyoid bone are named suprahyoid, whereas those from the hyoid to the clavicle and sternum are called the infrahyoid muscles.

Suprahyoid muscles

Digastric muscle

It originates at the mastoid process (retroauricular region), inserts anteriorly at the hyoid bone and posteriorly to the digastric fossa. Responsible for mandibular retrusive movement, the anterior belly is supplied by the mandibular division of the trigeminal nerve, whereas the posterior belly receives stimuli from the facial nerve.

Mylohyoid muscle

The mylohyoid muscle represents the floor of the mouth, originating from the mylohyoid line of the mandibular bone to attach at the hyoid bone. It depresses the mandible and elevates de hyoid. It receives innervation both from the mandibular division of the trigeminal nerve and the inferior alveolar nerve.

Geniohyoid muscle

It originates form the mental spine, and inserts mesially at the hyoid bone. It is also responsible for mandibular depression and elevation of hyoid bone. Also, the geniohyoid muscle is supplied by the lingual artery and innervated by the cervical nerve.

Stylohyoid muscle

It has its origins at the stylohyoid process and inserts at the posterior region of the hyoid bone. The stylohyoid moves the hyoid bone upward and backwards. It is supplied by facial and occipital arteries and innervated by the facial nerve.

Infrahyoid muscles

Homohyoid muscle

This muscle has two bellies divided by tendons. One originates from the superior border of the scapula and the other at the hyoid bone. Both parts join below the sternocleidomastoid muscle. During muscular contraction, they pull the hyoid bone downwards. This muscle is supplied by lingual and superior tireoid arteries, as well as the second and third cervical nerves.

Sternohyoid muscle

It originates from the upper and posterior part of the manubrium sterni and is inserted at the frontal part of the hyoid bone. It also pulls down the hyoid. It is supplied by lingual and superior thyroid arteries, as well as the second and third cervical nerves.

Sternothyroid muscle

It originates from the superior part of the sternum and inserts at thyroid cartilage of the larynx. When contracted, it brings down the larynx. This muscle is supplied by superior thyroid artery, as well as the second and third cervical nerves.

Thyroid muscle

It originates at the oblique line of lateral region of the thyroid cartilage and inserts at the hyoid bone. The hyoid is depressed when this muscle is contracted. It is supplied by the first cervical nerve and superior thyroid artery.

FACIAL MUSCLES: FACIAL MIMICS

Oral region

The muscles comprising the circumoral region influence facial expression and mastication (Figs. 2.27 and 2.28). These are:

- *Orbicular oris*

It is located at the labial region, inserted at the anterior nasal spine and at the midline below the chin. All muscles around the labial area have intertwined fibers.

- Levator labii superior

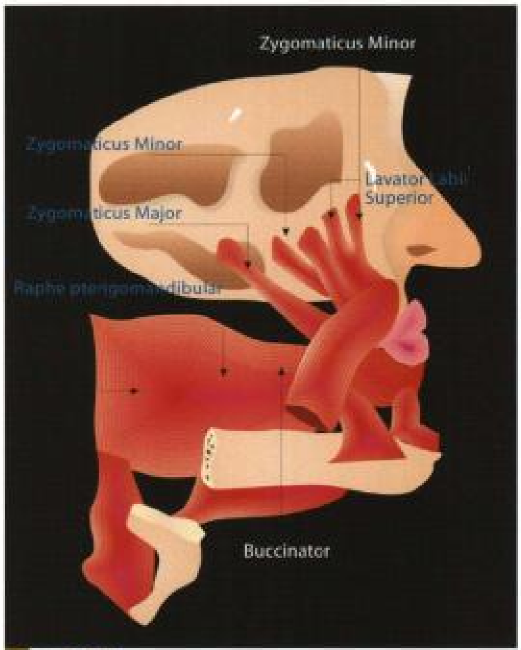
It elevates the upper lip. Its origin is near the inferior orbital margin. These muscular fibers run down and insert at the muscular fibers of the orbicular oris.

- *Zygomaticus minor*

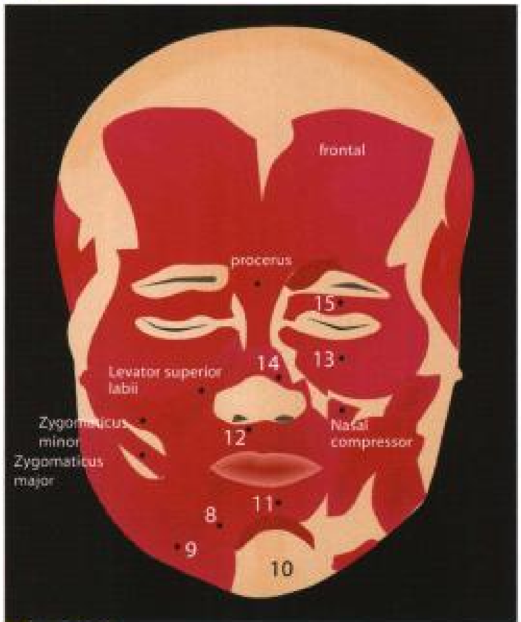
It is a small muscle that originates from the zygomatic bone. These fibers run down and insert at the orbicular oris, lateral to the levator labii superior. The zygomaticus minus is a poorly- developed muscle.

- *Zygomaticus major*

It originates lateral to the zygomaticus minor, at the most prominent portion of the zygoma. These



2.27



8. Inferior Depressor Labii
9. Angular Depressor
10. Mental
11. Orbicular Oris
12. Nasal Dilator
13. Lavator Angular Oris
14. Nasal Compressor
15. Orbicular (eyelid portion, ocular portion)

2.28

Fig. 2.27 and Fig.2.28 – Muscles of facial expression.

fibers run down to insert at the orbicular oris. It elevates the corner of the mouth, as in the smile.

- *Levator angular oris*

It can be found above the levator labii superior, zygomaticus minor, and zygomatic major. It orginates from the maxilla just below the infra-orbital foramen. Its fibers run down laterally to mix with the orbicular oris. It elevates the corner of the mouth toward the midline.

- *Depressor labii inferior*

It originates near to the buccal angle and below the inferior border of the mandible. Its fibers run in a superior and medial direction, inserting at the orbicular oris in the lower lip. It brings the lower lip down.

- *Depressor angular oris*

This muscle has the same origin of the depressor labii inferior. Its fibers superimpose and inserts at the orbicular oris, the corner of the mouth, bringing down the lower lip. Some of these fibers appear to be an extension of the platysma muscle.

- *Mental*

It originates at the inferior part of the mandible, just below the lateral incisors. Its fibers run down to cross the midline, inserting at the chin. Once contracted, it brings the chin down.

- *Buccinator*

It is the most important of the facial muscles in the oral cavity. Although it is a facial expression muscle, it also participates in masticatory function. It originates from the pterygomandibular raphe, beginning at the pterygoid hamulus, in the inferior portion of the medial pterygoid muscle, below the mesial surface of the mandible, and near to the posterior border of the mylohyoid line. It also originates from the maxillary alveolar bone, at the molar region. Its fibers run laterally to insert at the orbicular oris. When activated, it pulls backward the corners of the mouth, at the cheek region.

- *Risorius*

It is a small muscle originating from the soft tissue near to the mandibular angle. Its fibers run toward the buccinator muscle and inserts at the corner of the mouth. It also appears to be the posterior extension of platysma muscular fibers. This muscle helps during the smile.

Auricular region

- *Anterior auricular muscle*

It originates from the connective tissue of the scalp at the anterior auricular region. This muscle pulls the ear forwards.

- *Superior auricular muscle*

It originates from the connective tissue of the scalp with fibers inserting at the posterior auricular region.

- *Posterior auricular muscle*

It originates from the nucal superior line, occipital and mastoid areas. These fibers insert at the posterior auricular region and pull the ear backwards.

- *Scalp*

These muscles have anterior- posterior mobility.

- *Occipital*

Its group of muscular fibers originates at the connective tissue of the scalp.

Cervical region

- *Platisma*

Its most superior fibers insert at the inferior border of the mandible, near to the corner of the mouth.

They run beneath the cervical skin and terminate near to the clavicle.

Ocular region

- *Orbicularis oculi*

It is divided in two parts, around the eyes (orbital), which inserts into the cranium, lateral portion of the eye and mesial to the orbits. These fibers squeeze the eyelids, closing the eyes. The other part has its origin in the posterior border of the orbit and inserts at the most superior palpebral area (levator eyelid muscle). The orbicularis oculi is supplied by the occulomotor nerve, being considered an orbital muscle because is not innerved by the facial nerve.

- *Corrugator*

It extends from the nasal crest and laterally to the eyebrow region.

- *Procerus*

From the nasal crest, its fibers elevate to the middle region of the eyebrow, pulling it mesial and downwards.

Nasal region

- *Dilator nasis*

It pulls the nostrils down.

- *Compressor naris*

It closes the nostrils through compression.

Oral cavity – blood supply

It rises from two branches of the external carotid artery. The facial and maxillary arteries are responsible by the blood supply of the jaws, along with facial and maxillary veins (Fig. 2.29).

2.29

1. Mandible
2. Maxillary artery
3. Inferior alveolar nerve
4. Lingual nerve
5. Mylohyoid nerve
6. Lingual artery
7. External carotid artery
8. Superficial temporal artery
9. Common carotid artery
10. Facial vein
11. Deep temporal artery

Fig. 2.29 – Facial lateral dissection. Blood supply.

Facial artery

It emerges from the inferior border of the mandible, between this bone and the submandibular artery. It runs directly by the inferior border of the mandible before it reaches the outer surface, providing the submental artery that supplies the mental tubercle. Before it reaches the corner of the mouth, the facial artery gives the labial artery, which runs medially at the lower lip and anastomosis at the other side.

The superior labial artery, another branch of the facial artery, runs to the upper lip and anastomoses with its correspondent at the other side. After, the facial artery continues laterally to the nose until reach the medial canthus of the eye. Then, it becames the angular artery. The angular artery then joins the terminal branch of the oftalmic artery. However, in some individuals, the angular artery is to small, almost negligible.

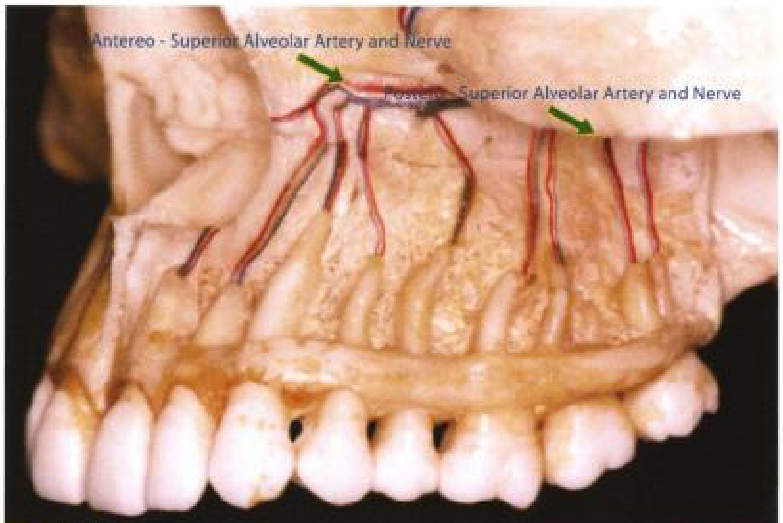
Maxillary artery

It is one of the branches of the external carotid artery, at the posterior border of the mandibular ramus, running forward medially and horizontally, below the mandibular notch. The maxillary artery has several branches.

Near its origin, there is the small auricular artery, which supplies the temporomandibular joint (TMJ) and the external acoustic meatus. Anteriorly, the maxillary artery gives rise to two long ramifications: the median and the inferior alveolar arteries.

When the maxillary artery reaches the inferior border of the lateral pterygoid muscle, it originates the masseteric branch. After, it gives origin to the temporal and buccal arteries. Now, the maxillary artery passes at the depth of the pterygomaxillary fossa, where it originates the posterior superior alveolar artery, that runs inferiorly over the posterior maxillary surface and enter through the foramina, in front of the alveolar process, supplying the posterior superior teeth.

Other terminal branches of the maxillary artery (Fig.2.30) are the thin vessels of the pterygoid canal and of the pharynx branch. The palatal descending artery is the largest of the palatal arteries. The sphenopalatine artery runs medially to the pterygopalatine fossa towards the nasal cavity.



2.30

Fig. 2.30 – Maxillar lateral view. Observe the maxillary artery and its branches. (Antero-superior alveolar artery and nerve, Postero-superior alveolar artery and nerve).

Facial vein

At the highest point of the facial vein, the angular vein begins adjacent to its arterial counterpart. As the vein runs down, it receives drainage from the superior labial veins. The deep facial artery also supplies the buccinators muscle, which emerges from the mandibular branch adjacent to the buccal artery, and from the buccal branch of the mandibular nerve. The facial vein also receives final drainage from the infra-orbital vein. Finally, the facial vein is supplied by the submental vein, finally reaching the internal jugular vein.

Maxillary vein

Numerous branches drain to the maxillary vein, as the inferior oftalmic, middle meningeal, the pterygoid plexus, as well as the superior and inferior alveolar veins. All these branches follow the same trajectories of their arterial correspondents. The maxillary vein forms the retromandibular component, which runs posteriorly to the mandibular ramus, and divides in posterior and anterior branches before reaching the mandibular angle. The posterior branch joins the posterior auricular vein to form the external jugular vein, while the anterior branch joins the facial component, opening at the internal jugular vein.

Oral cavity - innervation

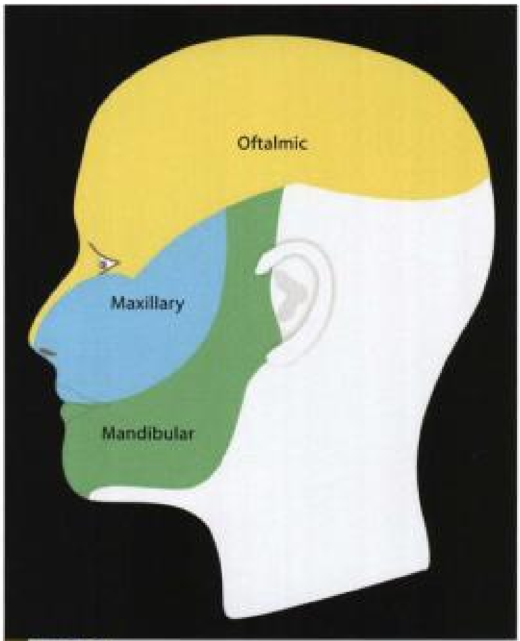
The trigeminal nerve (V) provides sensitive (to the mucous skin and internal structures of the cranium) and motor (masticatory muscles) fibers.

It divides in three branches, namely ophthalmic (V1), maxillary (V2) and mandibular (V3) nerves (Fig. 2.31). The ophthalmic nerve carries only sensitive information and supplies the upper eyelid, nasal dorsum, superior lateral nasal area, scalp and frontal parts posteriorly until the intra-auricular line.

The maxillary nerve (V2) also carries sensitive information to the facial middle portion, lower eyelid, ala of the nose, upper lip, nasopharyngeal mucosa, maxillary sinus and adjacent skin, soft palate, tongue and floor of the mouth, superior mucosa and teeth.

The cutaneous branches of the maxillary nerve are: infra-orbital, which emerges at the infra-orbital foramen, runs superiorly to the ala of the nose, upper lip and lower eyelid; the facial zygomatic, which emerges from the zygomatic foramen, supplying the adjacent skin and the correspondent bone; the temporal zygomatico, which emerges from the same foramen, supplying the skin of the temporal region.

The mandibular nerve (V3) provides sensitive and motor information, with the sensitive branches running 5 to 10 mm apart of the motor components. The sensitive aspect have three branches: the first comprehends the buccal nerve and the lingual nerve, supplying the oral mucosa; the second (inferior alveolar nerve) supplies the lower teeth, skin and lower lip mucosa, as well as the mental skin; finally, the third (auriculotemporal) supplies the outer face (posterior cheeks and posterior temporal region), extending inside the auditory apparatus. On the other hand, the motor fibers comprehend the masseteric, the anterior, deep, and posterior temporalis, as well as the medial and lateral pterygoid nerves.

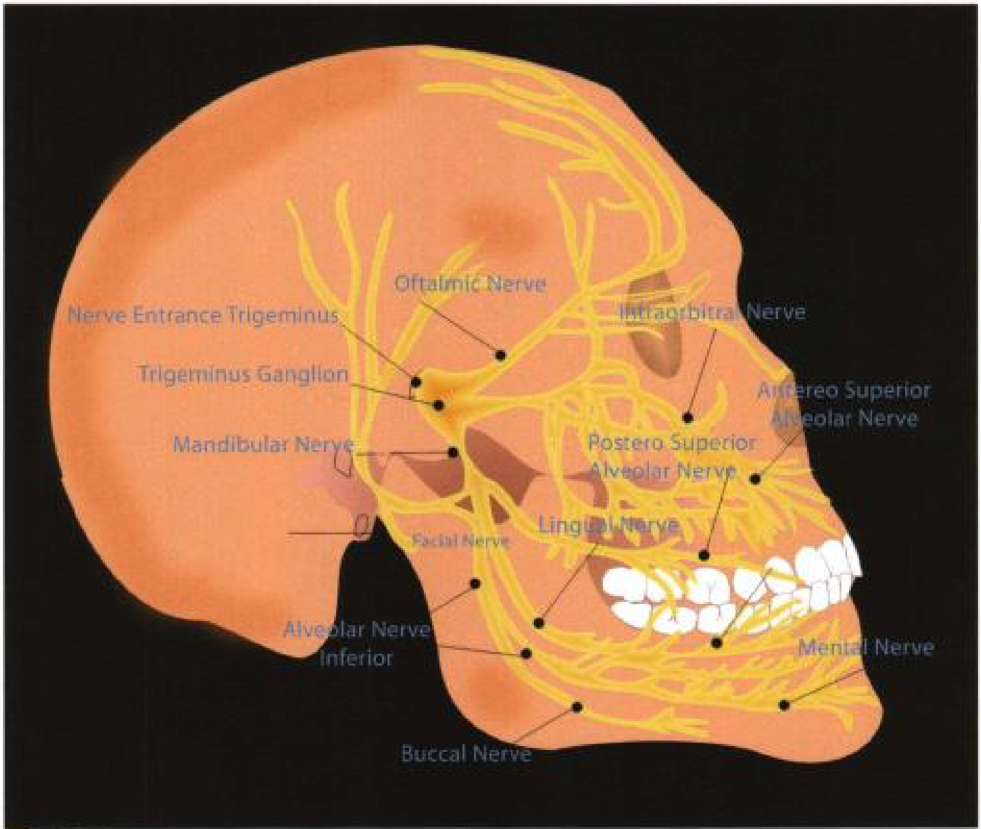


2.31

Fig. 2.31 – Trigeminal nerve (V). Oftalmic (V1), Maxillary (V2), and Mandibular (V3) regions.

Facial nerve

It emerges from the cranium through the stylomastoid foramen, between the mastoid and styloid processes of the temporal bone. Also, it runs straight into the parotid gland. However, it runs superficially on the parotid gland before split into five terminal branches: temporal, zygomatic, buccal, mandibular marginal and cervical nerves (Fig. 2.32).



2.32

Fig. 2.32 – Facial nerve distribution – lateral view.

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3

PERIODONT
TISSUES

José Bernardes das Neves


4
1
5
3
2
6

Periodontal Tissues

INTRODUCTION

The periodontium is composed of gingival tissue, periodontal ligament and the alveolar bone (maxillary alveolar bone process) and cementum. It develops during tooth eruption and its integrity is maintained by balanced occlusal forces. The alveolar process diminishes gradually as soon as teeth are lost.

The tissue that covers the alveolar process and that circumvents the cervical portion of teeth is called gingiva. It protects the subjacent periodontium, especially the alveolar process. The periodontal ligament is a fibrous connective tissue which inserts on one side to the radicular cementum, and to the alveolar bone on the other side. Mature collagen fibers are the principal component of the periodontal ligament; they serve as a cushion layer against occlusal forces transmitted to the bone. The alveolar bone houses the teeth through the periodontal ligament. The cementum is a hard tissue that covers the radicular surfaces. Finally, the Sharpey fibers can be found between the cementum and periodontal ligament.[1]

The dentogingival complex is formed by hard (teeth, cementum, and alveolar bone) and soft tissues (periodontal ligament, gingival and alveolar mucosa). It has the primary functions of mastication, swallowing and speech, proprioception, facial musculature support, and related self-steam.

The periodontal tissues are organized to execute the following functions:

- attach the teeth to their alveolar sockets;
- support and dissipate forces generated during mastication, swallowing and speech;
- form a barrier against noxious substances found in the oral cavity;
- constant rem odeling due to wear and aging;

GENERAL ASPECTS OF GINGIVAL TISSUES

The oral cavity is lined by a mucous tissue that extends anteriorly to the labial skin and posteriorly to the soft palate and pharyngeal regions. The oral mucosa has three components: the masticatory (keratinized) mucosa covering the hard palate and the alveolar bone, the specialized (sensory) mucosa that comprises the dorsum of the tongue, and the lining (reflecting) mucosa that involves the rest of the oral cavity. The portion of the oral mucosa that covers the alveolar bone and attaches to the cervical portion of teeth is called gingiva. The healthy gingival tissue is pink, stippled, free of fluid exudates and bacterial plaque. The gingival margin has a knife-edge configuration at the cervical aspect of dental crowns.

Histological analyses reveal that healthy epithelium and connective tissues are free of inflammatory cells, although some neutrophils can be found into the inner gingival epithelium. The underlying connective tissue is composed by dense collagen fibers attached to the basal membrane.

The gingival tissue can be divided in three regions: the marginal gingiva, which extends from the most coronal aspect of the gingiva to the free gingival groove; the interdental gingiva, which fills the area between adjacent teeth; and the attached gingiva, which extends from the level of the epithelial attachment to the junction between gingival and alveolar mucosa. At the palatal aspect, there is no demarcation line between attached gingival and palatal mucosa (Fig. 3.1).

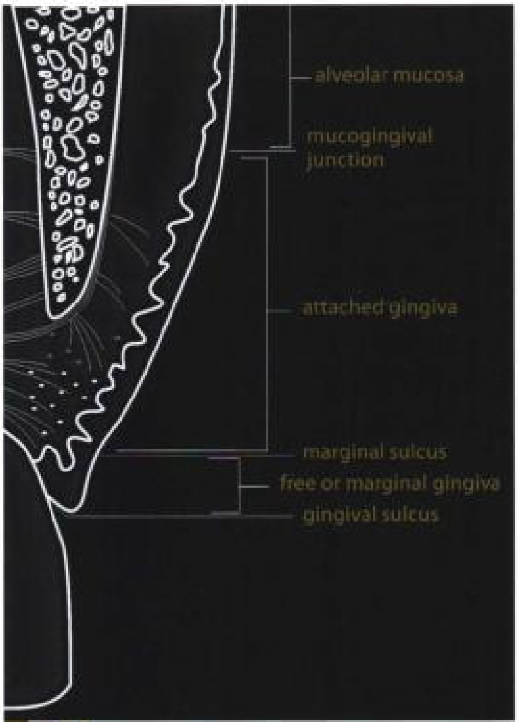
The marginal and the interdental gingiva are special since they constitute the junction between dental crown and the soft tissue, and the site of gingival and periodontal inflammatory diseases as well. The buccal (vestibular) and palatal (lingual) aspects of the marginal gingiva are 0.5 to 2.0 mm thick and follow the scalloped course of the cemento-enamel junctions (Fig. 3.2).

The oral gingival component is keratinized and delimitated by the convex contours of cervical portions. The mesio-distal, mesio-lingual, disto-bucal and disto-lingual transition line angles, along with the interden-

1. Gingival sulcus
2. Gingival margin
3. Attached gingiva
4. Mucogingival line
5. Stippled aspect
6. Alveolar mucosa

3.1

Fig. 3.1 – Health gingival tissue in young adults. Observe the mucogingival line between the attached gingival and the alveolar mucosa.



3.2

Fig. 3.2 – Schematic drawing showing anatomical landmarks in the gingival tissue.

3.3

Fig. 3.3 – The "col" area represented in the molar, pre molar and canine.

tal contact areas, determine the form and extension of interdental papillae. In the anterior tooth segment, the papilla generally is keratinized and assumes a conic or triangular configuration. On the other hand, the papillary apex is flattened and smooth bucco-lingually at the pre-molar and molar regions. This finding is known as the col area, being also determined by the width and the level of contact point between adjacent teeth. In general, the larger the width and depth of col regions, the larger the bucco-lingual dimensions of posterior teeth. Besides, this is a non-keratinized surface and can be susceptible to harmful stimulus, such as dento-bacterial plaque (Fig. 3.3).

The marginal gingiva attaches to the tooth surface and its slightly, rounded-edge forms the soft lateral wall of the gingival sulcus. The tissues that comprise the marginal gingiva include the oral sulcular epithelium, the junctional epithelium[3], and the underlying connective tissues. The marginal gingiva and the coronal portion of the interdental papilla do not attach to the bone, but are joined to the tooth surface by at the junctional epithelium.

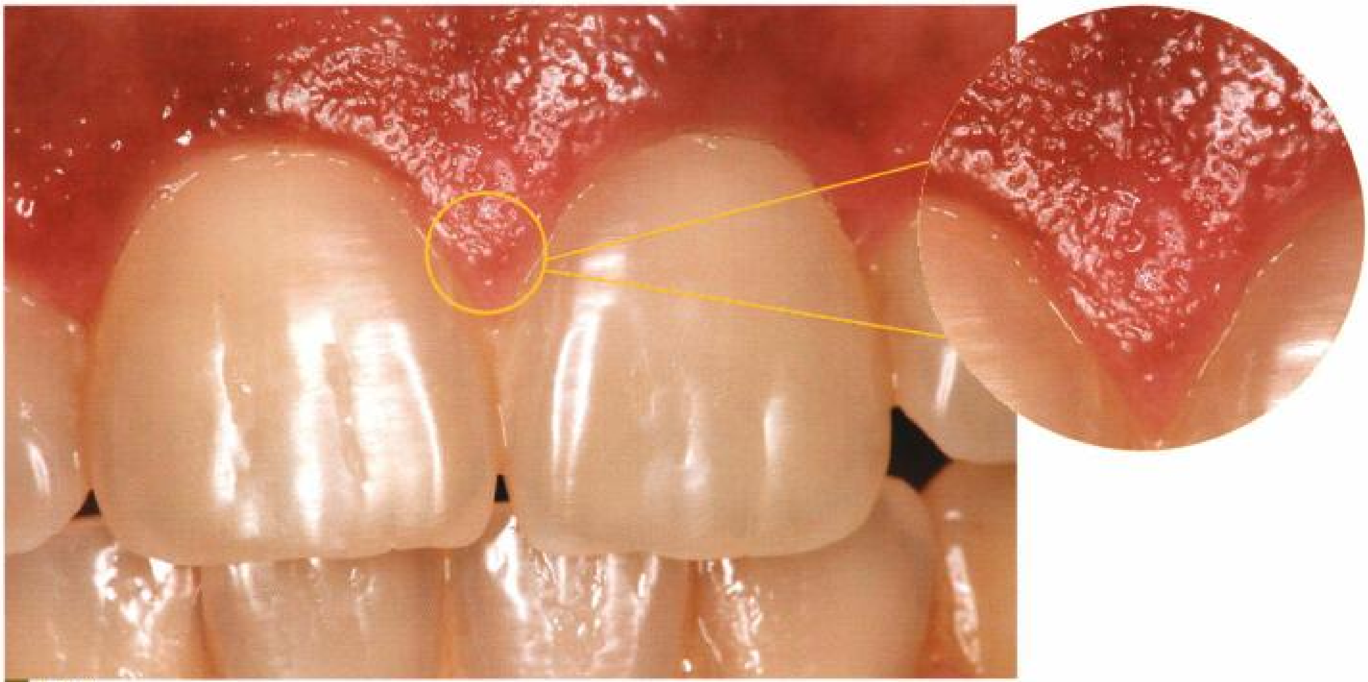
The marginal gingiva is 0.5 to 2.0mm coronal to the cemento-enamel junction, forming a cuff separated by the gingival sulcus[1]. A healthy gingival sulcus rarely exceeds 2.5mm in depth (Fig. 3.4).

Gingival sulcus

The gingival crevice or sulcus is a shallow space limited by the dental surface and the epithelial lining of the free gingiva. Also, it has a V-shape depression that allows periodontal probe to penetrate without resistance. Mean clinical probing depths of gingival sulcus are around of 1.8mm, ranging from 0 to 6mm.[5] Other studies have related values of 2.0mm, 1.5mm and 0.69mm [6], while Gottlieb[7] considers ideal sulcus depth near zero.

Oral epithelium

It has been described as a stratified, squamous epithelium com-



3.4

Fig. 3.4 – Observe papillary tissue format (pyramidal) in the anterior region and the stippled aspect of gingival tissue.

posed of four distinct layers: basal, spinous, granular, and corneal. The oral epithelium provides lining and protection: the thicker the tissue, the higher its barrier properties.

First, it is important to note that some gingival regions have different functions being the epithelium already adapted to them.

The basal layer is responsible for epithelial cell renewing and thus, must be present in all regions. The spinous layer is found between the basal and the outer layers, not being present only at the apical area of juncional epithelium. On the other hand, the outer most layers have more desmosomal junctions and few spaces between cells, which results in less nutrition from the connective tissue. Also, reduced metabolism at the cell nucleus is verified.

The cells in the granular layer are closely united and form granules to the keratinization at the epithelium surface, representing an increase in its protective function.[8]

Sulcular epithelium

The sulcular epithelium is an extension of the oral epithelium that surrounds the gingival margin to cover the gingival sulcus. Its most coronal limit is the height of the gingival margin, with the apical portion in the beginning of the junctional epithelium. All epidermal layers described above can be found at the sulcular epithelium, but a keratinized layer does not developed there. It is claimed that the lack of keratinization at the gingival sulcus compromises the host response to pathogenic microorganisms and their byproducts.

The sulcular epithelium is formed by cube-shaped keratinized cells, while the junctional epithelium comprises a non-keratinized tissue. It is in closer contact with the dental surface and presents a sparse basal membrane. The contact between basal cells and the dental surface is determined by the lamina densa, which faces the teeth via desmosomes and glycoproteins, and the connective tissue via collagen fibrils.[4]

Junctional epithelium

This is the only portion of the gingival epithelium attached to the dental surface. Also, the junctional epithelium is structurally different from the oral and sulcular epithelium.

Approximately 15-20 cells layers can be found at the most coronal part of the junctional epithelium, which narrows to a cell monolayer at its apical portion. Differences found in the junctional epithelium are due to localization and functions. It has only the basal and the first three suprabasal layers, thus providing cellular migration and renewal. Its most superficial cells are flat and parallel to the dental surface, showing an interface similar to a basal membrane, where hemidesmosomes can be found. Although it has cells with more intercellular volume, the intercellular space is wider and the number of desmosomes is lower, which results in a more permeable and less resistant tissue. The junctional portion is responsible for the anchorage of the epithelium to the dental surface and can be found either in the crown or in the root. Also, enamel, dentin or cementum provide insertion to the junctional epithelium, regardless of the level of therapy provided or the developmental conditions found.

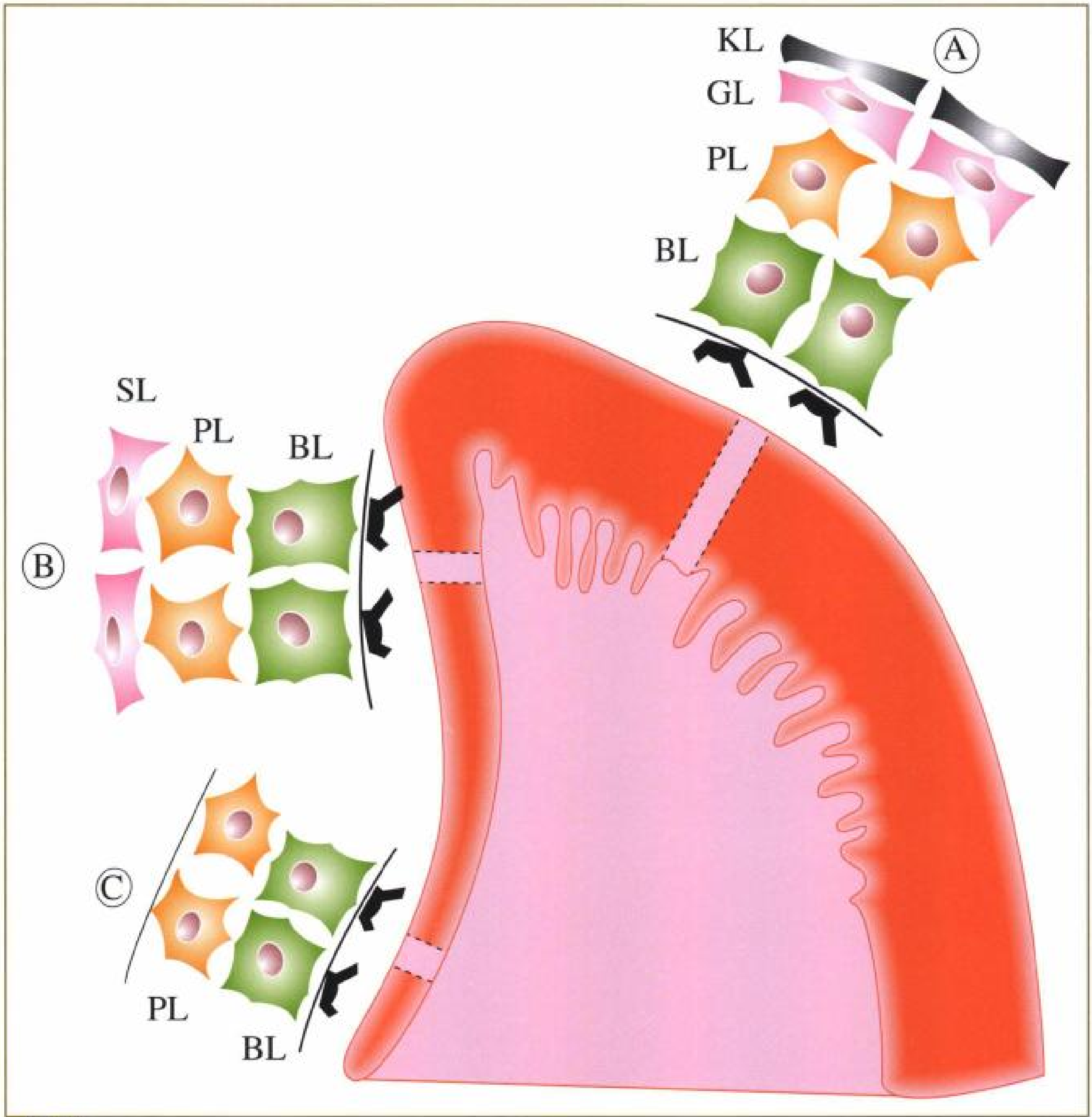
As in the oral and sulcular epithelium, the junctional epithelium is renewed through cellular divisions occurring at the basal layer: cells migrate toward the sulcus depth, where other cells exfoliate. The junctional epithelium adheres to the enamel tissue by hemidesmosomes. (Fig. 3.5).

Alveolar mucosa

The alveolar mucosa joins the attached gingiva to the mucogingival junction and continues with the other oral soft tissues. The epithelium has a smooth, thin and non-keratinized layer poorly adhered to the alveolar bone. On the other hand, the attached gingiva is firmly keratinized and covered by a stratified epithelial layer. The scalloped pattern that characterizes the gingival surface represents epithelial projections toward the connective tissue that covers the alveolar bone.

Gingival tissue has a pinky appearance with intermingled pigments, depending on the skin color. A person with a dark skin color has melanin pigments in the gingival area. The gingiva is attached to the teeth by collagen fibers produced via fibroblasts. All gingival fibers embedded in the cementum are known as Sharpey fibers. They run from the cementum area to the papillary interdental tissue.

The blood supply is provided by supraperiosteal vessels. The gingiva



3.5

Fig. 3.5 – the three major types of epithelial organization within the gingival epithelium.

A – The four layers characteristic of orthoceratinized gingiva are seen. These include cuboidal cells of the basal layer (BL), spinous layer (PL), granular layer (GL) with flattened cells containing keratohyaline granules, and a keratinized layer (KL) with flattened cells packed with keratin filaments. When dark nuclei are present in the KL, the epithelium is termed parakeratinized. When no nuclei can be seen in the KL, the epithelium is "orthokeratinized".

B – nonkeratinized epithelium. Although a BL and PL are still present, the cells in the more superficial layers (SL) are not as flat as the parakeratinized or orthokeratinized epithelium, contain fewer keratin filaments, and still have nuclei.

C – junctional epithelium. Only two layers are seen: a BL and a PL. The cells of the most SL of the PL attach to the tooth in part through hemidesmosomes. Note that in all types of epithelium (A, B, and C), the basal layer is anchored to the underlying connective tissue through hemidesmosomes, wich interdigitate with anchoring collagen fibrils extending from the connective tissue. (Adapted from Rose LF et al.[16])

is rich in capillary vascularization (Fig. 3.6).

Gingival connective tissue

The gingival connective tissues are highly organized and provide the necessary tonus to the free and attached gingiva, as well as to the hard/soft tissue interface. Collagen fibers, vessels and fibroblasts are the main components observed.

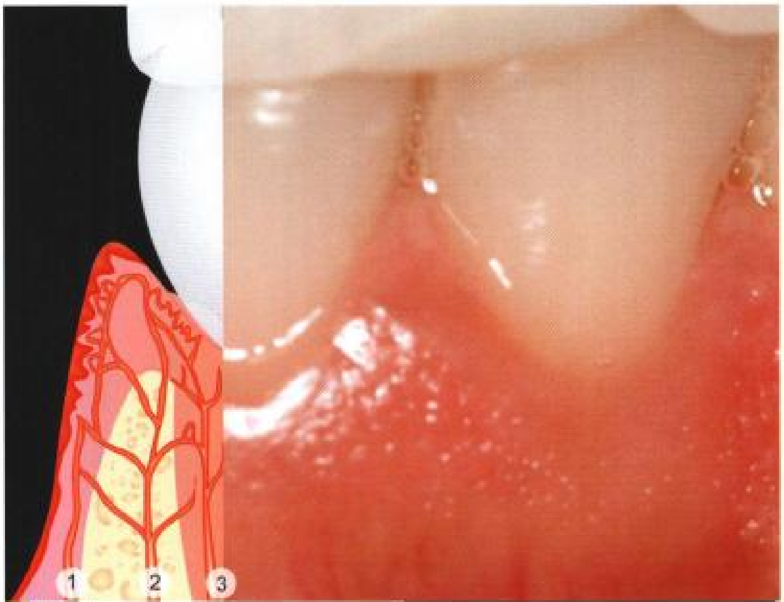
Gingival architecture

The gingival blood supply arises from three sources (Fig. 3.7): first, from the posterior-superior and posterior-inferior alveolar arteries, that supply the teeth. Branches of these vessels perforate the interdental bone area at the apical part, running toward the crowns and exit at the cortical plates to provide nourishment to the marginal and attached gingiva. Other vessels enter the marginal gingiva from the periodontal ligament. An additional blood supply from the periosteal branches of the lingual, buccinator, mental, and palatal arteries perforate the gingival at the vestibular fornix, floor of the mouth, and the palate region. This secondary source is enough to provide success during periodontal flap surgery. Several anastomoses can be found from both sources. Veins and limphatic vessels follow a similar course, and the gingival limphatic drainage is made through the submental and cervical lymph nodes. Sensory fibers from the connective tissue innervate the gingival epithelial layer. Meissner and Krause's specialized nerve endings can be found within the connective tissue layers.

There is a specialized zone of connective tissue just beneath the basal lamina of the junctional epithelium,

3.6

Fig. 3.6 – Compared to the gingival tissue, the alveolar mucosa is a mobile, more red and smooth tissue.



3.7

Fig. 3.7 – Periodontal vascularization. The numbers indicate the origins of blood supply to the hard and soft tissues.

1 – Supraperiosteal arterioles along buccal and lingual surfaces provide branches to the gingival sulcus. Some branches perforate the bone to reach the periodontal ligament.

2 – Longitudinal vessels of the periodontal ligament irrigate the col area anastomose with the capillary vessels at the sulcus area.

3 - Arterioles perforate through the interdental septa and run to the osseous crest to anastomose with vessels of the periodontal ligament and of the sulcus area, together with another vessels along the osseous crest.).

similar to the lamina propria, rich in cells and poor in collagen bundles but with a noteworthy zone of anastomosis called gingival plexus. Still, there are numerous macrophages and mononuclear cells important to the host response.

Gingival fibers

The collagen found in the connective tissues is organized in fiber bundles. These have been classically described according to its localization, origin, and insertion, such as the dentogingival, dentoperiosteal, alveologingival, circular, and transseptal fibers (Fig. 3.8A to C).

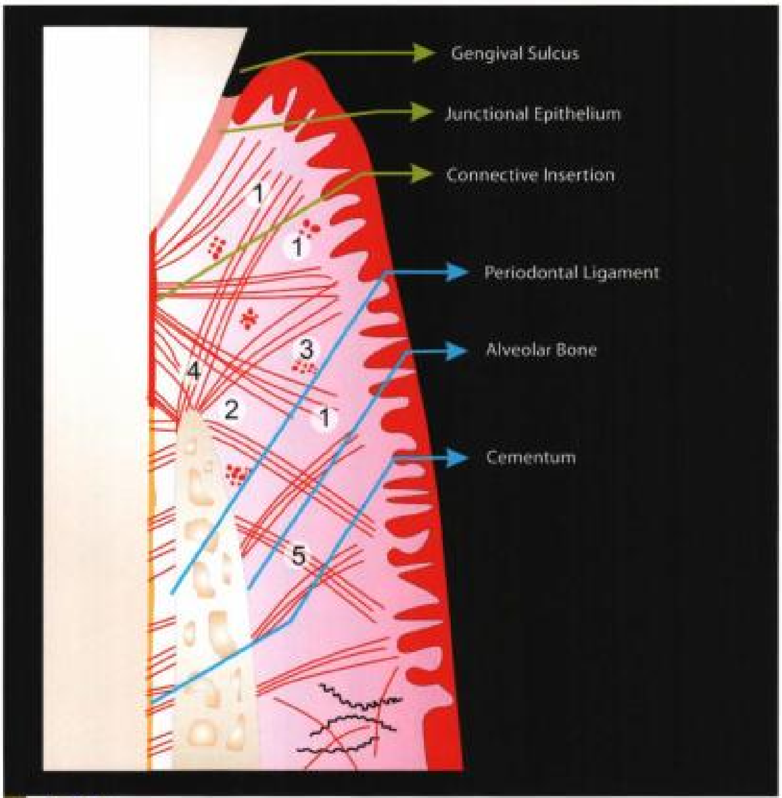
The dentogingival fibers come from the radicular cementum just apical to the junctional epithelium and near the cemento-enamel junction, finally spreading into the gingival tissue. Part of these fibers run towards the crown, subjacent to the junctional epithelium and end near the basal lamina of the gingival margin. Another group runs laterally, and a third group, the dentoperiosteal fibers, bend apically over the alveolar crest and attaches to the buccal and lingual sides of the periosteum. The alveololingual fibers emerge from the ridge of the crest and run a coronal direction towards the marginal and interdental gingival tissues. The circular fibers circumvent the cervical tooth crown region at the level of the marginal gingival margin. Additional groups of fibers have been shown in the gingiva of squirrel monkeys. The semi-circular fibers emerge from the proximal cementum, apical to the circular group, run across the marginal gingival margin of the buccal or lingual side and insert on the correspondent opposite side. The transgingival fibers begin at the cementum of the cemento-enamel junction and extend to the marginal gingival margin of the adjacent teeth, while the intergingival fibers extend between the buccal and lingual portions of adjacent teeth; the transgingival fibers have a cross-shape configuration at the lateral portion of the interdental osseous crest. These groups of fibers form the bulk of the free gingival connective tissue and are collectively known as the gingival ligament.

The transseptal fibers come from the cementum surface apical to the base of the epithelial attachment, cross the interdental area and insert at the correspondent region of the adjacent teeth. The transseptal fibers form an interdental ligament interconnecting all teeth in each arch. This ligament appears to be very important to maintain the integrity of the dental apparatus; once excised, it heals soon. When transseptal fibers are involved during the inflammatory disease, regeneration generally occurs at the apical level, with the interdental ligament being positioned more apically. Residual portions of the transseptal fibers are seen even in later stages of periodontal disease.

The anatomic relationships of gingival fibers can have a profound effect during the behavior of dentogingival pathologic situations. There is considerable interrelationship between the different gingival segments. Most of the fibrilar structure of the buccal, lingual, and marginal gingival portions arises from the radicular surface or from the adjacent gingival region. Thus, the homeostasis of gingival tissue depends on the health of the adjacent tooth structure. The presence of inflammation into the gingival sulcus of one tooth can lead to the rupture of the transgingival, intergingival or transsep-

Fig. 3.8A – Pathways of gingival fibers.

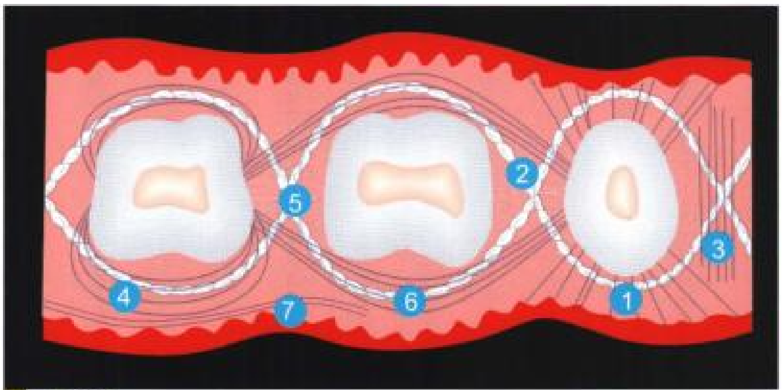
1. Dentogingival:
   - Coronal
   - Horizontal
   - Apical
2. Alveologingival.,
3. Circular, semi-circular,
4. Dentoperiosteal,
5. Periosteogingival.



3.8A

Fig. 3.8B – Gingival fibers: schematic horizontal representation of supralveolar collagen fibers.

1. Dentogingival:
   - coronal
   - horizontal
   - Apical
2. Transgingival
3. Interpapillary
4. Circular
   Semi-circular
5. Transseptal
6. Intercircular
7. Intergingival.



3.8B

Fig. 3.8C – Mesio-distal schematic representation of alveolar collagen fibers at the interdental area.

1. Transseptal
2. Interpapillary.

3.8C

tal fibers in the adjacent tooth. Similarly, tooth extraction can affect the periodontal state of remaining teeth. These anatomic aspects can help to explain the behavior of the gingival inflammatory disease and the harmful effects of this procedure over the periodontium and remaining teeth.

Cementum

The cementum is a mineralized mesenchymal tissue that covers the radicular portions of teeth. It warrants stability to the teeth through the collagen fibers inserted on it (Sharpey fibers). The cementum can compensate physiological tooth wear over the years through deposition of incremental layers.

Two types of cementum can be distinguished at the microscopic level: cellular and acelular cementum. Both are formed by cementoblast cells, but in the cellular type the cementoblasts become entrapped into the cementum matrix.

The acellular cement, which is more mineralized than its cellular counterpart, covers the radicular cervical third and sometimes extends over the entire root except at its apical portion. On the other hand, the cellular cementum covers the radicular apical portion and sometimes can extend above the cellular cementum. The cellular cementum is similar to the bone tissue.

The cellular cementum has parallel, intrinsic, and sparser, thinner Sharpey fibers than the acelular cementum, which represents the cementum pathway to the periodontal ligament.

The cemental apposition is continuous throughout life, with a non-mineralized layer of cementoblasts found at the superficial region. Changes in function and pressure exerted on teeth influence growth and development of cementum layers. While the alveolar bone is been constantly remodeled, the cementum is modified by physiological process, although in less frequency than the bone tissue. Cementum resorption can occur due to the lost of periodontal ligament and, during the reparation process, the bone becomes fused to the teeth, generating an ankylosis. The ankylosis can be found under conditions such as occlusal trauma, reimplanted or non-erupted teeth, and also after periapical chronic diseases.

The continuous cementum apposition allows the passive eruption and the mesial displacement of teeth. Reinsertion of new periodontal ligament fibers occurs at the cementum level.

PERIODONTAL LIGAMENT

The periodontal ligament is a soft connective tissue found between the cementum and the alveolar bone. It attaches teeth to the jaws by the Sharpey fibers at both sides.

Contrary to the other tissues, the periodontal ligament has an intense metabolic activity and the greatest repair potential of all tissues. It establishes connection between the gingival connective tissue and communicates with the medullary alveolar spaces through the vascular channels. It is formed by collagen fibers and cells.

The fibers of periodontal ligament are divided in the following types:

Alveolar crest fibers: fibers that run from the cervical area of teeth to the alveolar crest. They keep teeth in position opposing the apical fibers;

Oblique fibers: run obliquely from bone to the root apex. They can be found in greater numbers and withstand vertical loads, avoiding tooth intrusion;

Horizontal fibers: run horizontally from bone to the teeth. Are less numerous, but very strong. They can withstand lateral forces;

Apical fibers: run apically from bone to the teeth. They avoid tooth dislodgment to the apical region.

Inter-radicular fibers: can be found between the roots of bi or multirradicular teeth. It also avoids tooth intrusion (Fig. 3.9).

The shape and size of the roots help to dissipate occlusal forces at lateral and apical portions. Besides, the periodontal ligament fluid contains small blood and limphatic vessels.

The functions of periodontal ligament can be described as: physical, constitutional, nutritive and sensorial.[9,10]

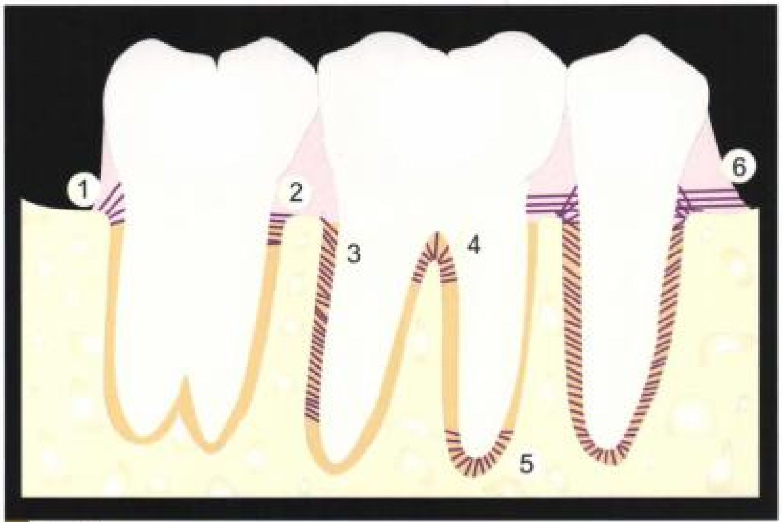
It is through the periodontal ligament that masticatory forces are transmitted to the bone, the cushioning of external forces is exerted, the tooth is attached to the bone, the cellular renewal occurs by fibroblasts, cementoblasts, and osteoblasts, as well as the nutritive and specialized sensory functions.

According to Parfitt[11], the resistance to occlusal forces in more related to the four systems of the periodontal ligament than in its principal fibers, which have a secondary effect in providing lateral support to teeth and avoiding ligament deformation under occlusal forces.

The four systems that resist to occlusal forces are:

Vascular system: acts like an impact absorber and still absorbs tensions of sudden and intense occlusal forces;

Hydrodynamic system: consists of tissular fluids and the liquid that runs through the smaller vessels to the surrounding area (alveolar foramen) withstanding axial forces;



3.9

Fig. 3.9 – Pathways of periodontal fibers

1. Crest fibers
2. Horizontal
3. Oblique
4. Interradicular
5. Apical
6. Transseptal.

Leveling system: controls vertical position of teeth into their alveolar sockets;

Resilient system: brings the tooth to its original position when occlusal forces are removed. It comprehends the fundamental substance and the fluid vessels found in the collagen fibers of the periodontal ligament.

The periodontal ligament provides nutrition to the cementum, bone and gingival tissues through blood vessels and also is responsible for the limphatic drainage. Its innervation gives proprioceptive and tactile sensitivity,[12] which detects and localizes external forces, and still has an important role in the neuromuscular mechanism that controls the masticatory apparatus.

As in all periodontal structures, the periodontal ligament undergoes constant remodeling.[9] The fibroblasts form collagen fibers and can also differentiate into osteoblasts and cementoblasts. Collagen formation increases with the eruption movement.[13]

The periodontal ligament is thinner in non-erupted and non-functional teeth. When the functional demand exceeds normal periodontal capacity, the number and the diameter of collagen fibers increases,[14] and the ligament becomes thicker.

On the other hand, the periodontal ligament thickness diminishes with aging. It is narrower at the middle portion of dental roots. Still, it serves as a link between the cementum and alveolar bone.

The cells of the periodontal ligament participate in the formation and resorption of these tissues, for example, in a physiological displacement, during tooth adaptation to occlusal forces, and wound healing. The alternate phases of apposition and resorption allow for the control of periodontal fibers according to forces imposed on teeth.

Alveolar bone

The alveolar bone is the portion of the maxillary and mandibular bone that houses the alveolar sockets. The alveolar bone formed at the moment of tooth eruption becomes atrophied soon after tooth loss.[9] It is constantly remodeled throughout life, with the trabecular pattern following changes in magnitude and force direction (resorption and apposition, for example).

Osseous anatomy

It can be divided in two basic types:

Compact bone: refers to the cortical bone.

Trabecular bone: refers to the medullar bone.[15]

The bone that covers dental roots is thicker at the palatal than in the buccal aspect of oral cavity. The alveolar walls are lined by compact bone, and the inter-alveolar zones contain trabecular bone. The trabecular bone is more frequent in the interdental septa than in the buccal or palatine regions. The bone trabeculae are partially determined by genetic heritage and influenced by occlusal forces exerted on teeth. In the mandibular bone, the buccal cortical plate is thin at the incisive and premolar region, and thick at the correspondent lingual regions. On the other hand, the buccal molar region has a thicker bone than the same lingual region. (Fig. 3.10).

Compact bone

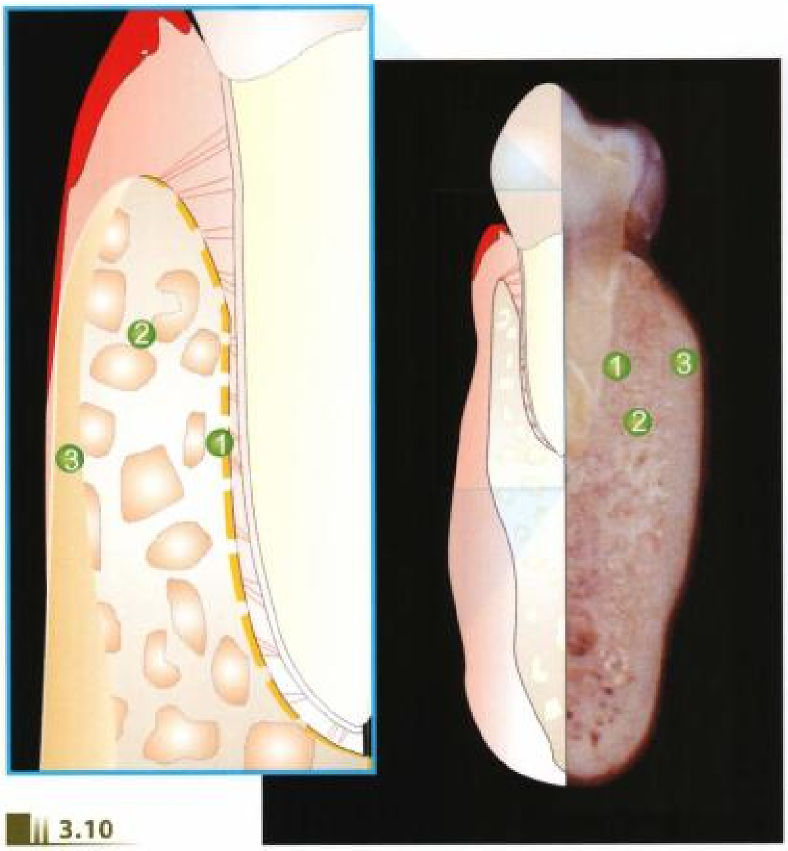
It is formed by organic and inorganic components, lamellae (cell membrane). The osteocytes can be found in lacunae and receive nutrition by diffusion.

The bone matrix (osteoid) has 40 wt% of collagen type I, glycosaminoglycans, osteonectin, and proteins responsible for adhesion. The inorganic component also provides 40 wt%, being constituted by hydroxyapatite (calcium and phosphate apatite crystal) and traces of other substances (sodium, magnesium, and fluoride).

Most of the hardness and density of the compact bone is due to the outer and inner circumferential layers, as well as the interstitial layers and the Harvesian system. Also, collagen fibers, osteoblasts and osteoclasts can be found in the osseous matrix. The periosteum covers and is attached to the compact bone through the collagen fibers, serving

Fig. 3.10 – Schematic drawing of alveolar process.

1. Alveolar bone
2. Trabecular bone
3. Compact bone



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as a protective layer. The trabecular bone forms a three-dimensional, less hard and dense structure compared to compact bone. The osteoblasts, cells responsible for bone formation and resorption, are observed in this large network. Numerous blood vessels run perpendicular to the trabecular bone.

Trabecular bone

The trabecular bone is not adequate for primary bone stability because it is less hard and dense than the compact bone.

When bone cells are viable in the trabecular region, a highly dense area forms around the titanium fixture in the process known as osseointegration. In terms of bone density, mandibular bone offers ideal conditions. Thus, a strong bone-to-implant interface in the maxilla can only be achieved after longer periods. The surgical process is crucial to achieve successful results (Fig. 3.11).

Bone remodeling

The osseointegration process requires bone remodeling around the titanium fixture. Also, this phenomenon helps to regulate the level of calcium into the blood stream without significant alterations in the bone mass. In the compact and trabecular bone, osseointegration takes place in the vicinities of available osteoblasts and osteoclasts, where the occlusal forces provide stimuli for bone remodeling; also, this can lead osteoprogrenitors cells to differentiate into osteoclasts and osteoblasts.

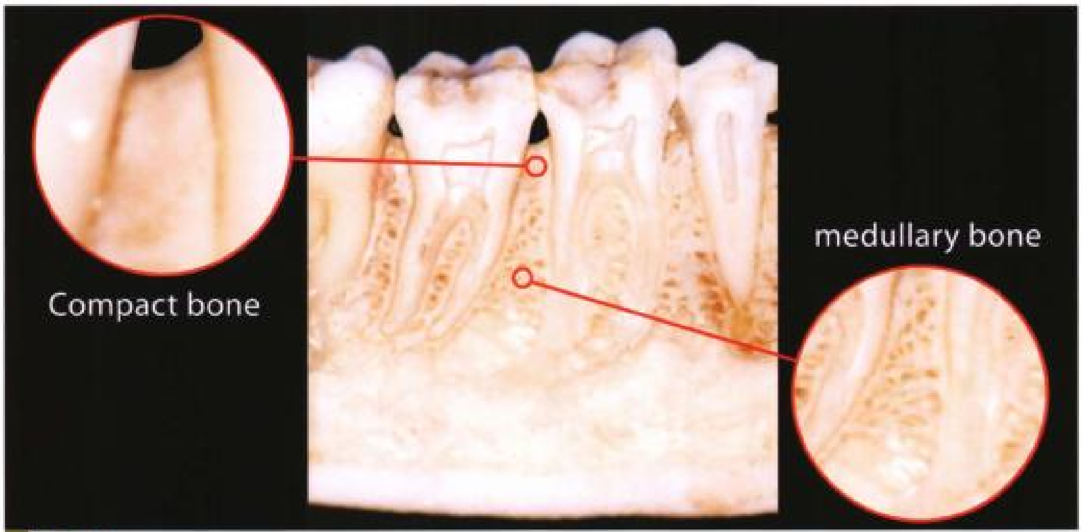

Fig. 3.11 – Mandible. Dry skull showing compact and trabecular bone in the molar region. Observe the osseous trabeculate.

The osteoblastic activity in adults and older persons is characterized by a slow decrease in the bone forming capacity, which leads to a gradual loss in bone density. This stage is modified during drilling on implant surgery. Osteoblastic cells are triggered and produce proteins associated to collagen formation, one of the steps in bone formation. To keep collagen production at constant levels, TRH, calcitonin and vitamin D, as well as adequate stimulus, are crucial. Ongoing input from mastication and good general health are important factors to the success of bone remodeling.[15]

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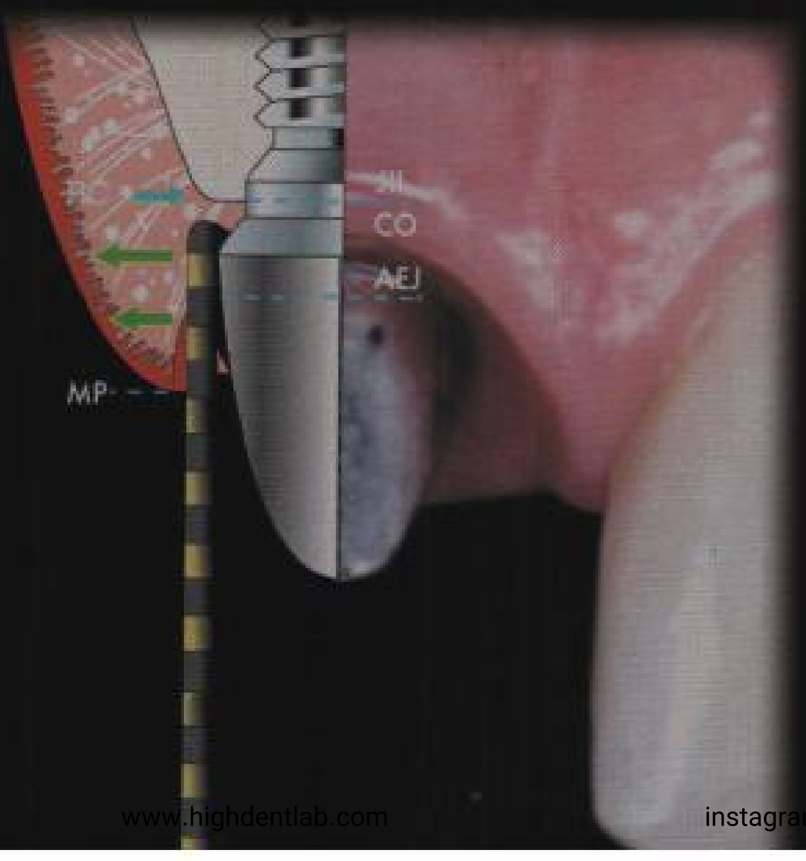
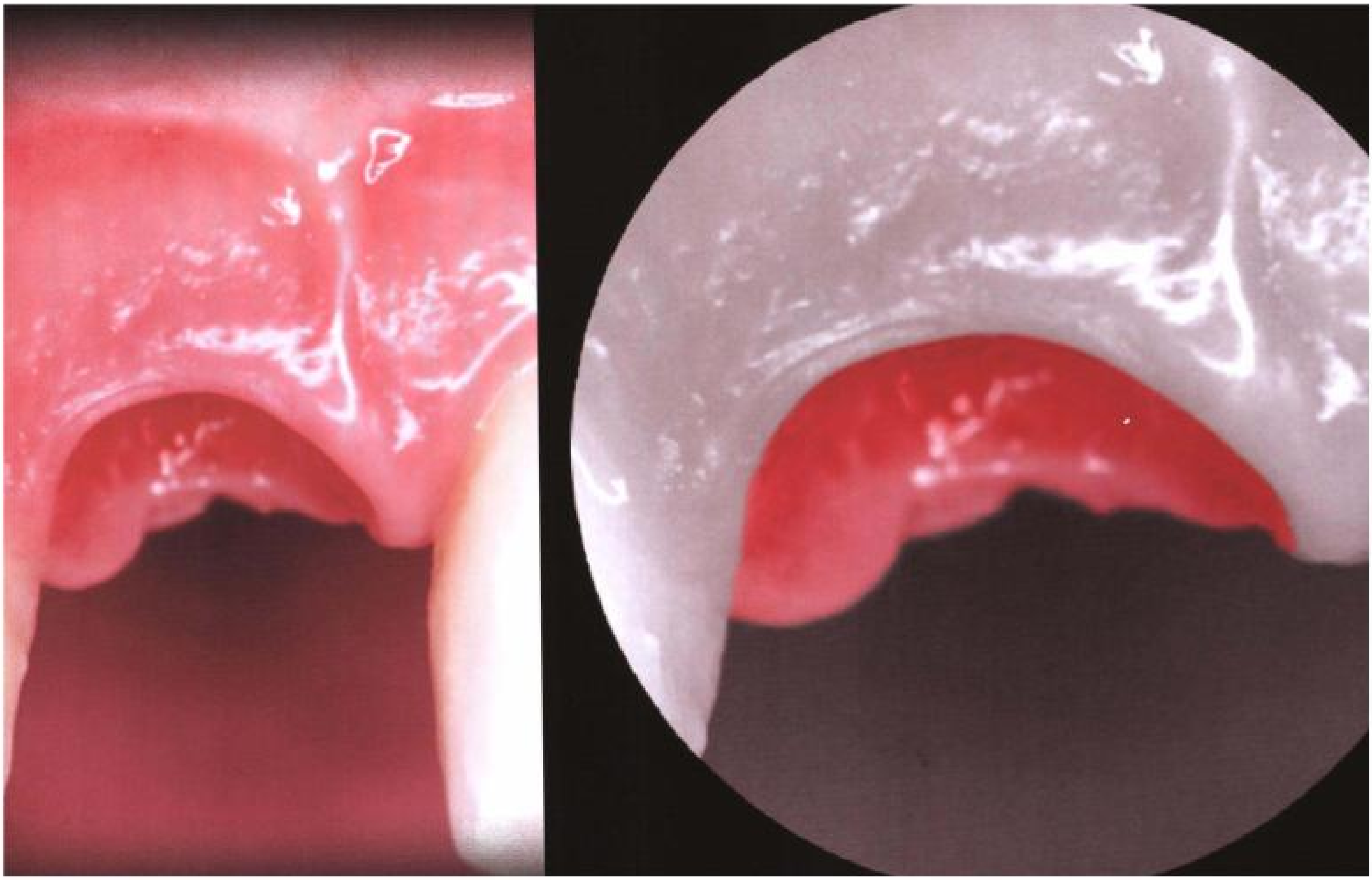
4

PERIIMPLANT TISSUES

José Bernardes das Neves





Periimplant Tissues

PERIIMPLANT BIOLOGIC WIDTH

Similar to teeth, researchers have verified the existence of a "biologic width" around osseointegrated implants. Morphology of the soft tissue from dental and implant abutments has revealed such similarities: an oral keratinized epithelium ending at the apex of the marginal gingiva, as well as non keratinized epithelium facing the implant side, that runs from the gingival apex to the depth of the junctional epithelium.[1]

Several in vivo and in vitro experiments with different types of fixtures[36], abutment dis/reconnection[39], immediatelly loaded or not[40], materials and surface roughness[41], and with alterations in the height of the soft tissue[42] have shown that a stable biologic sealing can only be obtained in the presence of a 3 mm supracrestal barrier in the corono-apical direction. The junctional epithelium covers up to 2 mm, while the connective tissue attachment is responsible for 1 mm. This "biologic width" is dimensionally stable for 12 months without loading, considering good mechanical and hygiene procedures (Fig. 4.1).

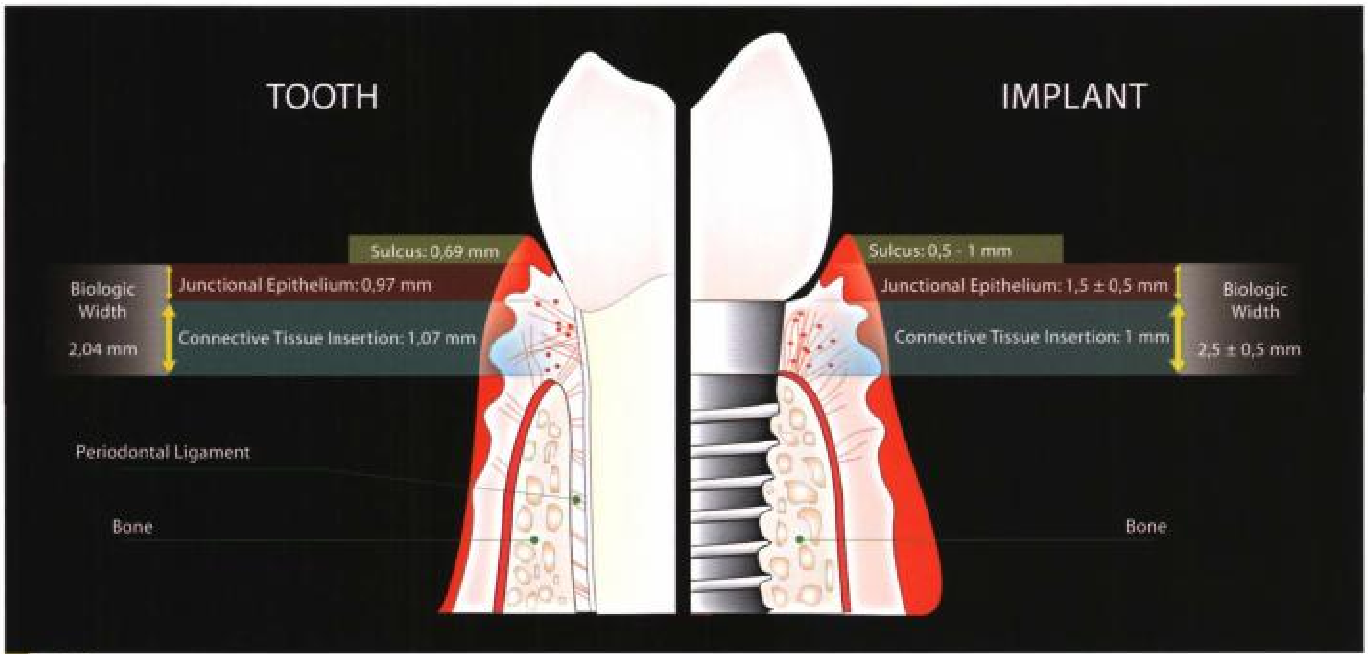
EPITHELIUM

The sulcular epithelium has a depth around 1mm.[2]

The junctional epithelium can be found at the level of the cemento-enamel junction. On the other hand, it has a considerable distance from the marginal gingival region around dental implants. The epithelial tissue is attached to the commercially pure implant surface through hemidesmosomes.[3,4]

After precise implant placement, and due to its capacity of proliferation and dislocation, the epithelium extends from the granulation tissue to the incision line. Once the epithelium has reached the implant surface, it forms an apico-coronal extension, originating the junctional epithelium with 2 mm depth.[5,6]

The tissue found in the wound margin has morphological and phenotypic characteristics similar to the oral epithelium; also, the sulcular and junctional epithelium have differences on morphology, structure and phenotypic expression. These



4.1

Fig. 4.1 – Comparison between periodontal and periimplant biologic width. (sulcus, junctional epithelium, connective tissue insertion, biologic width, periodontal ligament, bone).

changes can be seen as the tissues around dental implants go through external influences that result in functional alterations.

The granulation tissue serves a barrier to the the apico-coronal movement of the epithelium.[5] Also, it has been demonstrated in animal models that the connective tissue prevents the epithelial downgrowth.[7,8]

It appears that the mature connective tissue interferes more than the granulation tissue during the epithelial downgrowth. It was supposed that the interaction between the soft tissue and the titanium surface can be the reason for this phenomenon.[9,10] Mackenzie & Tonetti[11] suggested in a recent work that the adult epithelial tissue, although presenting a phenotype acquired during epithelial-mesenchymal interactions, can react against new stimuli coming from the mesenchymal tissue.

Mackenzie & Hill[12] hypothesized that epithelial differentiation is triggered by the underlying connective tissue. In addition, stimuli from different sources can affect its final phenotypic expression. Besides, it has been shown[12] that significant stimuli do not originate from the connective tissue but only from the subepithelial layer. Thus, the lack of signals from the supracrestal connective tissue prevents apical migration of oral epithelium.

Other studies have stated that epithelial migration across implant surface is driven through topographic orientation.[8] These characteristics can influence the degree of tissue movement and cellular growth.

Fitton et al.[13] demonstrated that the stratified epithelium can be inhibited according the surface topography. *In vitro* studies have shown that rough surfaces influence adhesion of epithelial cells, fibroblasts, and osteoblasts, with implications to the strength of the junctional epithelium, connective tissue insertion, and the degree of osseointegration as well.[14]

On the other hand, an indirect implant-epithelium interface has also been hypothesized.[15] Thus, considering a >200 μ thick, amorphous material, composed of glycosaminoglycans, glyoproteins, and laminin can be found between the cellular wall and the implant surface.

Recent human studies[11,16-18] have shown that the epithelium around the titanium implant has differentiation and functional patterns similar to the oral epithelium around teeth.

Microscopic[19] and ultra-structural[20,21] analysis of the sulcular epithelium revealed a non-keratinized pattern similar to that found in hard dental tissues. The sulcular epithelium contains cells parallel to the implant surface. These cells exhibit a basal membrane attached to the underlying connective tissue through hemidesmosomes. Also, the presence of intracellular substances such as extracelular protein matrix denotes the secretory activity of a rough endoplasmatic reticulum and a well-developed Golgi apparatus.[22,24] Besides, immunologic defense is provided by leucocytes originated from the sulcular epithelium.

The attachment of junctional epithelium on the implant surface has also been demonstrated.[24] First, mucopolysaccharides from the ***basilar lamina*** are laid down directly on the implant surface, which in turn receives hemidesmosomes from the basal layer and the subjacent ***lamina***. This provides a closer attachment of cells parallel to the basal membrane.[25]

The free gingival epithelium covers the periimplant soft tissue, being keratinized or not. Most clinicians believe that a keratinized oral mucosa increases tissue stability and renders less inflammation to the implant abutment,[26,27] although the role of a keratinized tissue on protection, maintenance of soft tissue attachment, and bone height has been questioned (Fig. 4.2)[28].

Connective tissues

The underlying periimplant connective tissue is different from its dental counterpart. By definition, osseointegration means a close contact between bone and implant, and consequently, no cement or periodontal ligament can be found at this region. Ultra-structural studies of this interface have shown a layer of amorphous material serving as anchorage to the collagen fibers. There is an avascular zone of connective tissue just beneath the epithelium, with collagen fibers running parallel to the implant surface.[29] However, a perpendicular insertion pattern has been described for ceramics[21,23] and rough titanium surfaces.[30]

The avascular zone of dense collagen fibers adjacent to the implant surface contrasts with a rich vascular plexus of connective tissue also found in the implant surface. Contrary to dental tissues, blood supply comes only from the alveolar periosteal surface.[32] The lack of an anastomosis similar to that found in the periodontal tissues can compromise the implant osseointegration due to periimplantitis or in the presence of

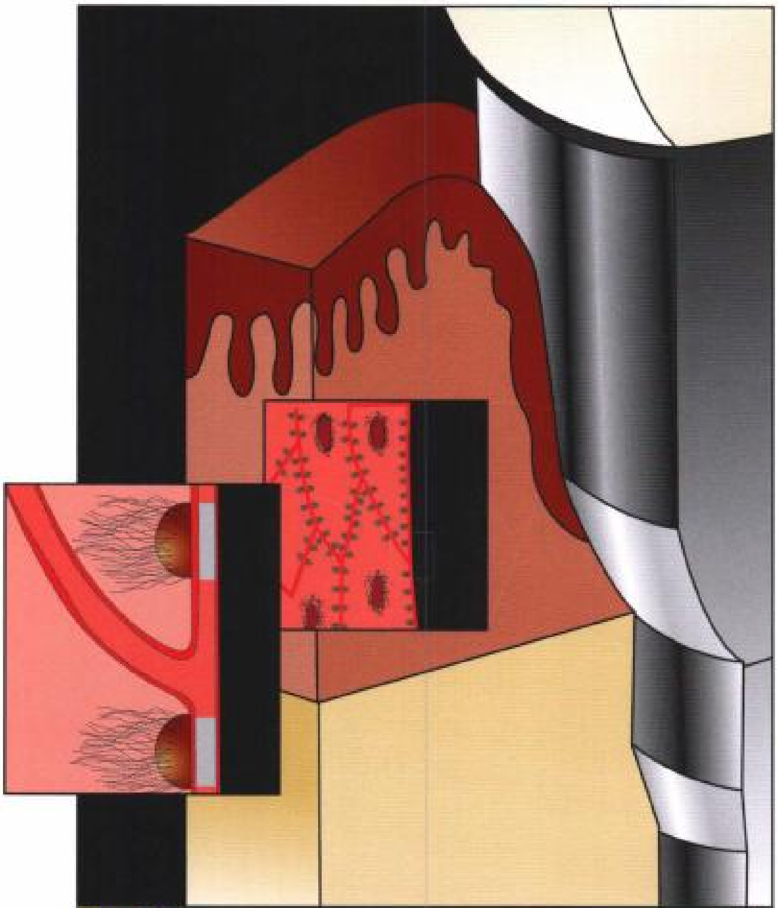

4.2

Fig. 4.2 – The attachment mechanism between abutment surface and periimplant tissues is similar to that found in natural dentition. The epithelial layer is formed by basal cells both with *lamina lucida* and *lamina densa*. Basal cells are attached to the abutment via glycoproteins. Below the junctional epithelium, collagen fibers are well organized e firmly adhered to the abutment surface (*Adapted from Hobo et al.*[15])

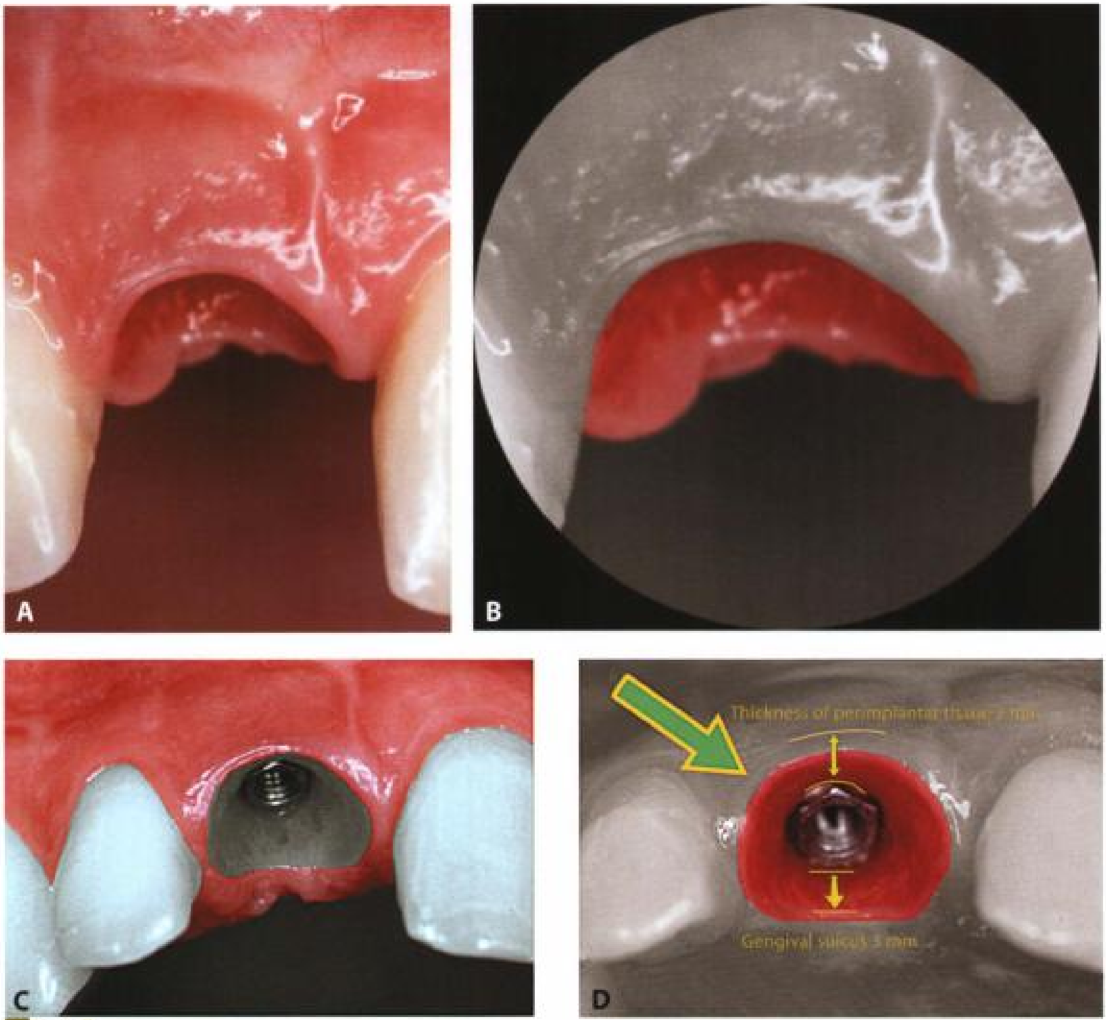
a membrane barrier for guided regeneration. A closer contact between the gingival connective tissue and the implant surface can be essential not only for protection against invading bacteria, but also for epithelial downgrowth, because this fact has been associated with implant failure (Fig. 4.3).[44]

Supracrestal connective tissue

Gingival and periimplant probing

Several studies have shown that a periodontal probe rarely identifies the apical region of the dentogingival junction. Thus, the junctional epithelium affords no resistance on probing. At the gingival connective tissue filled by leukocyte cells, the periodontal probe can even reach the lateral border of the inflammatory infiltrate.[44]

Ericsson & Lindhe,[45] following the model established by Berglundh et al.[10], examined soft and hard tissue relationships on tooth and implant specimens. The gingival tissue around lower premolar teeth was considered healthy after longer periods of plaque control. A 0.5 mm-diameter periodontal probe was inserted at the buccal pocket side under a load of 0.5 N. Histological sections from the surrounding tissues and the inserted probe were obtained from tooth and implant models. In the tooth model, the results showed that a slight compression



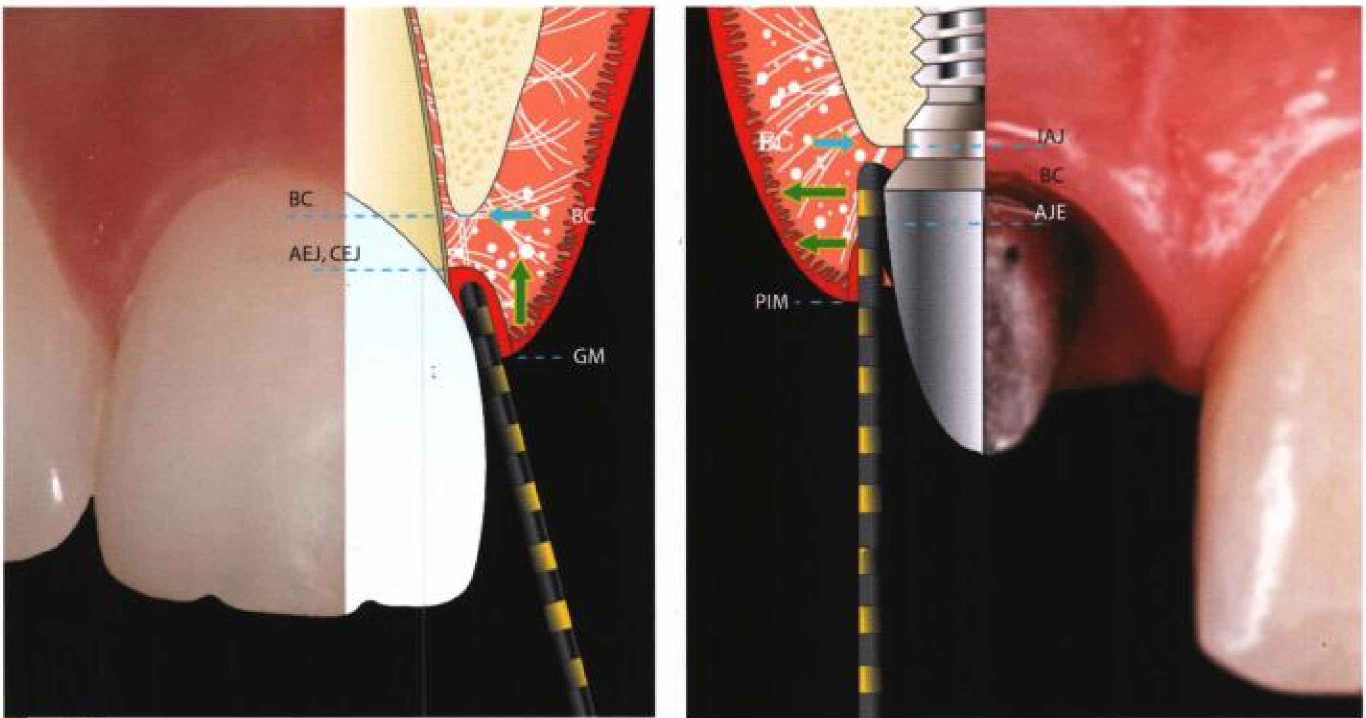
4.3

Fig. 4.3A – Gingival form and contour six months after soft tissue conditioning with a provisional crown, moments before impression transfer procedures. Observe papillary healthy in the periimplant tissue. **Fig. 4.3B** – Contour of the periimplant tissue. **Fig. 4.3C** – Clinical aspect of periimplant mucosa after seven months of conditioning ready for final transfer. **Fig.4.3D** – Observe the health of periimplant tissues.

could be observed at the gingival tissue, with a probing depth of 0.7 mm. The probe tip was found only at the level of the junctional epithelium cells, in a corono-apical direction. On the other hand, periimplant probing caused compression and displacement of periimplant mucosal tissue, with a mean periimplant probing of 2.0 mm. In this model, the probe tip was constantly found at the connective tissue/implant interface, apical to the epithelial barrier. The distance between the probe and the osseous crest in the tooth model was approximately 1.2mm, while in the implant model the distance almost reached the osseous surface (0.2mm). Based on these findings, the authors concluded that the interface between periimplant mucosa and the implant is more fragile than the that found between gingiva and teeth, and that preventive measures need to be considered when probing depths of tooth and implant models are compared (Fig. 4.4).

Schou et al.[46] compared probing depths in implant and tooth models of *cynomolgus* monkeys. The authors made histological sections of (1) clinical healthy, (2) slightly inflamed (mucositis/gingivitis), and (3) severe inflamed (periodontitis/periimplantitis) areas. A 0.5 mm-diameter periodontal probe (Peri-Probe) was inserted under a load of 0.3-0.4 N. It was shown that probing depths were similar for healthy tooth and implant areas. On the other hand, areas with mucositis and periimplantitis presented the probe tip more apically than areas with gingivitis/periodontitis). The authors concluded that the tooth provides different parameters and little alterations in the probing depths of titanium implants reflect changes in soft tissue inflammation rather than loss of the supporting tissues.

Thus, correct periimplant parameters at implant sites can only be properly established when one uses a mild probing force around 0.3-0.4 N. Greater probing forces can compromise the interface between mucosa and the implant, resulting in lateral displacement of mucous tissue and a more apical position of the probe tip near the osseous crest. When periimplantitis is seen, the probe tip extends even apically than the inflamed areas. Sometimes, bleeding



4.4

Fig. 4.4 – Probing depths of Brånemark osseointegrated implant and natural tooth.

PIM = periimplant margin
AJE = apical termination of junctional epithelium
IAJ = implant-abutment junction
BC = bone crest
GM = gingival margin
CEJ = cemento-enamel junction

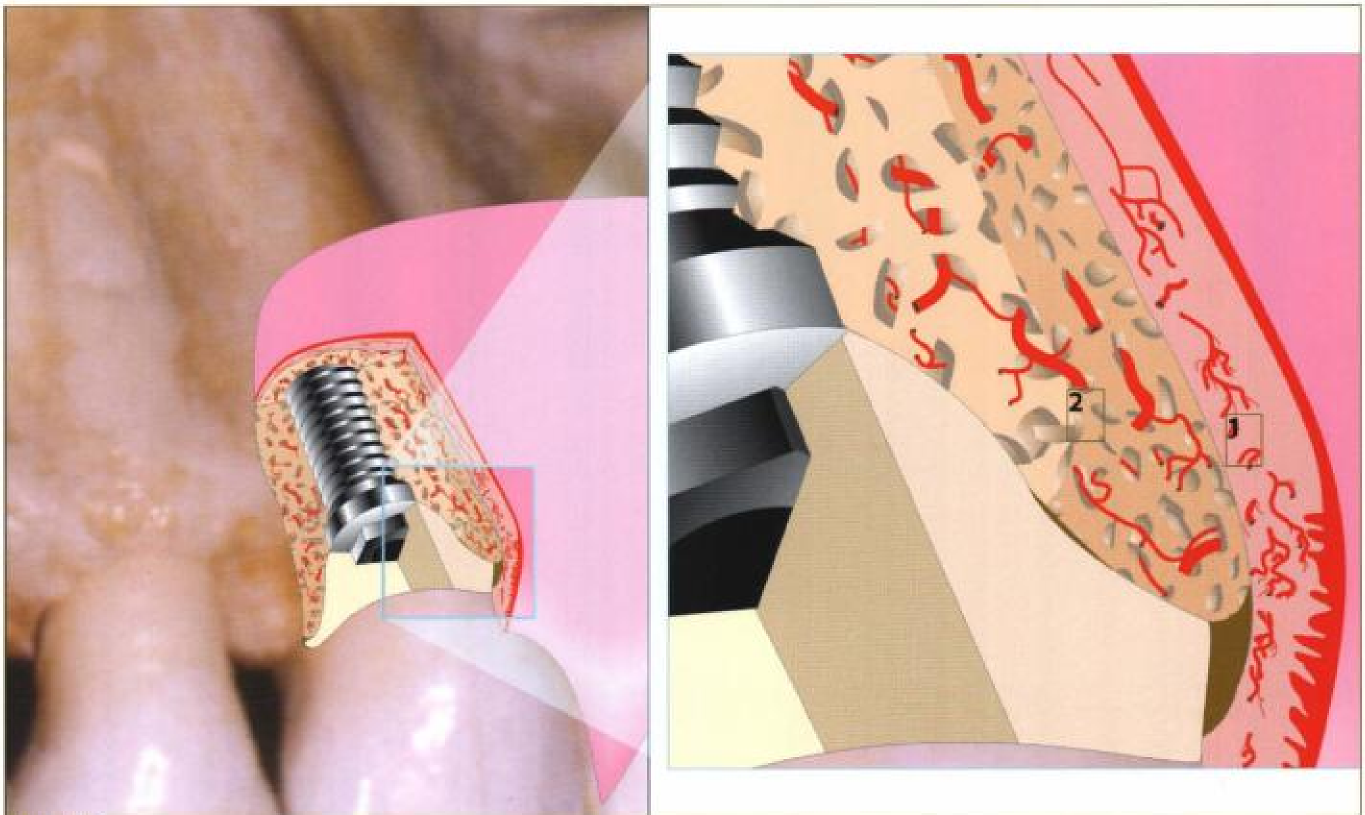
on probing was observed in implant sites although still rare in the dental organ situation.

Periimplant vascular nourishment

The gingival blood supply originates from two different sources (Fig. 4.5):

The first source is a great supraperiosteal vessel, which gives branches to form (1) capillary vessels of the underlying connective tissue and (2) the vascular plexus lateral to the junctional epithelium. The second is the vascular plexus of the periodontal ligament, with coronal branches that cross over the alveolar crest to end at the supra-alveolar portion of the free gingival tissue. Thus, it is important to bear in mind that the blood supply to the connective tissue junction that makes the periodontium comes from two independent sources.

Berglundh et al.[35] observed the periimplant vascular mucosal system in dogs had an exclusively supra-periosteal localization. This vessel branches to the supra-alveolar mucosa to form (1) the capillaries beneath the oral epithelium, (2) and a vascular plexus found lateral to the epithelial barrier. Besides, no



4.5

Fig. 4.5 – Vascularization around periimplant tissues: nutrition comes from blood vessels of alveolar bone and supra-periosteal vessels to the periimplant area, since the implant has no periodontal ligament. 1. Supra-periosteal vessels, 2. Alveolar bone vessels.

periodontal ligament exists at the bone-implant interface being the supra-periosteal vessel the only source of irrigation to underlying mucosal tissues.

There is a consensus that the supra-crestal connective tissue has a fundamental role as an effective sealing between the oral cavity and the intra-osseous implant surface.[2,30,34]

Buser et al.[34] pointed out that the connective fiber orientation can be influenced by the quality of the underlying mucosa. These are parallel to the implant in the presence of alveolar mucosa, while being more perpendicular when a keratinized tissue is present.

The connective tissue found between the osseous surface and the apical part of the junctional epithelium can be divided in two regions. The inner zone is 50-100 µm-thick and in close contact to the implant surface. It has abundant fibers with few, sparse cells and blood vessels, similar to the tissue found at wound areas.[31] The other region present fibers with multiple directions, being rich in cells and blood vessels.[31]

Berglundh et al.[10] studied the response of the soft tissue around titanium abutments of the Brånemark system, and observed that in the absence of plaque, the adjacent periimplant mucosa was clinically healthy, pink, firmly attached, with no inflammation signs or bleeding on probing. Also, histological sections showed no signs of inflammatory infiltrate.

The connective tissue found apical to the junctional epithelium had the following proportions of tissues and cells:

collagen 87.2%
fibroblasts 0.8%
vascular elements 6.4%
leukocytes 0.6%
others 4.8%

The connective tissue adjacent to the sulcular and junctional epithelium around teeth has less collagen (approximately 63.1%), more fibroblasts (15.7%) and blood vessels (7.3%).

Also, some significant differences were found between tooth and implant models. The more important was the orientation of collagen fiber bundles running parallel to the abutment's surface. These findings were different from that observed by Schoroeder et al.[31], Buser et al.[31], and Steflik et al.[25], which can be related to the surgical technique and implant surface topography and design. In addition, it was observed that the gingival connective tissue can be divided in two zones, one facing the sulcular and junctional epithelia, and the other between the apical part of the junctional epithelium and osseous surface. The connective tissue of the periimplant mucosa, in turn, is more uniform without significant differences between the supra-crestal and the apical part portions. Generally, the gingival connective tissue contains less collagen and more cells than the periimplant mucosa.

Conclusion

The implant-soft tissue interface is formed by epithelial and connective tissues. Both constitute a biologic seal to prevent the contamination of the tissue by oral bacteria and its related toxins. The epithelial cells attach to the implants through hemidesmosomes of the basal lamina, similar to the tooth-epithelium interface. The connective tissue, which is rich in collagen fibers but poorly vascularized, has an adhesion mechanism to the implant surface to prevent epithelial downgrowth. The collagen fibers of the periimplant mucosa run parallel to the implant surface. The presence of circular fibers at the implant area have also been demonstrated. On the other hand, the periimplant connective tissue has less collagen and fibroblasts compared to its gingival counterpart.

Studies in cell cultures demonstrated that the material and implant surface influenced on the adhesion and cellular proliferation. Titanium implants have shown good properties for cellular adhesion.

Host response to bacterial plaque was found similar for periimplant and gingival mucosal tissues. Also, this phenomenon does not depend on location, type or composition of the offending bacteria. However, longer periods of exposition to bacteria cause apical migration of the inflammatory infiltrate in the periimplant mucosa.

Histological sections through periimplant mucosa from human biopsy tissues often revealed the presence of inflammatory cells at the connective tissue near the junctional epithelium. The presence of T cells in the periimplant mucosa was demonstrated by immunohistochemical analyses, similar to that found in the gingival mucosa around teeth. The establishment of a functional barrier around implants begins when the junctional epithelium is exposed to bacteria, with a concomitant, effective, and well-controlled host response.

IMPLANT OSSEOUS INTEGRATION

The surgical procedure for implant placement creates a contact area between bone and fixture. This interface is composed by bone, medullary tissue, and the blood clot mixed with bone chips formed during surgical drilling. Similar to the bone fracture or defect healing, inflammatory cells and steam mesenchymal cells migrate from adjacent blood vessels and medullary stromal tissues, respectively, to the bone-implant interface. The clot is replaced by blood vessel proliferation and connective tissue removal. At this time, multinucleated giant cells cover the implant surface, which presents a non-mineralized tissue. This represents a classical signal of the foreign body response which can results in implant encapsulation. However, these cells diminish over time and the implant-bone contact is enhanced.

The healing process found in Brånemark implants is similar to that found during normal bone healing process, being primary or secondary as well. In the primary healing, the bone is well-organized with minimal or no infection at the site, being ideal after implant placement. To enhance this process, the surgical procedures must be conducted in healthy bone without infection or necrotic areas.

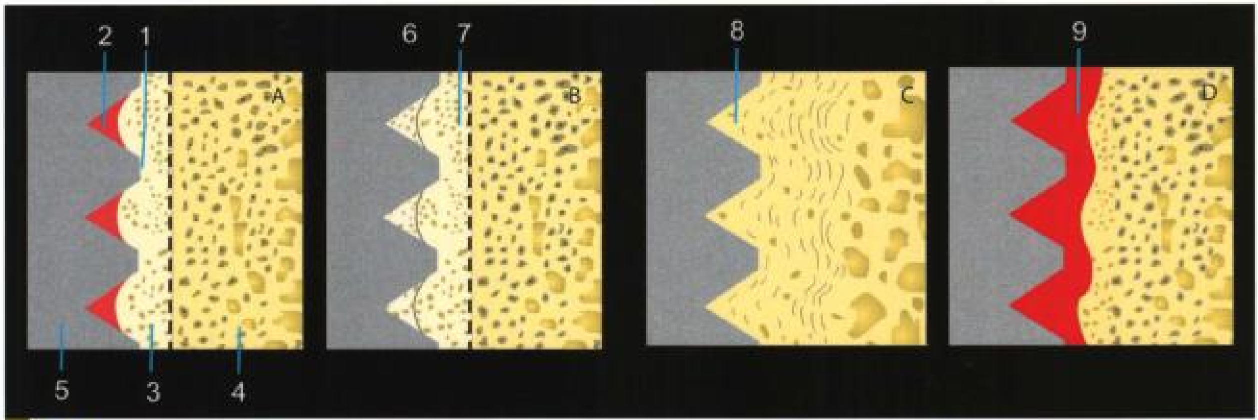
On the other hand, the secondary healing process may result in granulation tissue and infection at the surgical sites, extending or complicating this period. In some cases, a fibrocartilage is seen rather than bone tissue, being unfavorable for implant integration.

Healing at implant sites is similar to that found in the primary process. Initially, a blood clot is formed between the implant and the bone (Fig. 4.6). This clot is replaced by phagocytes, such as polymorphonucleated leukocytes, lymphoid, and macrophage cells. The level of phagocytic activity increases from the first to the third day after surgery. During this period, a bone callus is formed containing fibroblasts, fibrous tissue and phagocytes. This tissue is transformed into a dense connective tissue, as well as in osteoblasts and fibroblasts, originated from differentiated mesenchymal cells. The connective tissue at the implant surface now is referred as a callus. Osteogenic fibers derived from the osteoblasts found at this interface have the potential for calcification. The dense connective tissue forms a fibrocartilaginous callus, and the new bone and osseous matrix are called bone callus. The density and rigidity of this new bone formed increases as the bone matures (Fig. 4.7). Now, the prosthesis is connected to the implant to trigger the osseous remodeling.[24] The Harvesian system becomes dense and homogenous. Occlusal forces, in turn, lead to bone stimulation around implant, and the fixtures can withstand masticatory activity (Fig. 4.8).

OSSEOINTEGRATION AT THE ULTRASTRUCTURAL LEVEL

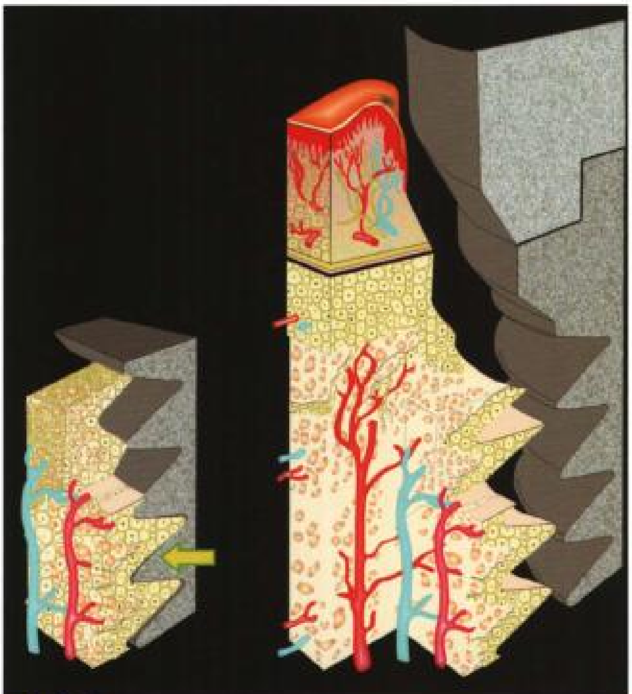
Osseointegrated implants are surrounded by cortical and medullary bone. When osseointegration is established and the prosthesis is designed for better stress distribution, the cortical bone is formed along the implant surface a few millimeters thick.[47] This cortical bone-implant interface has canaliculi for electrolyte transport near the titanium oxide layer. A network of collagen fibers surrounds the osteocyte cells and contacts a glycoprotein layer. This 100-Angstrom layer faces the oxide layer on one side, and contacts a glycoprotein layer 10-20µm thick at the opposite side. The harvesian bone is well organized and forms the osteon.

The osseointegration of trabecular bone occurs through direct approximation and in closer contact with the fixture. The blood vessels provide nutrition for trabecular bone modeling/remodeling. Fibroblast and osteoblastic cells change in shape and size as they became closer, finally adhering in the titanium oxide layer. The space between trabecular bone and the oxide layer is filled by the fundamental ground substance[48], similar to that observed in osseous microstructure of healthy human tissues and provides evidence for bone to implant adaptation.[49]



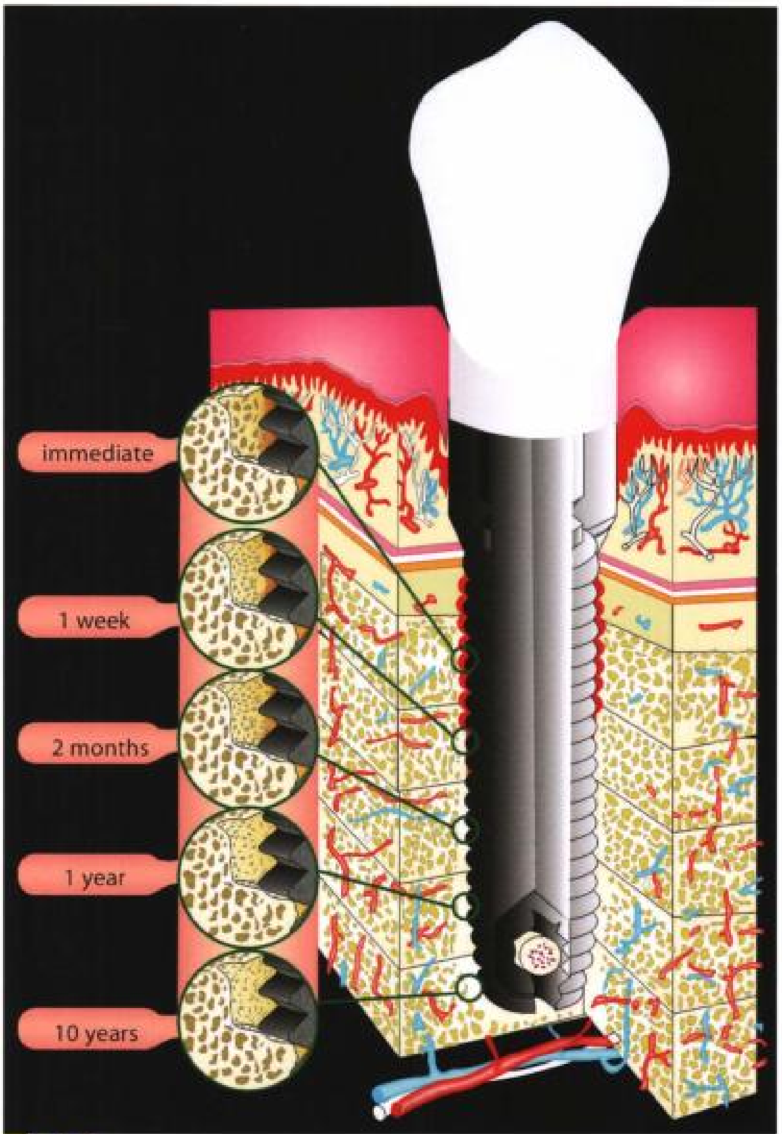
4.6

Fig. 4.6 – Diagrammatic representation of the biology of osseointegration. **(A)** The objective of a threaded bone socket is to provide immobilization of the fixture immediately after installation and during the initial healing period. However, the threaded bone site cannot be made perfectly congruent to the fixture. The dimensions of the fixture site are, therefore, crucial. A too-small fixture site could give rise to compression and torque lesion at forced fixture installation. If the site is too wide, initial fixture stability comes inadequate resulting in relative motion and non-integration. The diagram is based on actual dimensions of fixture and fixture site. **1.** Contact between fixture and bone = immobilization. **2.** Hematoma in closed cavity, bordered by fixture and bone. **3.** Damaged bone due to unavoidable thermal and mechanical trauma. **4.** Original, undamaged bone. **5.** Fixture. **(B)** During an unloaded healing period, of at least 3 months, the hematoma becomes transformed into new bone via callus formation **(6,7)**. The damaged bone also heals and revascularizes: and remineralization occur. **(C)** After the healing period, vital bone tissue is in close contact with the fixture surface, without any other intermediate tissue. The border-zone bone **(8)** remodels in response to the applied masticatory load. **(D)** In unsuccessful cases non-mineralized connective tissue **(9)**, constituting a kind of pseudo-arthrosis, forms in the fixture-bone border-zone. This development can be initiated by excessive preparation trauma, infection, too early loading in the healing period before adequate mineralization and organization of the hard tissue has taken place, or supraliminal loading at any time, even many years after integration has been established. The osseointegration cannot be reconstituted. To a certain degree the connective tissue can become organized but, it is not a proper anchoring tissue, because of its inadequate mechanical and biological capacities, resulting in creation of a *locus minoris resistentiae*.[2,12] (*Adapted from Brånemark Novum*[51], p.12).



4.7

Fig. 4.7 – Three-dimensional diagram of the tissue and titanium interrelationship showing an overall view of the intact interfacial zone around the osseointegrated fixture. (Adapted from Brånemark[50] p.40).



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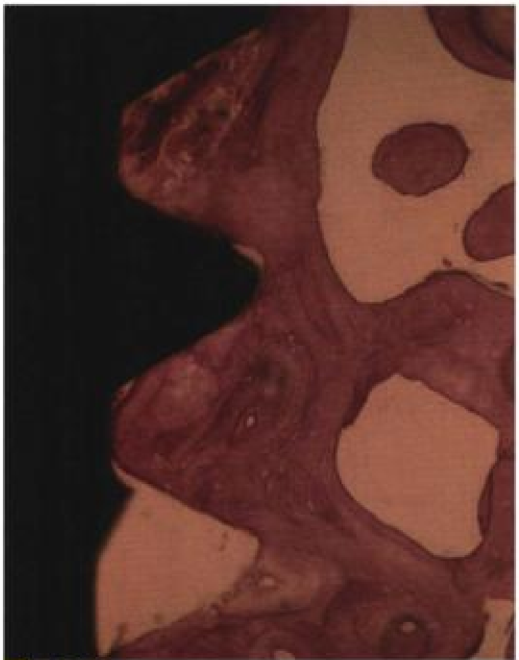

4.10

Fig. 4.8 – Physiologic evaluation of the biology of the interface over time. (*Adapted from Brånemark*[50] p.40).

Figs. 4.9 and 4.10 – Histological section at the implant-bone interface, four months after fixture placement.

Fig. 4.11 – Histological section showing mature bone over the implant surface 18 months after its installation.

4.11

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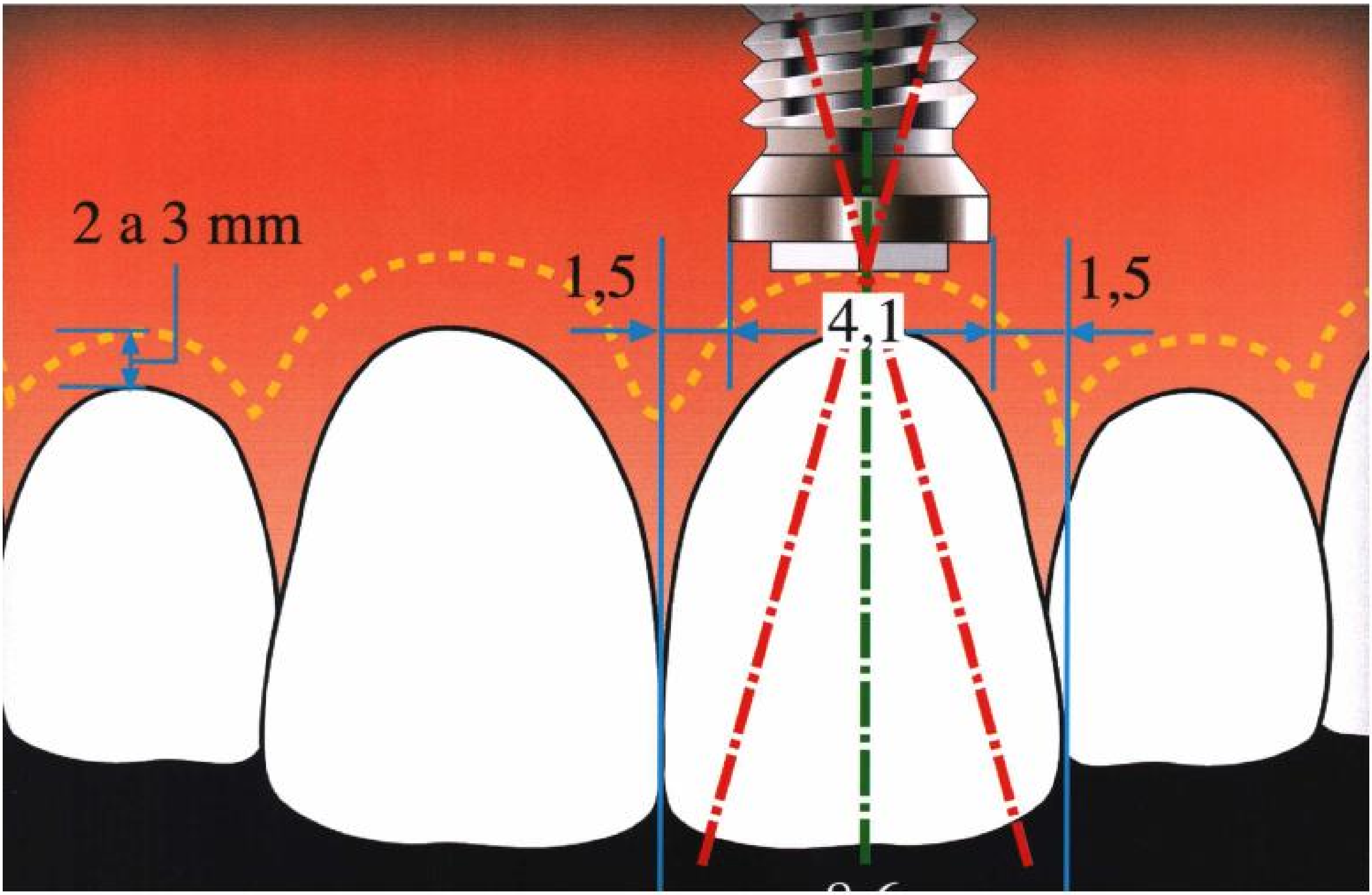
5

TREATMENT PLANNING

José Bernardes das Neves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Treatment Planning

The fundamental objective in Dentistry is to provide function, esthetics, phonetics, as well as comfort and oral health to the patients. These objectives are sometimes difficult to achieve at once, as the edentulous patient may present with severe anatomical limitations. However, implantology provides an effective mean to overcome this situation. Scientific and technological improvements in this area have lead to more satisfactory results for edentulous patients and dental clinicians.

The need for implant dental treatment has been associated with various factors[1]:

- aging population;
- associated tooth loss;
- anatomic complications;
- unfavorable performance of removable prostheses;
- emotional aspects of tooth loss;
- predictable results for implant-supported prostheses over time;
- advantages of implant-supported prostheses.

Osseointegrated implants became an important therapeutic modality in the last decades, mostly due to the work started by Brånemark[2] in 1965 while treating edentulous mandibular archs with metallic screw type implants. The direct apposition of bone to a metallic (titanium) biomaterial was called osseointegration.

The extrinsic and intrinsic factors that affect periimplant health are listed in Box 5.

The tooth has vital importance in bone stimulus and development.

Box 5.1 – Patient evaluation for implant placement

- Medical evaluation
- Dental evaluation
- Clinical examination
- Radiographic examination
  periapical
  panoramic
  occlusal
  lateral
  computerized tomography
- Dental study casts in the semi-adjustable articulator
- Photograph documentation

(Adapted from Neves[10], p.84)

Also, soft tissues are affected by dental loss, which can reflect in facial alterations such as narrowing of labial tissues, pragmatic appearance, nasolabial sulcus deepening, loss of muscle tonus and facial expression, increased display of lower anterior teeth, etc. (Box 5.1).

Although function and phonetics are common problems in completely edentulous patients, the surgeon dentistry must take into account that tooth loss plays a considerable effect in esthetics and social relationships (Box 5-2).

Indications for implant placement

- single, partial or total edentulism;
- patients with inadequate oral musculature control;
- unrealistic expectations in patients with total prosthesis;
- extra-oral prosthesis (nose, eye, ear, etc.) retention.

Several authors[3-6] suggest that the success in osseointegration means adequate balance of esthetic and functional factors, with an asymptomatic bone-implant interface and healthy surrounding soft tissues at all times.

In addition, the aim of implant treatment is to preserve the integrity of noble structures in the oral cavity, retrieving esthetics according to the patient objective and subjective experiences, e.g., a preview before implant placement.

Ideal implant positioning

Implant positioning requires treatment consideration. In completely edentulous cases, the clini-

Criteria for implant success[3]

Absence of mobility checked by individual stability testing
Radiographic evaluation shows no signs of periimplant radiolucencies
Vertical bone loss is less than 0.2mm annually after the first year in function
No signs of pain, infections, neuropathies, paresthesia, or damage to the mandibular canal
A success rate of 85% after 5 years and a rate of 80% after 10 years are minimal accepted criteria

Box 5.2 – Evaluation of the anterior maxillary region before implant placement

Mesio-distal dimension of the edentulous segment, including its comparison with the existing contra-lateral tooth
Three-dimensional analysis of the edentulous segment regarding to the soft tissue configuration and the underlying alveolar crest
Adjacent teeth
Volume (dental dimensions), basic characteristics of dental shape in the context and alignment of clinical crowns
Condition and structural integrity
Surrounding gingival tissue (scalloping of the gingival contours)
Endodontic and periodontal status
Crown-to-root ratio
Root length and their inclinations in the frontal plane
Presence of diastemas
Interarch relationships
Vertical dimension of occlusion
Anterior guidance
Interocclusal space
Esthetic parameters
Height of the upper lip line (high lip x low lip)
Lower lip line
Mucogingival line course
occlusal plane orientation
Facial x dental symmetry
Lip support

(Adapted from Lindhe et al.[25], p.894)

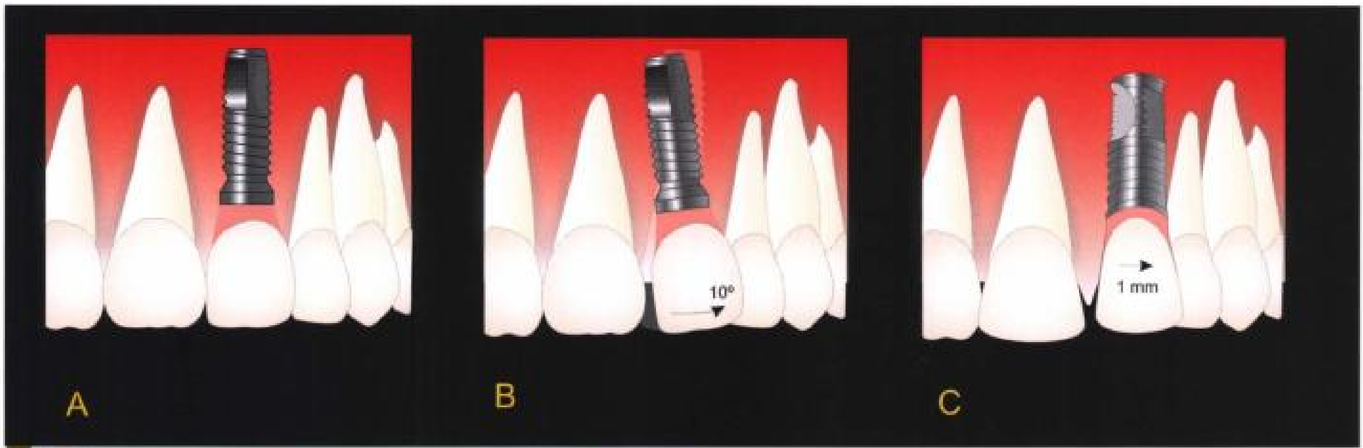
Box 5.3 – Extrinsic and intrinsic factors that determine the health of soft periimplant tissues[24]

Intrinsic factors	Extrinsic factors
• Patient's age	• Tobacco use
• Systemic healing	• Medications
• Periodontal status	• Oral hygiene
• Host resistance	• Implant design and surface characteristics
• Systemic disease	• Submerged x non-submerged implants
• Periodontal phenotype	• Surgical access
• pre-existing bone dehiscence	• Implant location
• Vestibule deep	• Implant apico-coronal depth
• Aberrant frenulum	• Implant-extraction socket relationships
• Thickness of attached gingiva	• Restorative technique
• Apico-coronal dimensions of the attached gingiva	• Restorative margin x biologic width

(Adapted from Sclar[24], p.4).

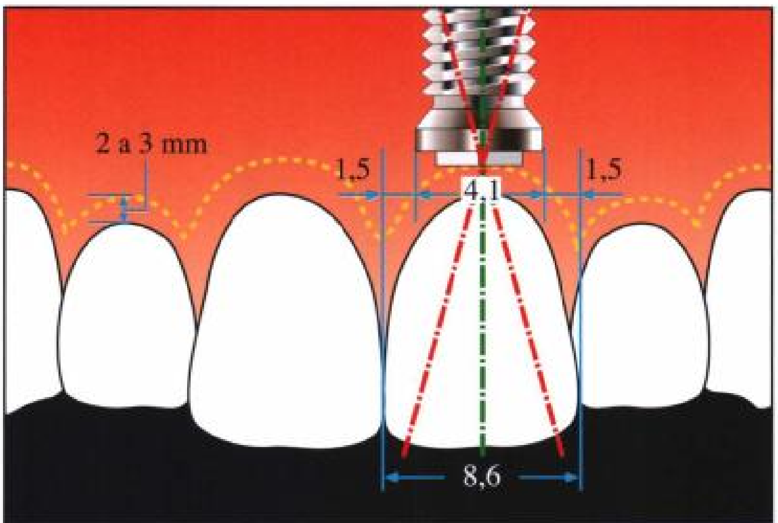
cian must observe bucco-lingual direction during insertion. Precision for implant placement increases in partial edentulous, maxillary arch and in cases with adjacent tooth-implant relationships. For example, a <1mm deviation or 10 degrees in the upper arch can compromise all esthetic planning (Fig. 5.1).

In this way, there is an ideal implant position into the bone tissue to regain esthetics, phonetics and adequate stomatognathic function (Fig. 5.2). Here, we consider the three-dimensional implant positioning: bucco-lingual, mesio-distal, and apico-coronal directions.



5.1

Fig. 5.1A – Ideal implant position. B, a 10-degree angulated implant. Observe superimposing of the implant crown on the adjacent tooth. C, mal positioned implant (1mm to buccal site).



5.2

Fig. 5.2 – Ideal implant position: 1,5mm from the adjacent tooth, 1-2mm from de cemento-enamel junction, and 2-3mm from the bone crest to the cemento-enamel junction.

Mesio-distal evaluation

Premature tooth loss leads to the migration of adjacent teeth to the edentulous areas. Consequently, two aspects are important in mesio-distal evaluation:

1. mesio-distal dimension at the cervical area;
2. the narrowest distance between adjacent teeth.

The suggested ideal space is of 7mm, but it varies according to the tooth to be replaced and the platform diameter of the proposed implant.

Also, 2mm are recommended between implant threads and adjacent root surfaces, and 3mm between adjacent implants to preserve a physiologic septum; besides, the implant must be parallel to the long axis of teeth.

The closer the implant platform diameter is to the mesio-distal dimension, the wider the prosthetic abutment necessary for restoration will be, further compromising the cervical morphology of prosthetic restorations.

Clinical Case 1 – Patient E.B, 28 years-old male. He fractured the middle portion of his lateral incisor (22) during a vehicle accident. After six months, patient was scheduled for implant placement (Fig. 5.3).

Implant placement at the mesio-distal dimension must be at the center of the clinical crown to not jeopardize embrasure region and the gingival papillae to be formed.

Clinical Case 2 – Patient C.M, 26 years-old male. He suffered implant loss at 22, which was replaced by a new titanium fixture (Fig. 5.4).

When the mesio-distal dimension is reduced or there is a narrow crest in the bucco-lingual direction, the available space must be compatible with necessary space for adequate restoration. For this, narrow-platform implants can be used or orthodontic treatment must be considered before implant surgery.

Clinical variables that influence papilla formation:

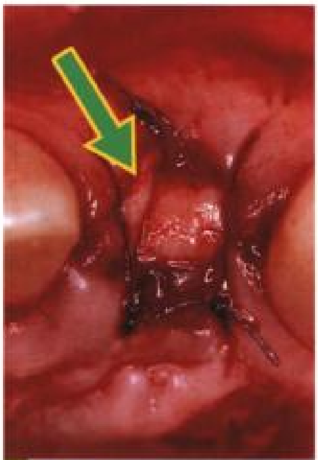
- the tip of the osseous crest between tooth and the implant;
- periodontal biotype;
- the distance between the osseous crest and the interdental contact;
- distance between adjacent teeth or implant (or between adjacent implants);
- shape of adjacent teeth;
- surgical techniques for alveolar ridge maintenance;
- soft tissue maturation time.

For this, it is worthwhile to:

- look for harmony and symmetry of marginal gingival tissue in the periodontal biotype;
- to align the marginal gingival contour along the contra-lateral sides;
- to match the bucco-lingual contours and the emergence profile of the restorations;
- to create pyramidal form of soft tissue papilla in the horizontal and vertical directions;
- to provide the scalloped arch of interproximal papillae.


5.3A


5.3B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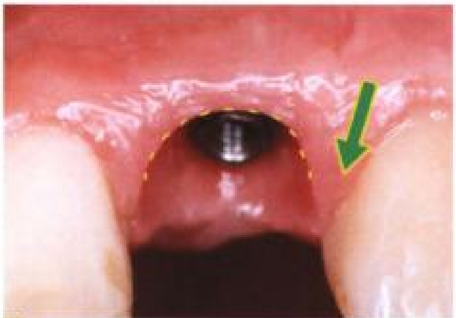
5.3D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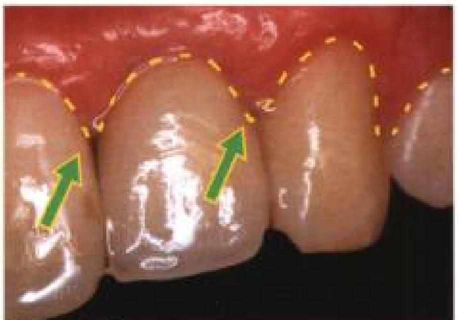
5.3F


5.3G


5.3H

Fig. 5.3A – Periapical radiograph of tooth 22. Middle root fracture due to car accident six months before.

Fig.5.3B – Removal of root fragment.

Fig.5.3C – A connective tissue graft was provided to preserve the remaining soft tissue.

Fig.5.3D – Ideal implant placement with an autogenous graft covered by a Gore-Tex membrane.

Fig.5.3E – Four months after papilla conditioning with provisional acrylic crown. Observe soft tissue maturation and the final emergence profile.

Fig.5.3F – CerAdapt abutment and Procera crown.

Fig.5.3G – One year after crown cementation. Observe maintenance of soft tissue profile and esthetics.

Fig.5.3H – Periapical radiograph after one year.

Fig.5.4A – Poor esthetics in the implant cervical zone.

Fig.5.4B – Implant fracture at its apical portion.

Fig.5.4C – Three months after implant removal. Observe great loss of soft and hard tissues.

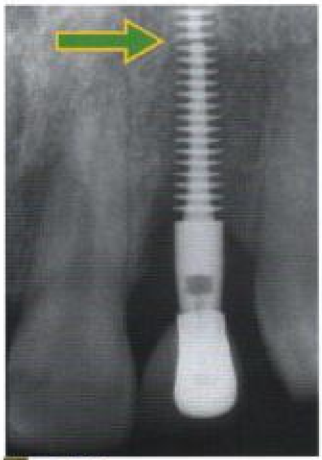
Fig.5.4D – Ideal implant placement at mesio-distal dimension.

Fig.5.4E – Autogenous bone graft and Gore-Tex membrane.

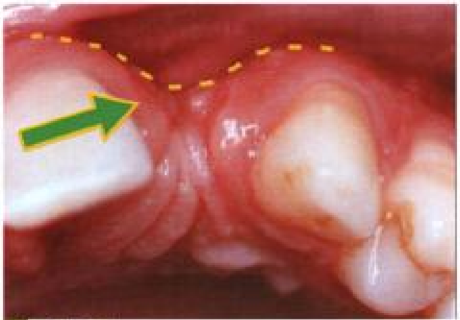
Fig.5.4F – Six months after implant placement. Observe irregular soft tissue contour at the buccal surface.

Fig.5.4G – Observe osseous guided regeneration on tooth 22.

5.4A



5.4B



5.4C

5.4D

5.4E

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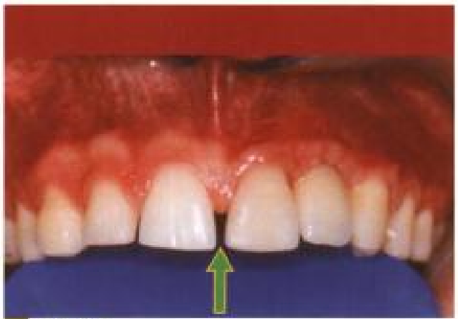
5.4G


5.4H


5.4I


5.4J


5.4K


5.4L


5.4M

Fig. 5.4H – A surgical envelop was made to augment the buccal contour.

Fig.5.4I – Six months after tissue conditioning with provisional crown.

Fig.5.4J – Occlusal view.

Fig.5.4K – Metal-free crown. The diastema in the midline was maintained.

Fig.5.4L – Final periapical radiograph. The apical portion of the fractured implant was preserved.

Fig.5.4M – Clinical aspect after three years. Observe excellent esthetics.

Bucco-lingual evaluation

In the bucco-lingual dimension, the retention mechanism proposed (screwed or cemented) must be considered. As an example, for cemented prostheses, the implant long axis must coincide with the tooth long axis. On the other hand, the implant must coincide with an imaginary point between the incisal edge and the cingulum. Variations on these culminate into mal-positioned implants (Fig. 5.5).

Two aspects must be considered here:

- The implant must be surrounded by at least 1mm of healthy bone tissue and be positioned at the center of the alveolar ridge due to biomechanical factors (Fig.5.6).

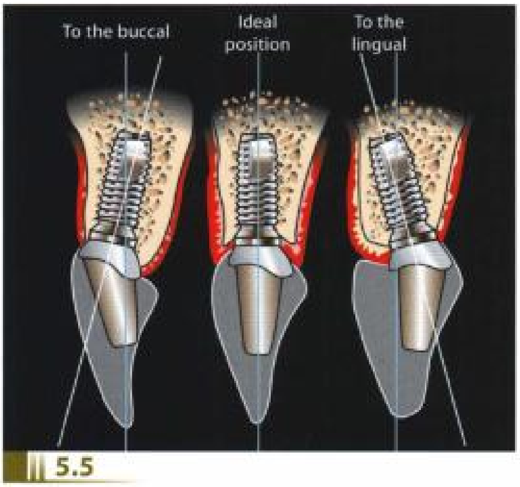


Fig.5.5 – Observe different implant angulations. **A**- to the buccal, **B**- ideal position, **C**- to the lingual.

- The implant must favors the crown's emergence profile. However, an accentuated osseous concavity in the apical-coronal direction will force the implant to be inclined bucally. Thus, the clinician must find a "compatibility region", otherwise, new planning for hard tissue surgery will be necessary to satisfy esthetic demands (Fig. 5.7).

Also, it is important to observe:

- implant platform position related to median center of the bone crest;
- implant angulation related to implant platform.

An implant platform extremely positioned to the buccal can generate and emergence profile more apical than that of the adjacent teeth, or a secondary gingival recession due to the lack of bone support (commonly seen in the thin-scalloped periodontal biotypes). This happens in immediate implant placement when the extraction socket is used as surgical guide (Fig. 5.8). On the other hand, an implant platform positioned to lingually will generate prosthetic overcontouring, which inhibits adequate oral hygiene. Also, screw loosening and cement dissolution can occur. In both cases, occlusal forces are unfavorable.

Most authors agree that the implant must be positioned slightly to the lingual because if favors optimal resistance to lateral forces through bicortical stabilization.

Saadoun, Lê Gall and Touati[11] reccomended to positioning the implant 5 to 10 degrees to the lingual, leaving sufficient bone thickness of 1.5-2.0mm in the buccal region.

An unfavorable situation for implant positioning (e.g., bone resorption, concavities, dehiscence, fenestrations, or trauma situations) can be corrected by means of GBR.

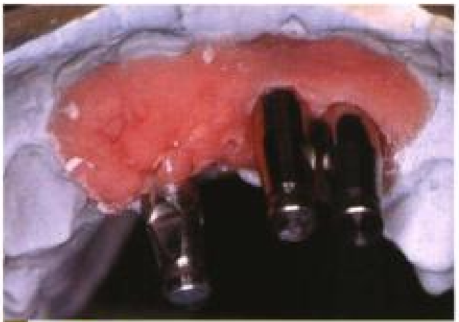
For screwed prostheses, the implant axis must coincide with the dental cingulum; on the other hand, it can be aligned with the incisal edge when the prosthesis has to be cemented, which contributes to an esthetic emergence profile.

In addition, implant positioning must consider occlusal schemes and the prosthetic options: adequate canine guidance and lateral excursions, with occlusal loads directed to the long axis of the fixture.

5.6A

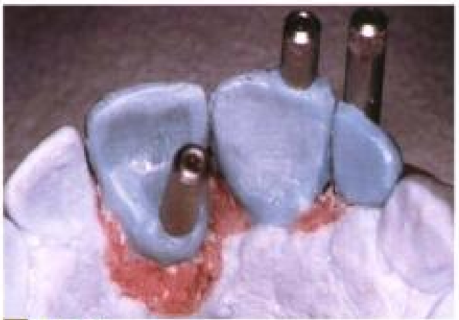
5.6B

5.6C



5.6D

5.6E



5.6F

5.6G

Fig.5.6A – A 32-year-old female patient that suffered a bicycle accident. She was treated with an iliac block crest graft and three implants were placed without planning.

Fig.5.6B – The element 11 is far positioned to the lingual and the elements 21 and 22 to the buccal.

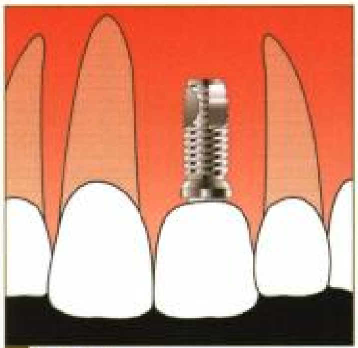
Fig.5.6C – Clinical lateral view. Observe incorrect angulations.

Fig.5.6D – Study cast.

Fig.5.6E – Diagnostic wax-up showing incompatibility between implant position and esthetics.

Fig.5.6F – The element 11 is far to the buccal.

Fig.5.6G – This arrangement will prevent correct oral hygiene. The transfer screws were removed to better visualize final esthetics.


5.7A


5.7B

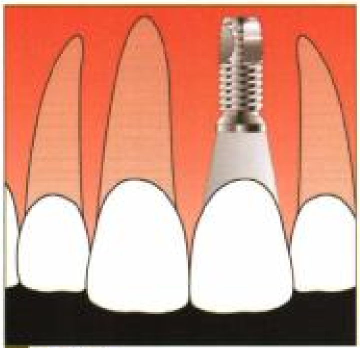

5.7C

Fig.5.7 – The apico-coronal position can affect crown contour and pocket depth. **A**- the implant is positioned too coronally. A short crown with overcontouring is observed. **B**- 2-3mm form the cemento-enamel junction is the ideal position. **C**- implant is positioned too apically (4mm or more) which creates an excessive gingival sulcus and prevents effective oral hygiene.

Fig.5.8A – This 17-year-old female patient has a high lip line. An implant was positioned at the 11 region. The final crown was too long and narrow, and the patient rejected the treatment.

Fig 5.8B – The implant was placed far to the buccal. A suppuration point can be observed.

Fig.5.8C – Final esthetic aspect.


5.8A


5.8B


5.8C

Apico-coronal evaluation

The implant platform must be positioned 2 to 3mm above the line of the cemento-enamel junction of the adjacent tooth if present. In cases without a dental reference, the implant must be 1.0-1.5mm from the bone crest. When there is a thin keratinized mucosa, additional length (1.0mm) to the surgical bone level is recommended. Variations on these schemes generate shallower and deeper periimplant sulcus, with adjoining long or short teeth.

When the implants are positioned too coronal, the crown contours can be flatter, and a grey hue is visible at the gingival margins. On the other hand, implants too apical will generate false periodontal pockets, susceptible to mucositis and periimplantitis (Fig 5.9).

To summarize, the implant position depends on the soft tissue and the distance from the bone crest to the occlusal plane. Three factors must be considered:

- the implant-abutment junction at the transition level, which represents the starting point for the subgingival emergence profile;
- the abutment-prosthetic crown junction, which corresponds to the cervical margin of a tooth-supported fixed partial prosthesis;
- the cemento-enamel junction of adjacent teeth, surgical reference for apico-coronal implant position.


5.9A


5.9B


5.9C


5.9D

Fig.5.9A – This 40-year-old female patient was upset with her final esthetics in the 21 region.

Fig.5.9B – Periapical radiograph.

Fig.5.9C – Clinical view of the implant site.

Fig.5.9D – Implant removal. Observe great bone loss.

Clinical Case 3. Patient D.F., 16 years-old female. When she was 9-years-old, the dental element 11 was extracted due a car accident. Orthodontic treatment was performed and the patient was screened for implant placement at the age of 15 (Fig. 5.10).

An adequate implant emergence profile must blend with that seen in natural teeth. Also, as the implant platform diameter approaches the cervical region of dental element to be replaced, less space is available for the prosthetic abutment.[12]

The transition space means the interplay among the implant platform, periimplant marginal area, and the prosthetic restorative margin. The mucogingival state of this space serves to cover the abutment-prosthetic crown junction, being very important when the periodontal biotype presents insufficient height and thickness of keratinized mucosa.

During prosthetic component selection, two elements must be considered:

- alloy (titanium, noble materials)
- component's cervical wall shape at the transition space; it must represent the diameter of the definitive prosthesis and provide an adequate (harmonious and progressive) emergence profile.

Consequently, the apico-coronal abutment positioning depends on:

- bone morphology;
- apical level of the fixture;
- difference between implant platform and prosthesis diameter;
- interarch distance.


5.10A


5.10B


5.10C


5.10D

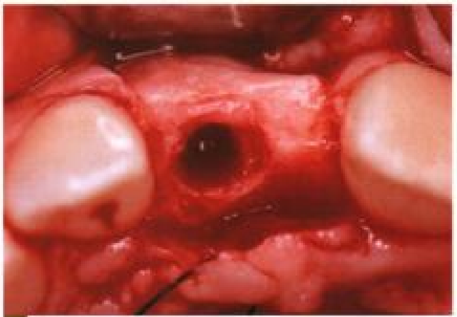
Fig.5.10A – Absence of papillae is visible.

Fig.5.10B – Periapical radiograph. Observe the extension of nasopalatine duct.

Fig. 5.10C – The neurovascular content was removed. Observe bone loss in the buccal region.

Fig.5.10D – Autogenous bone graft and Gore-Tex membrane in the exposed site.

5.10E



5.10F

5.10G

5.10H

5.10I

Fig.5.10E – Periapical radiograph 8 months after grafting procedure. Observe complete healing at the nasopalatine duct.

Fig.5.10F – Apico-coronal implant positioning.

Fig.5.10G – Buccal view of the exposed site.

Fig.5.10H – Five months after soft tissue conditioning. Observe papillary formation.

Fig. 5.10I – Final clinical aspect of the definitive prosthesis. An excellent esthetics was obtained.

Keratinized gingival tissue

Unlike the tooth supported fixed partial denture, the implant-supported prosthesis needs periimplant keratinized mucosa to achieve esthetic and functional integration of the restoration (Fig. 5.11).

The presence of keratinized mucosa around osseointegrated implants can be regarded as an important factor from the biological maintenance standpoint (Fig. 5.12).

Myasato at al.[13] stated that the height of attached mucosa around implants is not relevant, once the

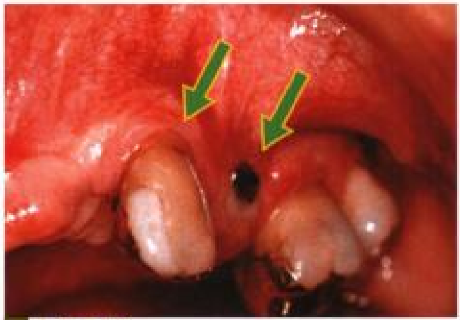
Fig. 5.11A – A 42-year-old female patient. An implant was inserted in the region of 24. Observe the lack of keratinized tissue.

Fig.5.11B – A free gingival graft was made at the region of 23 and 24 to improve the vestibular fornix as well.

Fig. 5.11C – Pos-operative view 15 days after.

Fig.5.11D – Three months after surgery. A cast post-core restoration was made in the canine. Observe the quality of soft tissue around the implant.

Fig.5.11E – Six years after prosthesis delivery. Observe preservation of keratinized mucosa and excellent esthetics around tooth and implant.



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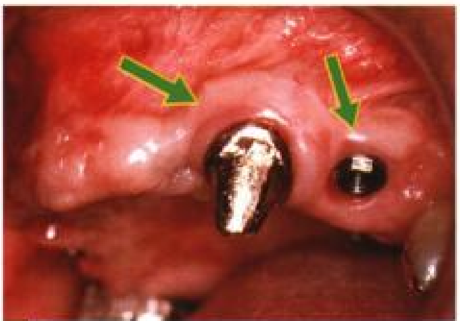


5.11E

periimplant tissue integrity can be guaranteed through adequate procedures.

Wennstrom et al.[14]affirmed that proper control of the bacterial plaque can be effective for tissues with insufficient keratinized mucosa, but still periimplant tissue present a poorer barrier to the bacterial challenge than periodontal tissues.

Block and Kent[15] argument that the height of keratinized gingival does not relate to the degree of inflammation; however, implants surrounded by a keratinized tissue presented fewer deep pockets and had a better prognosis. Schou et al.[16] stated that the direction of connective tissue fibers is related to the type of periimplant mucosa: perpendicular in case of a keratinized tissue and parallel in non-keratinized samples. On the other hand, Meffert[17] arguments that more periimplantitis and mucositis can be found without keratinized mucosal tissue.

Itic and Poirel[18] pointed out that an intra-sulcular prosthetic extension or muscular attachment near the gingival site requires a band of keratinized tissue.

When there is a barrier of keratinized gingiva around the implant, the periimplant soft tissues can resist better to mechanical aggressions (Fig. 5.12).[19]

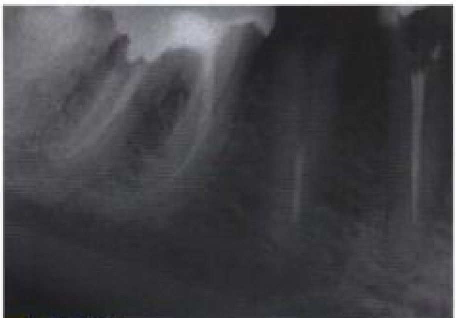
The creation of height and thickness in the surrounding gingival tissue provides adequate texture, color, harmony, balance and morphological continuity for teeth or implants.

The periodontal biotype (thin-scalloped), a gummy smile, reduced periodontal level and the lack of adequate hard and soft tissue contours can generate an interesting long-term tissue homeostasis.[20]

Advantages of keratinized gingival around teeth and implants

- it favors an esthetic integration for the restoration;
- emergence profile conditioning;
- acts like a barrier during inflammation;
- improves gingival tissue homeostasis ;
- stabilizes the gingival margin;
- resist to mechanical aggressions;
- facilitates daily plaque control and oral hygiene procedures;
- facilitates prophylaxis for the clinicians;
- facilitates impression procedures
- can masquerade the implant-prosthesis connection;
- comprises the transition space for implant prosthesis.

Although is generally accepted that an stable periimplant soft tissue promotes a transmucosal barrier against exogenous irritants and provides sufficient structural stability to resist mechanical injuries in the oral cavity, the literature have questioned whether those attached tissues are really necessary around osseointegrated implants and/or offer long-term biological advantages to the underlying mucosa. The clinician has to bear in mind that several factors can influence the health of periimplant tissues and titanium fixtures. Thus, it is difficult to cite one specific study that tries to respond the above question. Until evidenced-based studies have been published, the need for an attached gingival tissue must be based on clinical observations.


5.12A


5.12B

Fig.5.12A – A 48-year-old female patient. Periapical radiograph of tooth 45 showing an oblique fracture.

Fig.5.12B – Removal of root fragments. Observe fracture level.

Fig 5.12C – Observe height discrepancy between buccal and lingual bone walls after curettage and soft tissue removal.

Fig.5.12D – A resorbable membrane (Resolute) was used to protect the alveolar ridge.

Fig.5.12E – Gore-Tex suture.

Fig.5.12F – Five months after removal. Observe the absence of vestibular fornix and keratinized mucosa.

Fig.5.12G – Receptor site preparation for free gingival graft

Fig.5.12H – The graft is stabilized through sutures.

Fig.5.12I – Periapical radiograph six months after tooth extraction.

Fig.5.12J – Three months after surgery. There is an excellent band of keratinized gingival and the deepening of vestibular fornix was achieved.


5.12C


5.12D


5.12E


5.12F


5.12G


5.12H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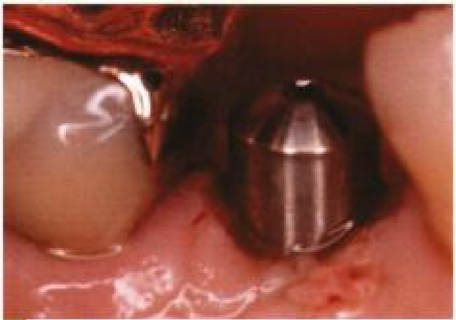

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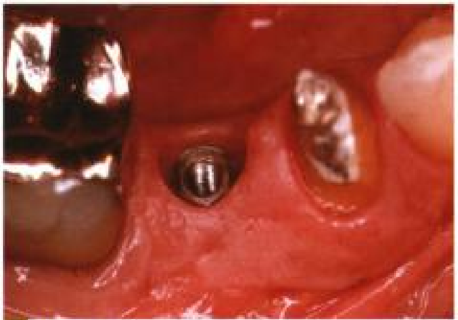

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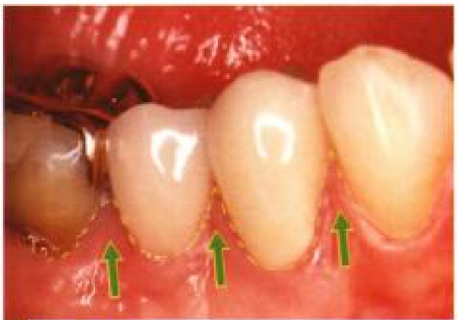

5.12P

5.12Q

Fig.5.12K – The leveling of buccal and lingual bone walls was obtained just with clot protection.

Fig.5.12L – Radiograph three months after implant placement.

Fig.5.12M – A circular punch was used to uncover the implant. Note the need for sutures.

Fig.5.12N – Observe the excellent soft tissue quality around the element 44 and the implant.

Fig.5.12O – Clinical aspect after two years. A single implant crown in the 45 region and a metalloceramic crown in the element 44

Fig.5.12P – Clinical aspect after five years. Observe the integrity of surrounding soft tissue (arrows).

Fig.5.12Q – Clinical aspect after seven years. The buccal fornix and a healthy gingival tissue.

Periodontal biotype

Becker et al.[25] pointed out to the existence of three periodontal biotypes: flat, scalloped and a pronounced scalloped pattern. Measurements were made from the height of the interdental bone to the alveolar crest, giving the following results:

- flat:2.1mm
- scalloped: 2.8mm
- pronounced: 4.1mm

Here, it is important to observe that the distance in the pronounced scalloped anatomic profile is two times the distance seen in the flat type.

Ochsenbein and Ross[26], Weisgold et al.[27], Olsson and Lindhe[28] and Kois[21] suggested two periodontal biotypes: a thick-flat and a thin-scalloped pattern. The periodontal biotype depends on the dimensions of the underlying structures, which influence the nature of clinical decisions (Box. 5.3A, B).

Advantages of attached gingival tissue around osseointegrated implants

- facilitates impression procedures;
- the soft tissue does not collapse over the implant top;
- the gingival height is maintained in a constant and predictable level;
- generates an esthetic harmony for all implant modalities;
- there is a compact, firm tissue around the implant;
- helps the plaque control;
- helps the dental hygienist;
- soft tissue integrity is better achieved than in the presence of an alveolar mucosa;
- a better prognosis of both soft and hard tissues before tooth extraction can be obtained through the judgment of five factors[21]:
  - relative tooth position
  - periodontal contours
  - periodontal biotype
  - tooth shape
  - the height of the bone crest

Thus, the clinical decision is even more complex: a tapered tooth with poor prognosis, surrounded by a thin and scalloped periodontium, represents a considerable risk of buccal recession and dark interproximal spaces after its extraction and implant positioning. However, if the tooth is more coronal than apical, and the biological width is less than 3mm in the proximal and buccal sites, the case can be managed with acceptable predictability.

The most favorable situation means a square tooth with a thick-flat periodontium, and less than 3mm from the contact point to the bone crest; flap or flapless surgery can be formed here with a long-term success of implant and the prosthetic restoration (Fig. 5.3C).

Box 5.3A- Clinical characteristics of periodontal biotypes

Thin-scalloped	
Position of marginal and interproximal gingiva	Accentuated disparity
Soft tissue characteristics	Flabby Translucent Fragile and brittle
Masticatory mucosa	Less amount of attached tissue
Nature of the underlying bone Keratinized gingiva Quality quantity	Thin and scalloped (dehiscence and fenestrations) Less keratinized Limited
Associated tooth shape	Less convexity in the cervical third Reduced contact point in the occlusal thirds Tapered Free gingival margin = cemento-enamel junction or superior
Tissue response to aggressions	Recession with loss of interproximal papillae, with deepening of periodontal pockets
Posterior cuspids	Inclined, stepper
Prognosis and predictability	Difficult (need for soft tissue surgery, e.g, free gingival graft).

Box 5.3B- Clinical characteristics of periodontal biotypes

Thick-flattened	
Position of marginal and interproximal gingiva	Minor disparity
Soft tissue characteristics	Dense, opaque, fibrous
Masticatory mucosa	Great amount of attached tissue
Nature of the underlying bone Keratinized gingiva Quality quantity	Wide Thick Well-keratinized Sufficient
Associated tooth shape	More convexity at the cervical third Contact point = surface contact Squared Free gingival margin= flatter cemento-enamel junction
Tissue response to aggressions	Pocket or gingival hypertrophy
Posterior cuspids	Shallow, flat
Prognosis and predictability	Favorable conditions

Box 5.3C- Factors that determine the periimplant esthetic success

Favorable/ low risk		**Unfavorable/high risk**	
Tooth position	more coronal	Tooth position	ideal
Free gingival margin		Free gingival margin	
Gingival contours	flat	Gingival contours	scalloped
Periodontal biotype	thick	Periodontal biotype	thin
Tooth shape	square	Tooth shape	taper
Bone crest position	high	Bone crest position	low
– <3mm at buccal and interproximal sites		– (>4mm at buccal and interproximal sites)	

(Adapted from Kois[21], p.206)

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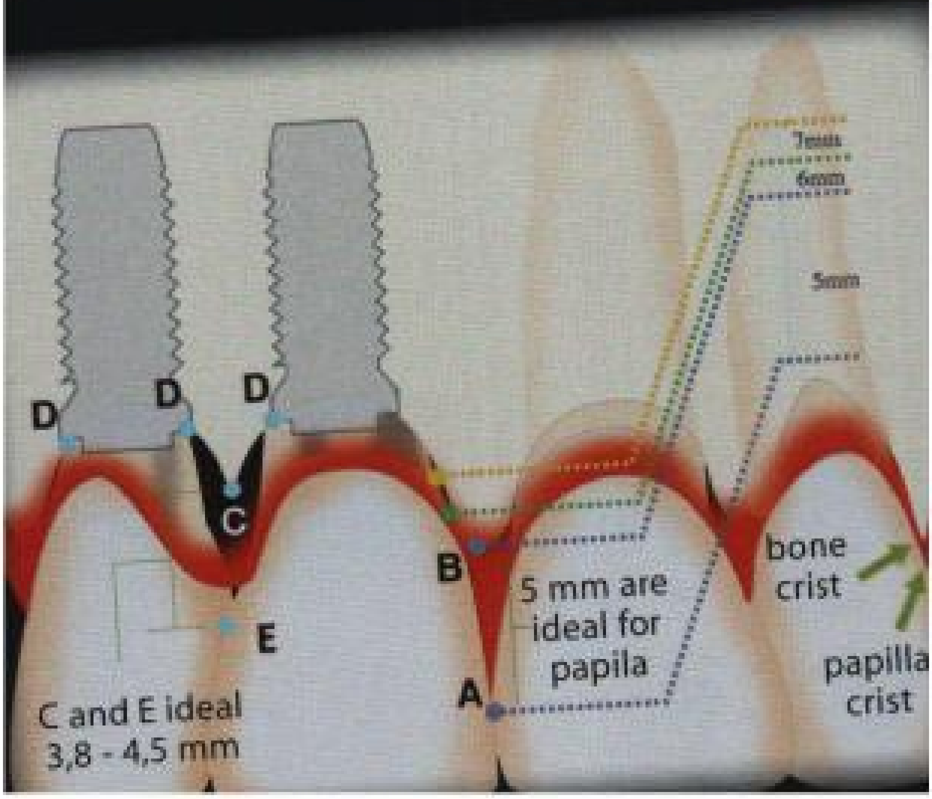
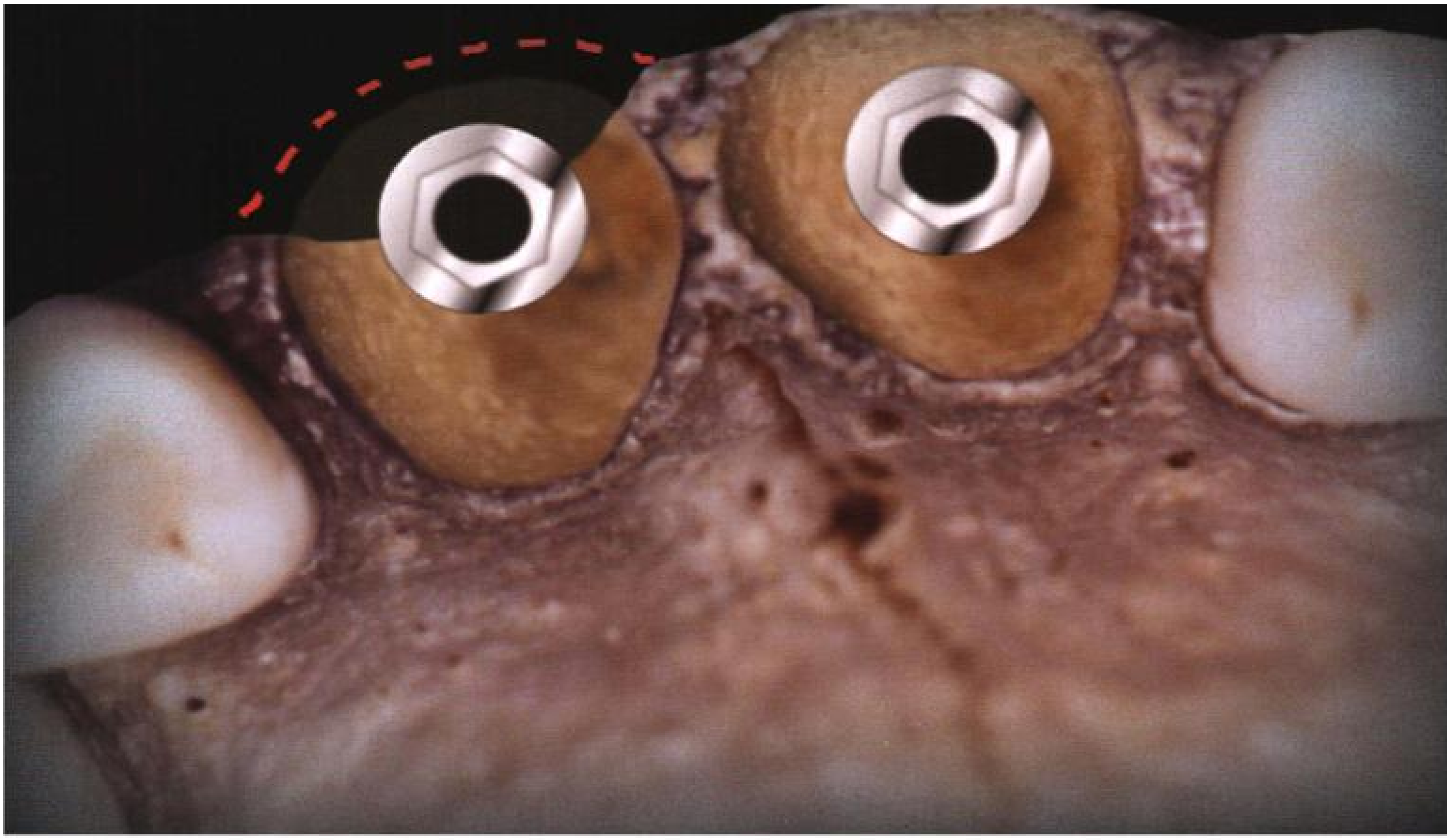




Soft Tissue Conditioning

Soft tissues: their importance and management in implantology

Initially, achievement of a stable, direct bone-to-implant contact was the main objective in Implantology, as well as the need for bone grafting procedures and their respective donor areas, problems on bone quantity and quality, etc. However, in recent years, an increasing esthetic demand and the search for more natural looking prosthetic materials drove our attention to the treatment of soft tissue imperfections, especially at the emergence profile area. Questions such as the presence of keratinized gingival tissue around implants, papillae formation through surgery, and the soft tissue complications after implant placement created a new and interesting scenario. For example, James[1], and Bauman et al.[2] believe that there is little relationship between the keratinized tissue and the implant success, while others argument that a band of attached mucosa is extremely important.[3]

When a natural tooth presents without an adequate band of keratinized tissue and a gingival recession is evident, the clinician needs to know why, when, and how to performance the best surgical technique for this situation. On the other hand, the same above considerations are very important because an injured soft tissue around a fixture already in function has a poorer prognosis.

For this, it is strongly reco mmended to obtain an adequate band of keratinized gingiva before implant insertion or during the second surgical stage. The importance of a keratinized tissue is described in the Box 6.1.

In this chapter, we will focus our attention to surgical strategies in hard and soft tissue manipulation, aiming to create, preserve or improve the emergence profile and the final esthetic appearance.

Soft tissues

The soft tissue has its role on papillae formation, emergence profile, acts like a barrier against mechanical trauma (e.g, toothbrushing) and microbial infections (mucositis, periimplantitis).[4] In addition, an adequate band of keratinized tissue during surgery can be necessary for vestibuloplasty procedures, to augment height and width of the anterior alveolar ridge (esthetic zone), and to help during primary soft tissue healing after fixture placement.[5,6] Also, it enhances passive tissue closure during bone grafting procedures and prevents implant premature exposition to the oral cavity.[8]

The following techniques can be used to create, augment or improve the band of keratinized tissue around osseointegrated implants.

Hard and soft tissue manipulation

- Free gingival graft
- Connective tissue graft
- Palatal sliding strip flap
- Abram's technique (envelop technique)
- Other mucogingival surgeries

Box 6.1. Advantages of keratinized gingiva around implants

Esthetics: facilitate papillae formation, with a more natural emergence profile in the anterior esthetic zone
Protection: the gingival margin becomes more resistant to recession, which in turn prevents implant thread exposure
Prevention of inflammatory process due to presence of less vessels
Protection against mechanical trauma (toothbrushing, root planning)
Excessive movement of the free gingival margin is avoided and thus implant thread exposure
Aids in primary healing intention after implant placement in the oral cavity
Management: it facilitates impression procedures and prosthesis fabrication
The periimplant mucosa does not collapse over the implant platform

However, partial or completely edentulous patients still present a great challenge since the achievement of ideal soft and hard tissue profile is difficult due to variations on bone resorption patterns. The aim of surgical reconstruction is to develop an adequate form, height and soft tissue quantity to avoid esthetic problems by means of bone regeneration or soft tissue manipulation techniques.

Classification according to keratinized tissue quantity

Considerations on the location and quantity of the keratinized tissue must be addressed even before implant planning and placement. The purpose here is to improve the final esthetic result. It is important to have in mind that the timing and surgical procedure elected for soft tissue management largely depends on the available keratinized tissue.

Ono, Nevins and Capetta Classification[8]

This classification is based on keratinized tissue around proposed implant site (Fig.6.1):

Type I. More than 5 mm of keratinized mucosa overlying the partial or completely edentulous ridge. Flap can be apically positioned to augment thickness of labial tissue.

Type II. Less than 5 mm of keratinized mucosa is found. This group can be divided into:

Type II, *Class 1:* minimal keratinized tissue at the alveolar ridge crest, with less or no tissue at the labial area. Also, sufficient attached gingival tissue on the lingual side can be found. A free gingival graft would address deficiencies on the labial side.

Type II, *Class 2.* The tissue on the lingual side will be excised. A free gingival graft is performed on the labial side and the flap is apically positioned on the lingual side to augment keratinized tissue on both sides.

Type III. Keratinized tissue is not found overlying either alveolar crest or labial side. A free gingival graft is indicated to augment the labial side along with apically flap positioned flap (Fig. 6-2).

Miller's classification[9]

Class I: marginal tissue recession that does not extend to the mucogingival junction. There is no periodontal loss (bone or soft tissue) in the interdental area, and 100% root coverage can be anticipated. There is a favorable prognosis for a free gingival graft.

Class II: marginal tissue recession that extends to or beyond the mucogingival junction. There is no periodontal loss (bone or soft tissue) in the interdental area, and 100% root coverage can be anticipated. Guided tissue regeneration with membrane and free gingival graft is favorable.

Class III: marginal tissue recession that extends to or beyond the mucogingival junction. Bone or soft tissue has been lost from the interdental area, or malpositioning of the

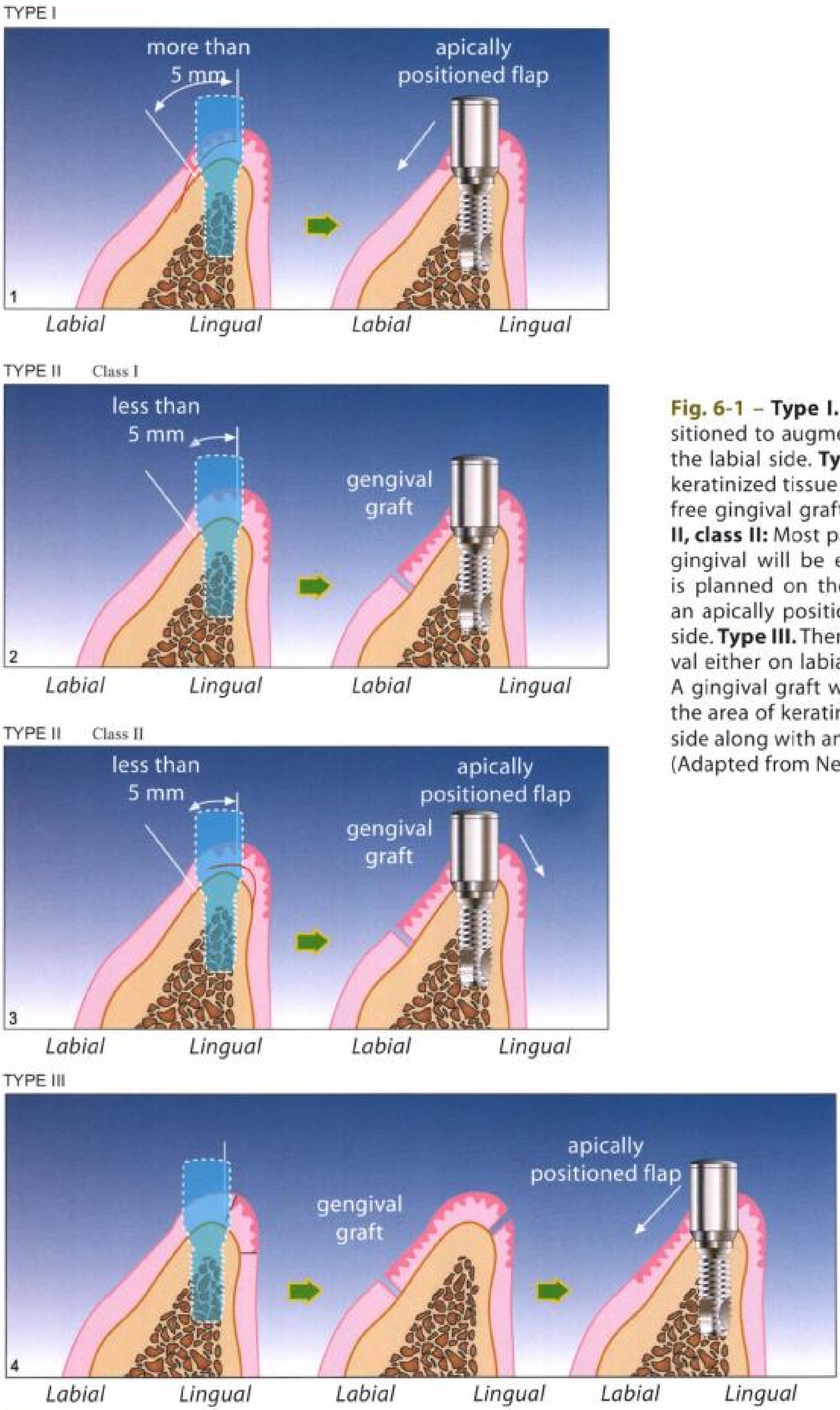
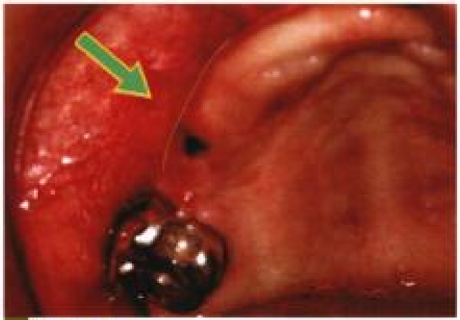


Fig. 6-1 – **Type I.** flap can be apically positioned to augment keratinized tissue on the labial side. **Type II, class 1:** less or no keratinized tissue is found on labial side. A free gingival graft is recommended. **Type II, class II:** Most part of lingual keratinized gingival will be excised. A gingival graft is planned on the labial side along with an apically positioned flap on the lingual side. **Type III.** There is no keratinized gingival either on labial or alveolar ridge crest. A gingival graft will be made to augment the area of keratinized tissue on the labial side along with an apically positioned flap. (Adapted from Nevins & Mellonig[8], p.231).

6.1



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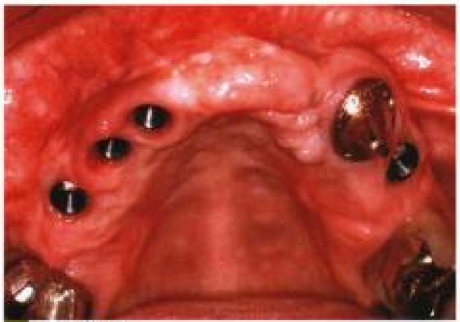

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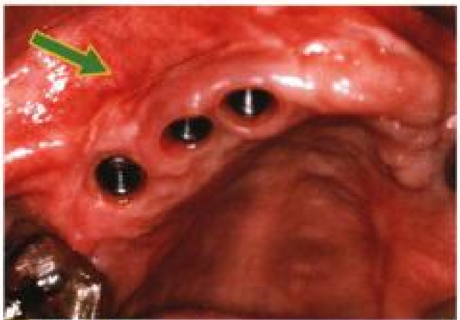


6.2E

Fig. 6.2A – This 45-year old female patient presented a Class III defect according to Ono, Nevins and Capetta[8]. Second surgical stage. The implant is in the region of 16. Note the lack of keranitized mucosa and the vestibular fornix.

Fig. 6.2B – preparation of receptor area for a free gingival graft.

Fig. 6.2C – Observe the donor site area (arrow). The free gingival graft was stabilized by sutures.

Fig. 6.2D – Three months after surgery. Now there is adequate keratinized mucosa and vestibular fornix near the implants.

Fig. 6.2E – Clinical view after 8 months. Observe the stability of soft tissues.

teeth prevents the attempt to achieve 100% root coverage. Partial root coverage can be anticipated.

Class IV: marginal tissue recession that extends to or beyond the mucogingival junction. The bone or soft tissue loss in the interdental area and/or the malpositioning of teeth is so severe that root coverage cannot be anticipated (Fig. 6.3).

Aspects related to esthetics

A multidisciplinary team is fundamental to achieve success during esthetic planning. In the anterior maxillary region, some considerations can be made[10]:

6.3A

6.3B

6.3C

6.3D

Fig. 6.3A – Miller's Class I.

Fig. 6.3B – Miller's Class II.

Fig. 6.3C – Miller's Class III.

Fig. 6.3D – Miller's Class IV.

- the proposed edentulous area must have adequate bone volume. This can be provided through alveolar distraction osteogenesis and/or graft techniques, before or during implant placement;
- implant insertion must be accurate and planned according to the prosthesis;
- the implant-abutment interface must be stable and margin gaps reduced to acceptable parameters;
- an adequate emergence profile is mandatory;
- the prosthesis must look like natural tissues.

The esthetic discipline on Implantology aims to create soft tissue harmony without abrupt changes on scalloping, bone crest and papillary height configuration[10].

During papillary creation, two important anatomic structures must be observed:

- bone crest height at interproximal areas;
- labial cortical plate height and thickness.

Factors that determine papillae formation between two adjacent implants

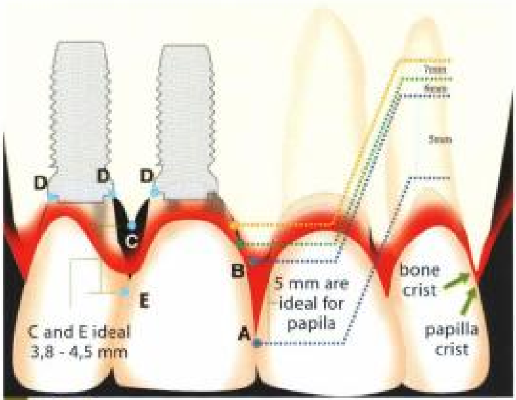
Tarnow et al.[10] demonstrated that the distance from the crest of bone to the base of contact area could be correlated with the presence or absence of the interproximal papilla in humans. When the distance was 5 mm, papilla completely fills the interproximal area. When the distance was 6 mm, the papilla was present 56% of time, and when the distance was 7 mm or more, the papilla was present 27% of the time or less (Fig. 6.4).

Salama et al.[11] suggested that the presence, contour, and thickness of periimplant papilla can be influenced in the same manner. They determined that interproximal height of bone between tooth and implant would be of 5.5 mm, between adjacent implant of 4.5 mm, and between adjacent teeth of 5 mm (Fig. 6-5).

These authors stated that predictable esthetics can be achieved only when lip line and bone scalloping favors adequate soft and hard tissue contours. Clinical observations suggested a prognostic classification system for the periimplant papillae (PPL). Their classification is based on the available interproximal height of bone for the maxillary anterior sextant.

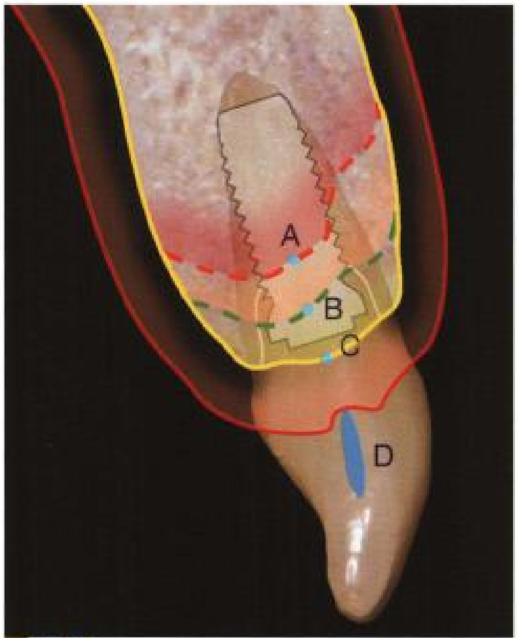
Choquet & Hermans (2001)[12] evaluated the papilla level adjacent to single-tooth implants. These authors determined that, when the height of bone crest to the proximal contact point was 5 mm, the papilla was present in 100% cases. However, when the same height was >5 mm, the papilla was present in less than 50% cases.

Similar findings were presented by Adell et al.[13], showing that a minimal distance of 1.25 to 1.5 mm between implant and the adjacent tooth is necessary to promote osseointegration and prevent damage to the dental organ. However, their observations were based on the thickness of the adjacent periodontal liga-



6.4

Fig. 6.4 – Schematic representation of relationship between bone crest height and interproximal papilla. **A**. Apical extension of contact point. **B**. interproximal bone height between natural teeth (bone crest). **C**. interproximal bone height between adjacent implants. **D**. implant top. **E**. Contact point between implants.



6.5

Fig. 6.5. Class 1 **(C)**: optimal prognosis for esthetic restorations; 2 mm from cementoenamel junction to contact point areas. IHB is 4 to 5 mm. Class 2 **(B)**: guarded prognosis; 4 mm from the cementoenamel junction to the contact point areas. IHB is 6 to 7 mm. Class 3 **(A)**: poor prognosis; >5 mm from the cementoenamel junction to the contact point areas. IHB is >7 mm. **(D)**: contact point.

ment. Today, it is also necessary to consider other requirements for papillae preservation and management (Saadoun et al., 1999)[14].

Papilla formation between two or more adjacent implants

Tarnow et al.[10] had already determined that a distance of 3 mm between adjacent implants is necessary to form or maintain the papillae. Their studies[15] published in 2000 shown in 36 patients that considerable bone loss can be seen when the distance between adjacent implants is less than 3 mm. Also, mesial and distal bone loss were of 1.34 mm and 1.40 mm, respectively, whereas 0.45 mm of lateral bone loss was seen with more than 3 mm between adjacent implants (Fig 6.6). They concluded that a 3 mm distance between adjacent implants or between tooth and implant is necessary to provide space for papilla. Also, crest bone loss is avoided and adequate emergence profile is created to facilitate oral hygiene and esthetics[16]. Besides, this study pointed out that is more difficult to form papilla between adjacent implants than in the tooth-implant situation.

Also, Tarnow et al.[16], in 2003, found the mean height of papillary tissue between adjacent implants was 3.4 mm, with a range of 1 to 7 mm. Also, probing depths were 2 mm in 16,9% cases, 3 mm in 35,3% cases, and 4 mm in 37,5% cases.

Grunder[61] stated at the 8[th] Symposium on Periodontics & Restorative Dentistry in Boston that a distance of 4 mm would be ideal to form papilla between adjacent implants.

According to the above cited situations, it is possible to conclude that one of the determining factors for papillary tissue formation between tooth/implant or between adjacent implants is the vertical distance from the bone crest to the contact point. Other important factors are listed in the Box 6.2.

CAUSES FOR PAPILLARY LOSS

Papillary loss can be due to periodontal treatment, surgical excision, trauma from extraction, apically positioned flap, periodontal biotype, etc. (Box. 6.3).

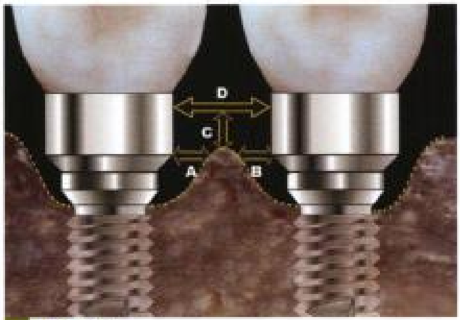
Classification for papillary loss

The development of new techniques for papillary augmentation must be benefited from a classification system for loss of papillary height. Nordland and Tarnow[18] determined a classification for papillary height loss in natural teeth. The contact points between adjacent tooth crowns and the distance from the cemento-enamel junction (CEJ) were used as reference marks. Also, Jemt[20] described a similar classification for implant-supported prostheses in 1997. Standardized photographs were taken from papillary contours within a 3-year period.

Fig. 6.6A – A and B, distance from implant to osseous crest; C, vertical bone loss; D- interimplant distance.

Fig. 6.6B – The distance between adjacent implants is ≥ 3 mm. Note bone crest height and papilla formation.

Fig. 6.6C – When the distance between adjacent implants is ≤ 3 mm, a lack of bone crest height and papilla is observed.



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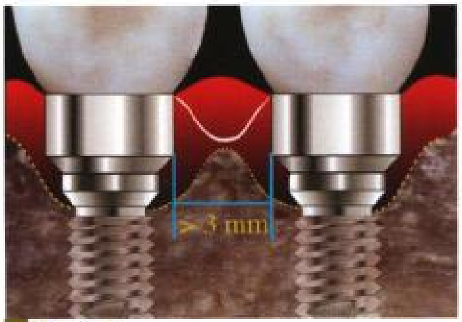

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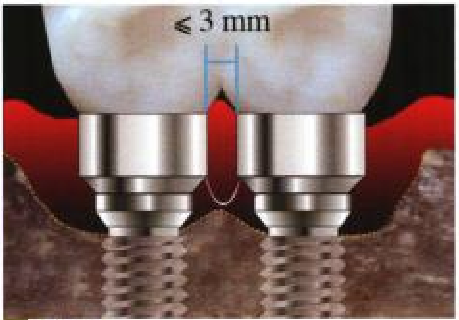

6.6C

Box 6.2 – Clinical conditions seen on tissue deficiencies in the anterior esthetic zone

Conditions	Cause and effect
Anatomic deficiency; the alveolar buccal process is lost; narrow alveolar crest	Cause: congenital tooth loss Effect: extensive bone loss
Pathologic condition	
Dental trauma	Tooth avulsion with fracture of buccal bone plate
Pos-traumatic conditions	Root ankylosis with infra-occlusion, resorption and root fracture
Acute or chronic infections	Periodontal disease, endo-perio lesion, periapical lesion
Bone atrophy	Long-term tooth loss

(Adapted from Belser et al.[62], p.44).

The distance from the highest point of the papillary tissue in the buccal region and the contact between adjacent tooth/implant crowns was registered and this information was used to create the following classification.

Box 6.3 – Factors that influence the presence or absence of interdental and interimplant papilla

Height of the alveolar crest	
Vertical – 1 to 3 mm (Gargiulo et al., 1961)	
2.1 to 4.1 mm (Becker et al., 1997)	
Horizontal – 3 mm (Tal, 1984)	
Interproximal dimension	
(distance from the contact point to the bone crest)	
Single implants	<5 mm (Choquet & Hermans, 2001)
Between adjacent implants	<3,5 mm (Tarnow et al., 2003)
Soft tissue aspect	
Scalloped	
Thin or thick periodontal biotype	
A thick-flat periodontal biotype has a better prognosis than a thin-scalloped biotype (Salama et al. 1985, Kois 2001)	
A thick periodontal biotype is better than a thin gingival tissue (Kois, 2001).	

(Adapted from Zetu, L, Wang, H. L,[17], page 833).

Classification of papillary height according to Jemt

Index 0: no papilla. There is no soft tissue scalloping adjacent to implant restoration (Fig .6.7A).

Index 1: less than half of the papilla is present. A convex soft tissue profile is found near the single-implant prosthesis (Fig. 6.7B).

Index 2: half of the papilla is present, but there is no contact point between adjacent teeth. The soft tissue profile levels with the adjacent tooth (Fig. 6.7C).

Index 3: the papilla fills the interproximal space. There is good soft tissue profile (Fig.6.7D).

Index 4: papillary overgrowth covering the implant restoration and the adjacent tooth. The soft tissue profile is irregular (Fig.6.7E).

Main complications related to soft tissues

- Irregular contour
- Scarring tissue
- Papillary loss
- Loss of buccal bone volume

Soft tissue manipulation to preserve papillary height

Conservative extraction techniques recommended to preserve papillary integrity have gained the attention of clinicians who try to maintain the soft tissue at its best. The presence of "dark triangles"

Fig. 6.7A – Index 0.

Fig. 6.7B – Index 1.

Fig. 6.7C – Index 2.

Fig. 6.7D – Index 3.

Fig. 6.7E – Index 4.

6.7A 6.7B 6.7C 6.7D 6.7E

due to papillary loss evokes an unpleasant sensation. Also, phonetics problems arise in addition to esthetic problems[17].

A thorough understanding of soft and hard tissue anatomy, as well as the course of human periodontal disease in the anterior region, is fundamental for a predictable prognosis when an implant-supported prosthesis has been planned.

The literature has been shown several techniques to improve and/or preserve the papilla, demonstrated in this chapter through clinical cases.

Classification of osseous defects related to gingival architecture

Deformities found in the alveolar ridge can be attributed to congenital and developmental factors, tooth loss, accidents, unsuccessful endondontic treatment, trauma, advanced periodontal disease, odontogenic cysts or tumors, traumatic tooth extraction, dehiscence or fenestration, and prolonged use of a tissue-supported removable partial prosthesis or complete dentures.

According to the literature, 90% of alveolar ridge deformities are due to premature tooth loss[21]. The residual ridge resorption has been described in the literature by several authors. Atwood[22] characterizes it in six clinical stages. The alveolar ridge looses much of its volume in the first year after tooth extraction (25%), reaching up to 40% after three years[21].

Over the last 15 years, several attempts have been made to treat the alveolar ridge deficiencies in the esthetic zone: guided bone regeneration (GBR) with a barrier membrane with or without titanium reinforcement, onlay bone grafts, block bone grafts with membrane, particulated bone grafts, autogenous bone grafts from intra/extra oral sites (iliac crest, cranial vault, oral cavity), freeze-dried demineralized bone allograft, and more recently the alveolar distraction osteogenesis technique. Also, studies have shown that vertical ridge augmentation has a poorer prognosis than the horizontal ridge augmentation[6].

Salama's Classification[24]

According to Salama's classification[2], the tooth to be extracted has two distinct zones: coronal and alveolar defects. In this way, there are three modalities regarding alveolar extraction sockets:

Type I (alveolar) – immediate implant placement is recommended with or without guided bone regeneration;

Type II (alveolar and coronal defect) – implant can be placed on facial surface. Treatment's sequence means orthodontic forced eruption with tooth removal, implant installation, barrier membrane and ridge augmentation;

Type III (coronal defect) – considered problematic, it cannot provide primary implant stability. Tooth extrusion, membrane and ridge augmentation are necessary. The implants must be installed only within 6 to 12 months after guided bone regeneration (GBR).

Meltzer's Classification

Meltzer[25] divided the defects in four types:

Class I: the defect is inside the bone socket, with the surrounding alveolar walls intact, and the bone site diameter is greater than the implant diameter.

Class II: three of the four bone walls are intact. The fourth wall has a dehiscence or fenestration defect.

Class III: two defects can be found. The defect type 1 has adequate bone height but lack of width (knife-edge ridge), and the defect type 2 has two bone walls with dehiscence and fenestration defects.

Class IV: the main defect is due to inadequate bone height.

Wang & Shammari Classification for bone ridge defects[21]

Class I: the defect is found in a bucco-lingual/palatal dimension, with normal tissue height at the apico-coronal dimension.

Class II: the defect is found in an apico-coronal dimension, with normal tissue width at the bucco-lingual/palatal dimension.

Class III: combination defect resulting in bone height and width loss.

Seibert[19] introduced his system in 1983, in which treatment options were based on defect type to be restored with a pontic. Width deficiencies had better prognosis than defects in height. With the advent of osseointregrated implants, this classification had to be broadened because other non described defects were found in the dental practice. Several different defects cannot be treated in the same way. The comprehension of type and defect size, as well as the extent is necessary for treatment planning, timing, and the need of additional implants. Wang et al.[12] proposed a new classification system based on Siebert divisions[14] but without further limitations: Horizontal, vertical and combined defects. Each category was further divided into **small** (≤3 mm), **medium** (4-6 mm) or **large** (≥7 mm) (Fig.6.8).

Palacci & Ericsson Classification[27]

This classification is based on the amount of vertical and horizontal loss of soft tissue, hard tissue, or both.

Vertical dimension classification for soft and hard tissue defect

Class I: intact or slightly reduced papilla.

Class II: limited loss of papilla.

Class III: severe loss of papilla.

Class IV: absence of the papilla.

Horizontal dimension classification for soft and hard tissue defect

Class A: intact or slightly reduced buccal tissue

Class B: limited loss of buccal tissue.

Class C: severe loss of buccal tissue

Class D: extreme loss of buccal tissue, often in combination with a limited amount of attached mucosa.

Also, Palacci described a step by step technique to create papilla at the second surgical stage. This protocol will be adressed in further sections.

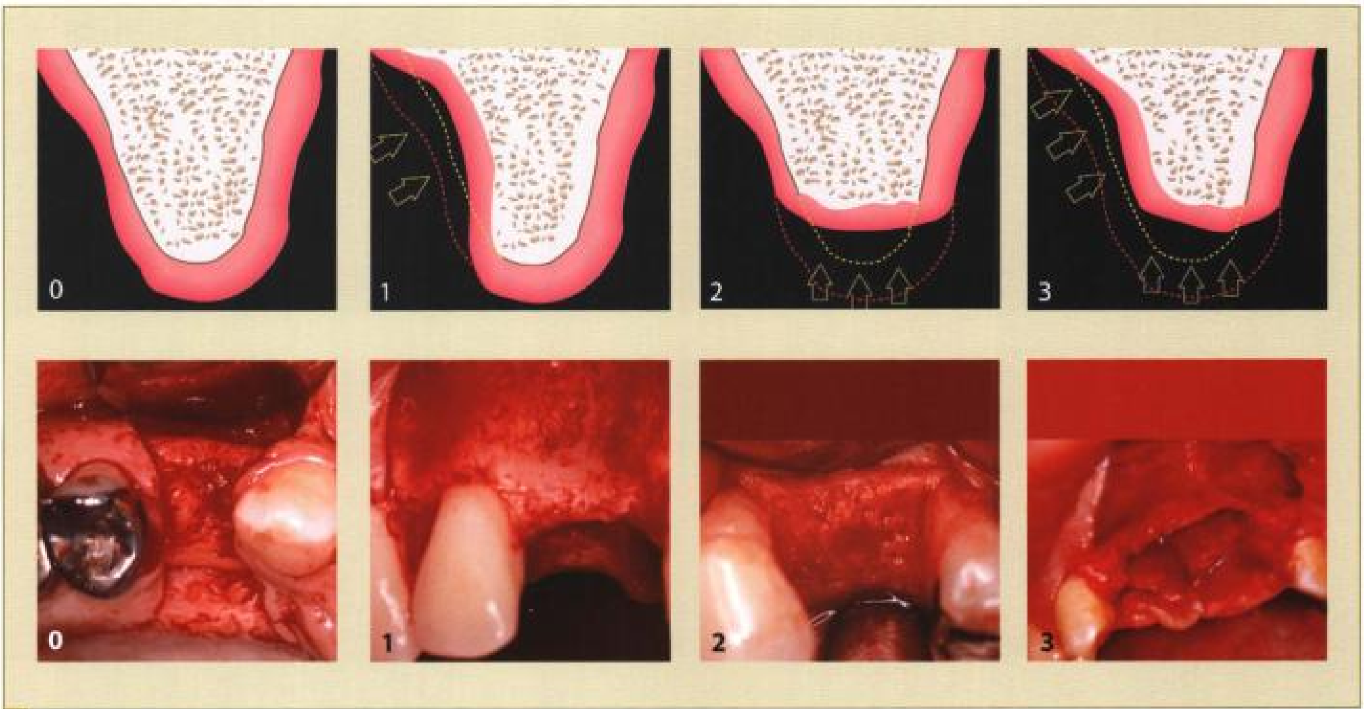

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Fig. 6.8 – 0 – Normal bone height and volume. 1.- Horizontal bone defect. 2- Vertical bone defect. 3- Horizontal and vertical combination defects. (According to Neves).

Tinti & Parma Benfenati Classification[28]

Based on the principles of blood clot protection and preservation, these authors classified osseous defects in 5 categories, divided into classes I and II, according to the following situations:

Alveolar bone walls after extraction

Here, alveolar walls are considered for immediate implant placement or to protect blood clot. **Class I**: After tooth removal, intact osseous walls are seen. The implant will be completely surrounded by bone (Figs. 6-9A, 6-10 and 6-11).

Class II: One of the alveolar walls was lost, and some threads will be exposed (Figs.6.9B, 6.10 and 6-12).

Fig. 6.9-A - Class I: the implant is surrounded by bone. **B** - Class II: some screw threads are exposed.

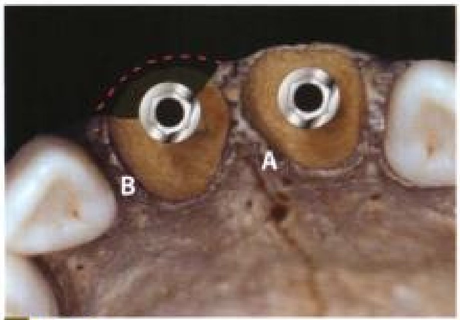
Fig. 6-10-A- Class I: the implant is completely surrounded by bone walls. B- Class II: the implant is partially involved by bone walls; guided bone regeneration (GBR) is necessary.

Fig. 6.11A – Observe intact alveolar walls after tooth extraction.

Fig. 6.11B – The implant was inserted and it is completely surrounded by bone walls.

Fig. 6.12A – Observe the lack of buccal bone wall after tooth extraction.

Fig. 6.12B – After the GBR procedure (autogenous bone graft and Gore-Tex membrane) there is good bone regeneration around the implant.



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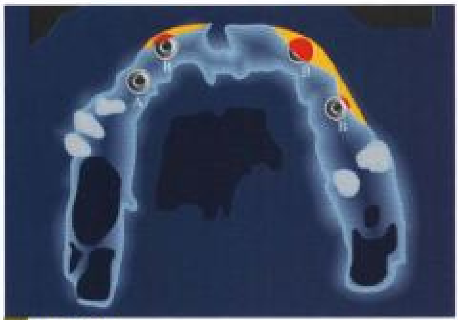

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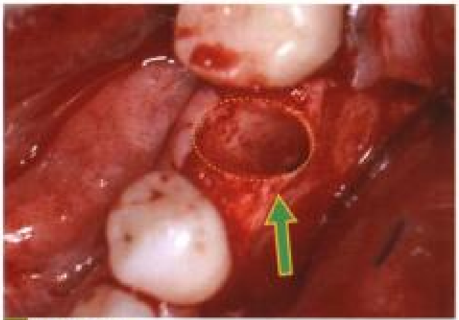

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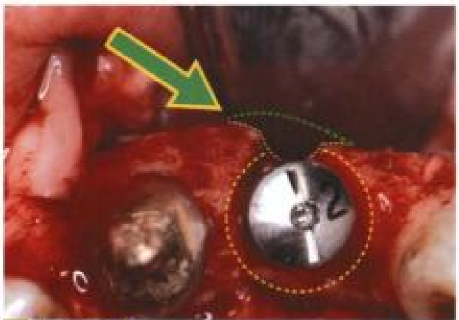

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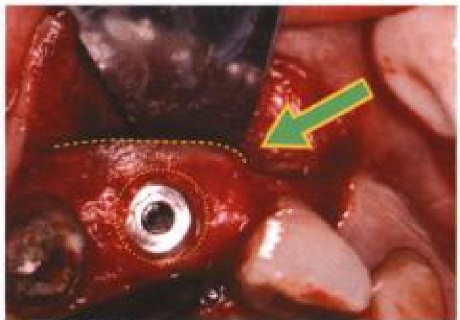


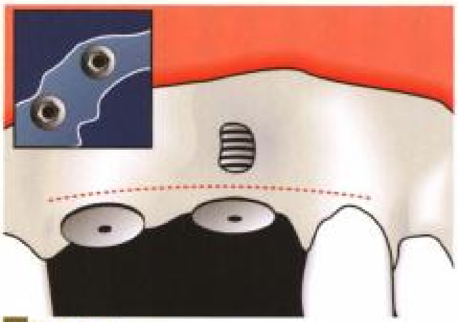
6.12B

Fenestration

Localized bone loss on the facial or palatal portion (lingual).

Class I: Implant is surrounded by less bone but remains inside the alveolar envelope (Fig. 6-13 and 6-15).

Class II: implant is outside the alveolar envelope. There is a convex defect with apical thread exposure (Fig. 6-14 and 6-16).



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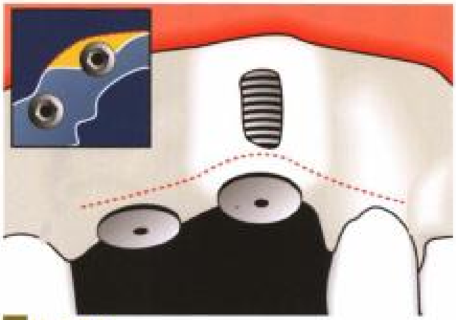

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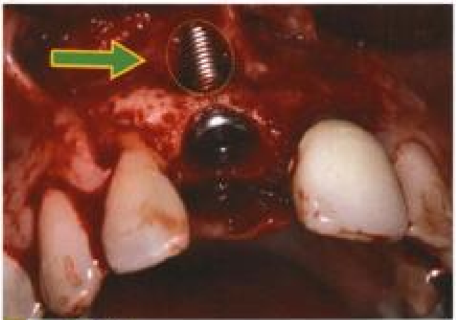
6.15A

6.15B



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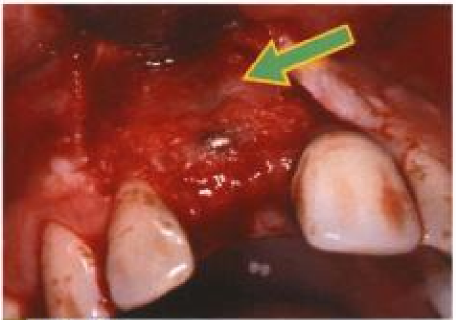


6.16B

Fig. 6.13 - Fenestration. Class I: the implant is surrounded by less bone, but is inside de alveolar envelope.

Fig. 6-14 – Fenestration. Class II: the implant is outside de alveolar envelope. The surgical convexity needs a GBR procedure.

Fig. 6-15A – The apical portion is exposed, but the implant is inside the surgical alveolus.

Fig. 6.15B - After GBR, observe excellent bone regeneration.

Fig. 6-16A – There is a fenestration and the implant is outside the alveolus.

Fig. 6-16B – After GBR, observe bone growth around the implant.

Bone debiscence

Bone loss is fewer than 50% from the top to apical portion.

Class I: Implant surface is inside the alveolar envelope. (Figs. 6-17 and 6-19)

Class II: implant surface is outside the alveolar envelope. (Figs. 6-18 and 6.20)

Fig. 6-17 – Dehiscence. Class I: implant is inside de alveolar envelope.

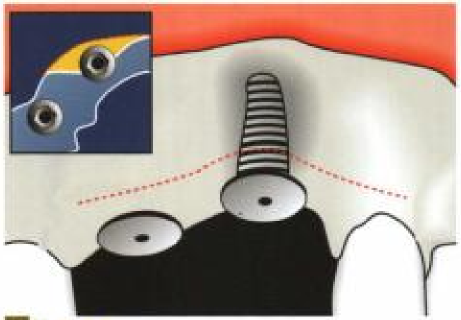
Fig. 6-18 – Dehiscence Class II: implant surface is outside de alveolar envelope and needs GBR.

Fig. 6-19A – Note buccal dehiscence on the implant surface. The implant is inside the alveolar socket.

Fig. 6-19B – After GBR, observe the bone formation.

Fig. 6-20A – The implant is outside the bone envelope.

Fig. 6-20B – After GBR, observe the bone formation.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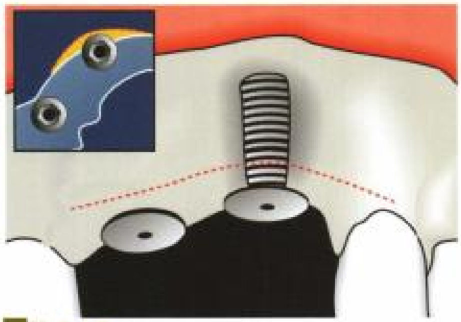
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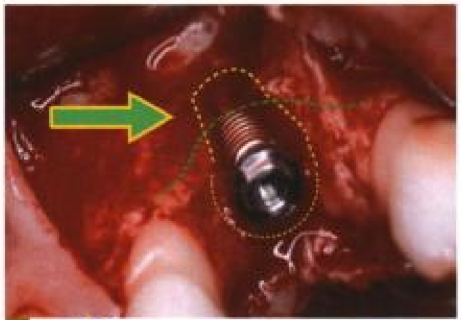
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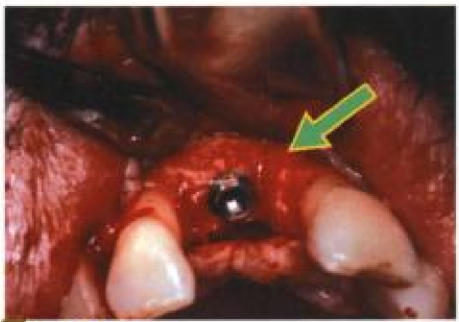
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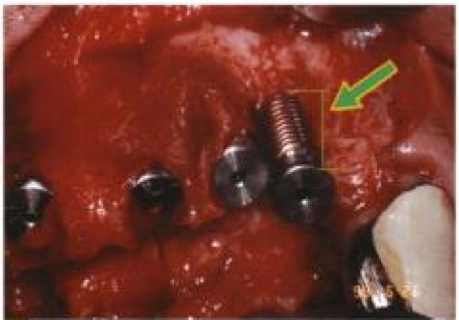

6.20A

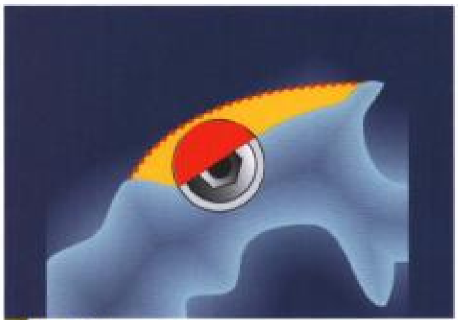

6.20B

Horizontal ridge defect

More than 50% bone mass was lost.

Class I: the implant is 50% outside, but inside the alveolar envelope (Fig. 6-21 and 6.23).

Class II: the implant is totally on the outer portion. Membrane barriers with or without bone graft are necessary for regeneration (Figs. 6-22 and 6.24).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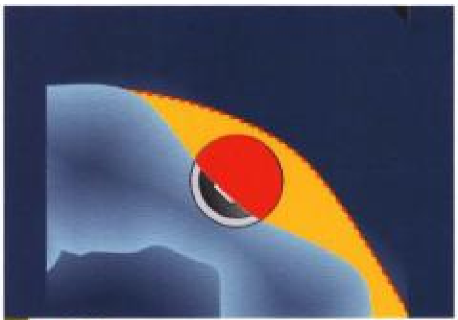
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6.23A


6.23B


6.24A


6.24B

Fig. 6-21 – Class I: the implant is 50% outside the alveolar ridge, but inside de envelope.

Fig. 6-22 – Class II: implant is completely outside de alveolar envelope. Barrier membranes with bone graft are necessary.

Fig. 6-23A – There is buccal bone loss in the implant surface, but it is still inside the osseous envelope.

Fig. 6-23B – GBR completed. Observe bone formation.

Fig. 6-24A – The implant is outside the bone envelope.

Fig. 6-24B – GBR completed. Observe bone formation.

Vertical ridge defect.

Class I: Lack of 3 mm in bone height. Blood clot itself guarantees osseous regeneration (Figs. 6.25 to 6-26).

Class II: Lack of more than 3 mm in bone height. Bone grafts are required (Fig 6-27 to 6-28).

Fig. 6-25 – Class I: vertical deficiency ≤3 mm. Guided bone regeneration with blood clot protection leads to osseous healing.

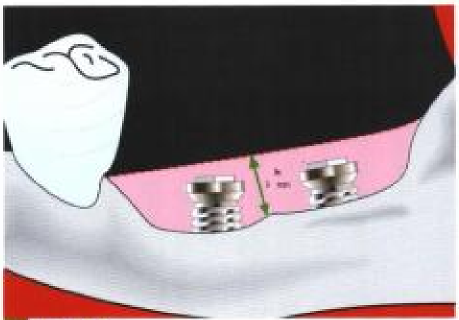
Fig. 6-26 – Class II: vertical deficiency ≥3 mm. GBR and grafts are necessary.

Fig. 6-27A – There is vertical deficiency <3 mm in the buccal implant surface.

Fig. 6-27B – GBR technique. Observe bone formation.

Fig. 6-28A – There is vertical deficiency >3 mm in the implant.

Fig. 6-28B – GBR technique. Observe bone formation.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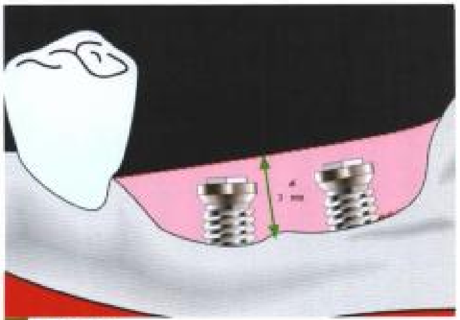
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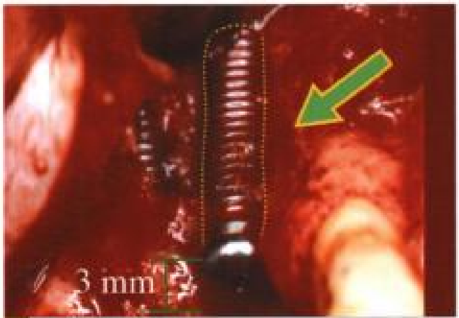
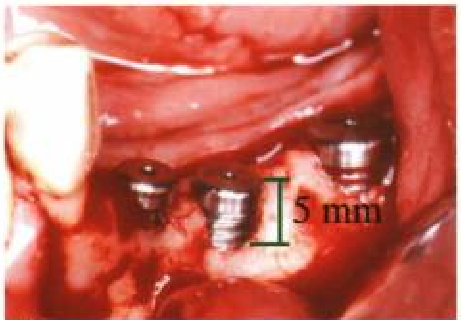


6.27A


6.27B



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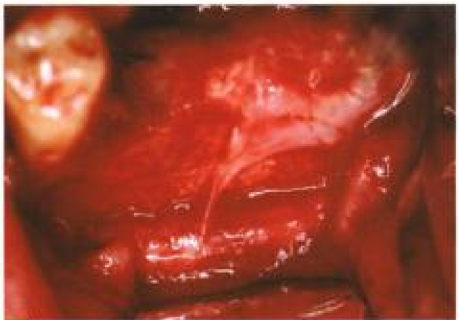

6.28B

Guided Bone Regeneration (GBR)

The guided bone regeneration is a reconstructive procedure derived from Guided Tissue Regeneration (GTR) techniques, which means the treatment of bone defects around natural teeth. The GBR implies the treatment of alveolar bone deficiencies before or during osseointegrated implant insertion.[6]

Thus, the GBR can be a therapeutic way to treat bone defects around implants. Its biologic principle is based on cellular selectivity, which further allows osseous neoformation.[29]

A membrane is used as a mechanical barrier against epithelial cell migration, and still protects the blood clot from flap compression. Thus, a space is provided for the blood clot, with migration of osteoprogenitor cells to this area and subsequent bone neoformation.[6]

Reports in the literature

Lazzara[30] published a report on three clinical cases with immediately implant placement in extraction sites. The alveolar sockets of the upper incisor and pre-molar teeth were thoroughly inspected and the implants positioned 2 mm below the level of the alveolar crest, with an e-PTFE membrane allowing enough space for blood clot. After 4-6 weeks, the membrane was removed and new bone formation seen around the implants. Desort[31]presented a similar case in the upper central incisor and found the same characteristics.

Becker & Becker[32] reported four clinical cases with immediate implants and e-PTFE membrane. In one case, the membrane was stabilized with a titanium ring (affixed to the cover screw). After periods of 5 and 8 months in the mandibular and maxillary bone, respectively, new bone formation was confirmed during the second stage surgery.

Simion[33-35] also verified the benefits of GBR and membranes in three clinical situations with bone dehiscence on implants, extraction alveolar sockets, and vertical ridge augmentation.

Wachtel et al.[36] demonstrated with clinical and histological findings vertical bone augmentation in periimplantitis defects through the use of e-PTFE membranes. This study was composed of 5 patients and 18 implants.

Jovanovic et al.[37] emphasized the advantages of e-PTFE membranes not only for immediate implant placement, but also in progressive bone defects around implants and periimplant dehiscence. The authors related that three factors are fundamental for GBR success: absence of bacterial contamination, sufficient space under the membrane for blood clot, and membrane stability during the healing period avoiding its exposure.

Clinical human and animal studies on GBR indicate that:

- GBR leads to new bone formation.
- Bone defects such as dehiscences and fenestrations can be corrected by GBR procedures.
- Circumferential bone defects created after tooth extraction can also be corrected.
- Vertical ridge augmentation is possible within certain limits.
- Bone grafts can improve new bone formation.
- The new formed bone will be in contact with the titanium and the hydroxyapatite covered surfaces.
- Premature membrane exposure difficult wound healing and limits bone formation.
- Implant premature loading can compromise the new bone formed through GBR.

Membrane characteristics for GBR

In the GBR technique, a membrane fabricated from e-PTFE (expanded polytetrafluorethylene) –a non-resorbable, inert material- behaves like a selective barrier to cells, inserted between the gingival connective tissue flap and the underlying alveolar bone defect.

These membranes can be titanium reinforced or not. The first are composed of an inner, rigid part, which permits avoidance of epithelial and connective tissue cells from the healing process. The outer part is flexible and provides excellent adaptation to the osseous defect.

In addition to space provision, the membrane protects the blood clot from mechanical deformation under the flap during the early stages of wound healing. In this way, the margins of the membrane need to be stabilized by pushing them under the flap or through lag screws. Wound stabilization is critical because membrane sliding over the blood clot during healing influences on the cellular differentiation.

Membrane role as a mechanical barrier[38]

- allow migration of osteoprogenitor cells toward the blood clot for cellular differentiation;
- exclude epithelial cells that can negatively interfere in bone formation;
- provide enough space to house the blood clot;
- Beyond the above cited factors, several factors can influence on GBR predictability:
- material's stiffness to warrant the desired volume;
- healthy and well-vascularized bed site;
- no membrane exposure during implant healing;
- minimal healing time of three months in the mandible and six months in the maxilla.

Indications for membrane insertion

- periimplant dehiscences;
- remaining intra-osseous defect;
- fenestration;
- alveolar extraction sockets;
- vertical ridge augmentation.

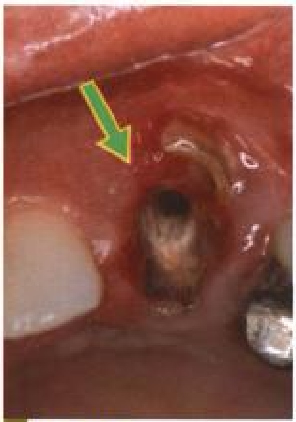
Healing time and membrane removal

There is no conclusive evidence over the necessary time for membrane treated defects to heal around osseointegrated implants. Also, this probably will depend on the site and patient factors. Seven months are suggested for autogenous bone and membrane, eight months for membrane alone, and nine months for membrane and allogenous grafts.[39] According to Tinti, the removal of the membrane should be after one year during vertical ridge augmentation.

The titanium reinforced membrane[29] *must be removed when:*

- there is bacterial contamination;
- soft tissue inflammation;
- flap necrosis;
- flap perforations;
- painful symptomatology.

Missika et al.[40], and Jovanovic et al.[37] stated that in case of premature membrane exposure, it must be immediately removed to preserve tissue neoformation and warrant its mineralization.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Clinical case 1

This 47-year old female patient had a root fracture on tooth 23 and was scheduled for implant surgery.

Fig. 6.29-1 – Clinical aspect. Observe fracture and tissue inflammation.

Fig. 6-29-2 – Periapical radiograph. Observe root fracture and periapical lesion.

Fig. 6-29-3 – After tooth extraction and granulation tissue removal. There is buccal bone resorption but papillae are still present.

Fig. 6-29-4 – Three months after soft tissue healing. Note soft and hard tissue deficiencies.

Fig. 6-29-5. Observe buccal bone loss in the region of 23.

Fig. 6-29-6. Implant placement. Observe osseous defect.

Fig. 6-29-7 – Particulated autogenous bone graft over the implant.

Fig. 6-29-8 – Gore-Tex membrane adapted over the implant and the bone graft.

Fig. 6-29-9 – Connective tissue graft over the membrane.

Fig. 6-29-10 – Gore-Tex suture. Observe soft tissue volume.

Fig. 6-29-11 – Membrane exposure two months after.

Fig. 6-29-12 – Membrane removal.

Fig. 6-29-13 – Observe bone regeneration.

Fig. 6-29-14 – Sutures.

Fig. 6-29-15 – Eight months after implant placement (second surgical stage).

Fig. 6-29-16 – Suture around the healing abutment.

Fig. 6-29-17 – Observe that flap was rotated to the buccal area leaving bone exposed in the palatal region.

Fig. 6-29-18 – Six months after soft tissue conditioning with the provisional prosthesis.

Fig. 6-29-19 – Observe soft tissue quantity and quality.


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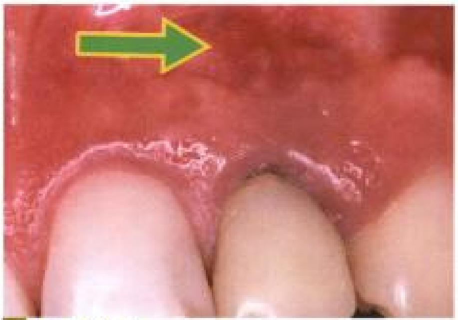
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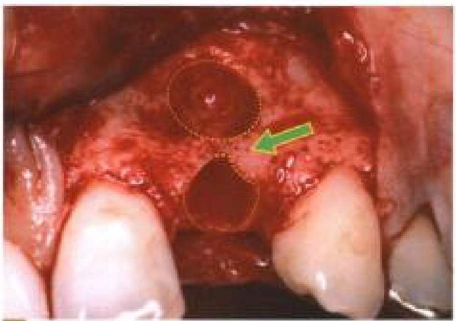
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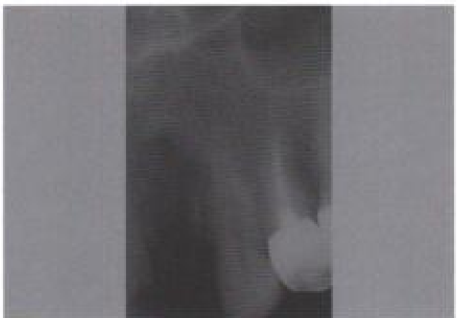
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Clinical Case 2

Patient MAM, 45-years old, female. After two unsuccessful apicectomies on tooth 22, tooth extraction and implant placement were scheduled.

Fig. 6-30-1 – Clinical aspect of tooth 22. There is a micro-abscess at the apical portion.

Fig. 6-30-2 – Observe the periapical lesion.

Fig. 6-30-3 – After 22 extraction and soft tissue curettage. There is a thin buccal bone wall.

Fig. 6-30-4 – Tooth 22 and the periapical lesion.

Fig. 6-30-5 – Suture.

Fig. 6-30-6 – Three months after. Observe soft tissue healing.

Fig. 6-30-7 – Observe the lost of hard and soft tissues.

Fig. 6-30-8 – Periapical radiograph three months after tooth extraction.

Fig. 6-30-9 – There is buccal bone wall resorption and a fibrous tissue in the area.

Fig. 6-30-10 – Occlusal view of buccal bone loss.

Fig. 6-30-11 – Implant placement.

Fig. 6-30-12 – Autogenous bone graft and DFDBA.

Fig. 6-30-13 – Titanium reinforced Gore-Tex membrane.

Fig. 6-30-14 – Tension-free suture.

Fig. 6-30-15 – Membrane exposure after 20 days.

Fig. 6-30-16 – Membrane exposure after 30 days.

Fig. 6-30-17 – Membrane removal. There is no complete tissue healing.

Fig. 6-30-18 – Suture after membrane removal.

Fig. 6-30-19 – The suture was placed at the buccal aspect as well.

Fig. 6-30-20 – Soft tissue healing after three months. The healing abutment is exposed.


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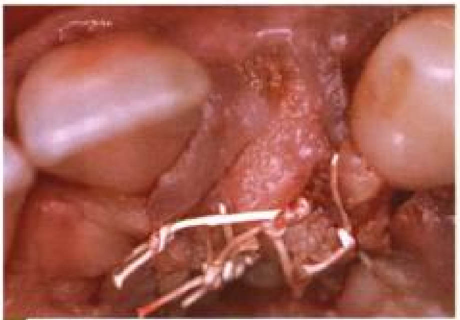
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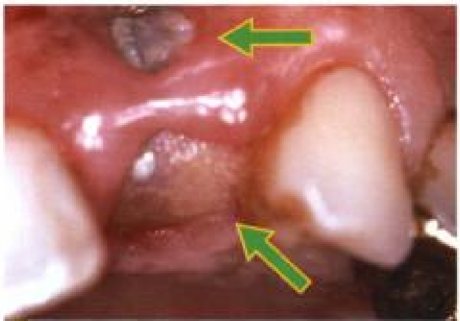
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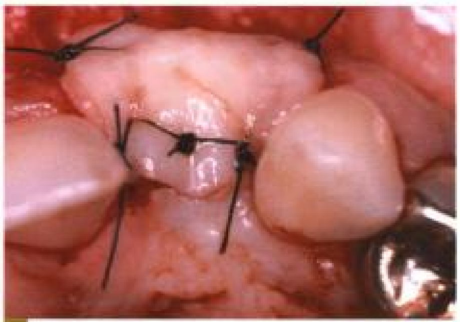

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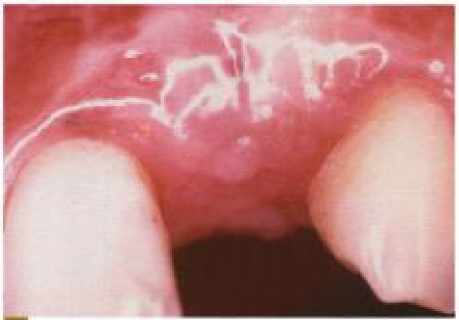

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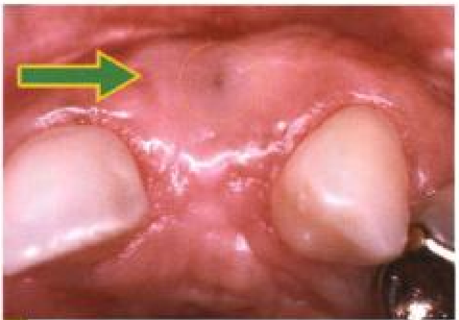

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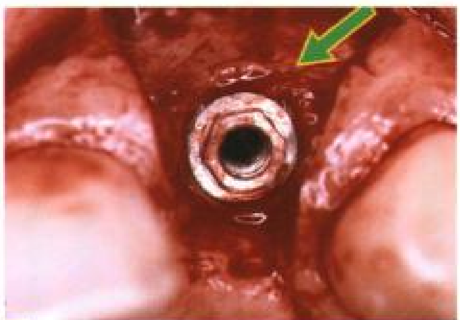

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Fig. 6-30-21 – Receptor site preparation. A free gingival graft will be made to create keratinized mucosa and vestibular fornix.

Fig. 6-30-22 – Free gingival graft removed from the palate.

Fig. 6-30-23 – The graft is stabilized by sutures.

Fig. 6-30-24 – Clinical aspect 4 months after surgery.

Fig. 6-30-25 – Periapical radiograph 9 months after.

Fig. 6-30-26 – The cover screw is showing through the mucosa, but the soft tissue has an excellent quality.

Fig. 6-30-27 – Schematic diagram. Observe local of incision.

Fig. 6-30.28 – Two vertical incisions were made to uncover the implant at the buccal site. Papillae were preserved.

Fig. 6-30-29 – Schematic drawing. A full thickness flat is elevated from palatal tissue and divided at the buccal aspect.

Fig. 6-30.30 – Occlusal view of the procedure described in Fig. 6-30-29.

Fig. 6-30-31 – Observe excellent bone regeneration.

Fig. 6-30-32 – Observe papilla formation around the healing abutment.

Fig. 6-30-33 – Schematic drawing.

Fig. 6-30-34 – Occlusal view. The palatal bone was exposed.

Fig. 6-30-35 – Suture. Observe that the soft tissue was apically positioned.

Fig. 6-30-36 – Three months after. Observe soft tissue quality and the vestibular fornix created.

Fig. 6-30-37 – Final esthetic aspect.

Fig. 6-30-38 – Clinical view after 8 years. Observe the condition of papillae and soft tissues. The graft has the same hue of the adjacent tissues.


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Immediate fixtures with GBR in alveolar extraction sockets

The first observations on this combined technique suggested that osseointegration and bone reconstruction can both occur in extraction sites. The clinical advantage is that this technique combines the pos-extraction healing period with the osseointegration phase and diminishes the wearing time of a removable appliance. Some occasional drawbacks are implant placement into the alveolar socket, impaired stabilization due to the lack of apical bone, and partial covering of membrane by the soft tissues.

The available scientific evidence suggests that:

The implants can be successfully inserted in extraction sites treated with GBR techniques. In addition, the GBR technique is adequate for space-maintaining and/or non-space maintaining defects. However, the space maintaining defects can be treated only with membranes. On the other hand, the non-space maintaining defects need bone grafting for better results. The GBR is successful around several types of implants in extraction sites. The most common used material in the Gore-Tex membrane is the e-PTFE. Another resorbable or non-resorbable membrane can be used with success. Membrane exposure is associated to less available bone, but not always prevents adequate results. Immediate implant placement not always allows complete wound closure. Otherwise, delayed implant placement (30-40 days to allow soft tissue maturation at the extraction site) can result in complete wound closure.

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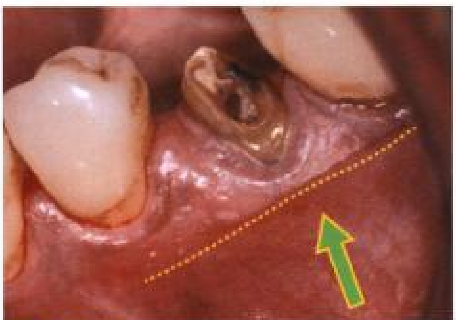

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Clinical case 3

Patient MSN, 63-years old, female. Root fracture on tooth 35.

Fig. 6-31-1 – Periapical radiograph showing lesion.

Fig. 6-31-2 – Clinical aspect. Observe the lack of keratinized mucosa and vestibular fornix.

Fig. 6-31-3 – Flap elevation.

Fig. 6-31-4 – Root removal. Observe oblique fracture and the periapical portion of the lesion already curetted.

Fig. 6-31-5 – The fractured tooth was removed with a periotome. Observe buccal plate conditions.

Fig. 6-31-6 – Immediate implant placement inside the osseous envelope.

Fig. 6-31-7 – Three months after. Note showing through of the healing abutment and the lack of keratinized mucosa around tooth 34 and 36.

Fig. 6-31-8 – Receptor site preparation for a free gingival graft.

Fig. 6-31-9 – Free gingival graft stabilized by sutures.

Fig. 6-31-10 – Periapical radiograph after six months. Observe excellent bone healing at the second surgical stage.

Fig. 6-31-11 – Three months after implant uncovering.

Fig. 6-31-12 – Observe the excellent condition of soft tissue and vestibular fornix.

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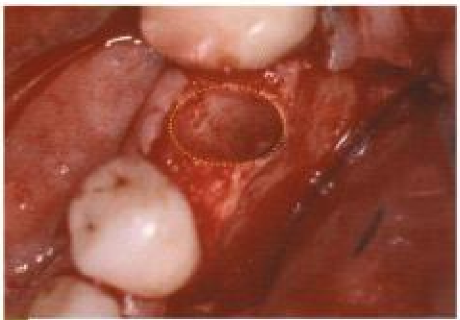

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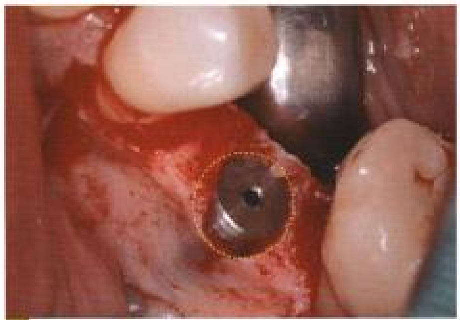

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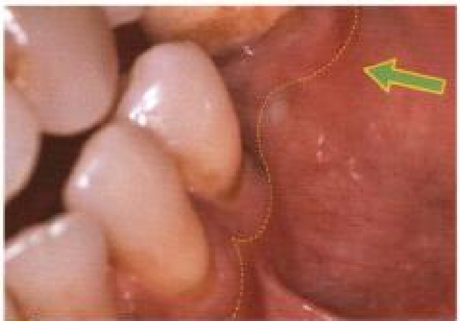

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Dehiscence and fenestration defects

The most common complications during implant placement on narrow alveolar crests or aiming an ideal esthetic position are dehiscence and fenestration. Several publications indicate that GBR techniques can form bone at these sites.

Association of materials such as DFDBA (demineralized freeze-dried bone allograft) or FDBA (freeze-dried bone allograft), or Bio-Oss (bovine bone) is necessary to fill large defects, because it avoids membrane collapsing[6,29], or when the morphology of the defect cannot maintain enough space for blood clot[38].

The following conclusions can be drawn on the use of GBR for dehiscence and fenestration defects around implants:

- The GBR technique can be used with success in dehiscence and fenestration defects around dental implants.
- The space maintaining defects can be successfully treated with membrane and with bone grafts (Box 6.4).
- Dehiscences and fenestrations that cannot maintain the space defect need bone graft.
- Autogenous bone graft, FDBA, DFBA, and Bio-Oss can be used with success.
- The most frequent allograft material used is the DFDBA[38].
- The most common used membrane is the e-PTFE (Gore-Tex), but another barriers can be used with success[5,6,29,38].
- Premature membrane exposure compromises GBR and can provide less than favorable results[5,6,29,38].

Box 6-4 – Membrane and bone graft indications in GBR technique.

Indication	Prognosis	Space maintenance
Bone deficiency	Simultaneous –easy	Only membrane
Bone fenestration	Insufficient	Membrane ABG + membrane TRM
Large osseous defect (localized)	Delayed	ABG + membrane TRM LS + ABG +membrane
Fresh alveolus (too wide for fixation)	Simultaneous –easy Insufficient	Membrane ABG + membrane TRM
Bone crest	Simultaneous, resorbed	ABG + membrane TRM
Large osseous defect	Delayed	ABG + membrane LS + ABG + membrane
Alveolar ridge defect Buccal soft tissue collapse Knife-edge Vertical defect	Delayed	ABG + membrane TRM LS + ABG + membrane

ABG = autogenous bone graft: particulate, block, DFDBA, Bio-Oss, etc.; LS = lag screw, titanium plate; TRM = titanium-reinforced membrane.
(Adapted from Neves[41], p.133).

Clinical case 4

Patient WF, 18-years old, male. The tooth 21 has a poor prognosis.

Fig. 6-32-1 – Clinical aspect of tooth 21. Observe large tissue loss.

Fig. 6-32-2 – Periapical radiograph. Root fracture and periapical lesion on tooth 21 can be seen.

Fig. 6-32-3 – Implant placement, autogenous bone graft and resorbable membrane (Resolut).

Fig. 6-32-4 – Seven months after tissue healing. Observe the lack of soft tissues around the implant site.

Fig. 6-32-5 – Connective tissue graft.

Fig. 6-32-6 – Suture.

Fig. 6-32-7 – One month after healing abutment connection.

Fig. 6-32-8 – Early soft tissue conditioning with provisional acrylic crown.

Fig. 6-32-9 – Six months after soft tissue conditioning.

Fig. 6-32-10 – Fourteen months after soft tissue conditioning. An excellent aspect is seen.


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Vertical ridge augmentation

Localized alveolar ridge defects are caused by extraction, developmental changes, periodontal disease, vertical dental fractures, periradicular infections, bone lesions, surgical trauma, and traumatic injuries. Non-esthetic deformities and inadequate bone volume can be found in the proposed implant sites. Further, implant positioning in these situations often results in esthetic compromise of prosthetic restorations, dehiscence and fenestration.

The GBR technique can aid in the horizontal and vertical bone regeneration of a compromised alveolar ridge, providing an adequate morphology for the edentulous crest. It is a reliable procedure for defects with a width and height loss of 4 and 3 mm, respectively (Fig. 6.33).[29]


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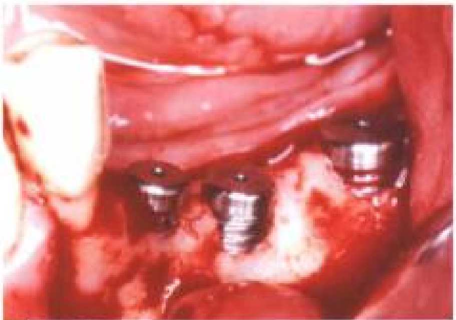
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Clinical case 5

Patient WB, 58-years old, male. His partial fixed prosthesis fractured and the patient was scheduled for implant surgery.

Fig. 6-33-1 – Three months after teeth extraction. Observe alveolar ridge healing with a knife-edge aspect.

Fig. 6-33-2 – Periapical radiograph. The alveolar crest is near the inferior alveolar canal.

Fig. 6-33-3 – Implants positioned at 35, 36 and 37 regions. Note the lack of bone height and width.

Fig. 6-33-4 – Titanium-reinforced Gore-Tex membrane shaped with a buccal mirror.

Fig. 6-33-5 – Vertical ridge augmentation at 35, 36 and 37 areas. The membrane was stabilized by screws. The autogenous bone graft is underneath the membrane.

Fig. 6-33-6 – Gore-Tex suture.

Fig. 6-33-7 – Clinical aspect 9 months after guided bone regeneration.

Fig. 6-33-8 – Periapical radiograph showing screw stabilization and the GBR process.

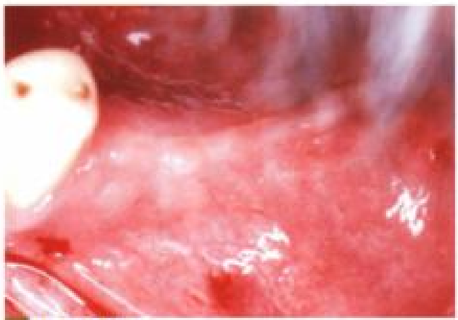
Fig. 6-33-9 – The membrane is stable after 9 months.

Fig. 6-33-10 – Membrane removal.

Fig. 6-33-11 – Healings abutments connected. Observe bone vertical and horizontal bone regeneration.

Fig. 6-33-12 – Suture.

Fig. 6-33-13 – Note excellent tissue quality three months after surgery, as well as papillae and the buccal fornix ready for final impression procedures.



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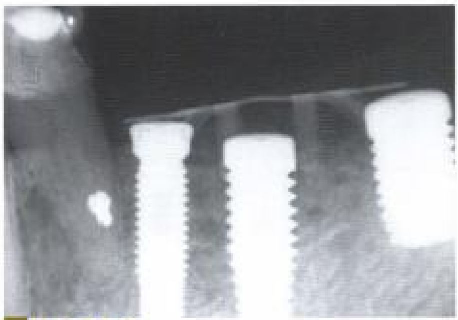

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Surgical techniques

Clinical tissue conditions in the maxillary anterior region

The practice of implantology in the anterior maxillary region is complex, because it depends on how the surgeon will manage the existing bone architecture for implant placement. Here, deficiencies are caused by two conditions: pathological and anatomic (Box 6.5).

For years, surgeons have focused attention on the osseointegra-

Box 6-5 – Recommended distance from the contact point to the bone crest to maintain soft tissue papillae – different clinical situations

Recommended distance (mm)		Author
Interdental papilla	<5 mm	Tarnow, 1992
	≥4.5 mm	Kois, 2001
Papilla between tooth/implant	<4.5 mm	Salama et al., 1998, 2002
		Salama, 2001
Interimplant papillae	<3.5 mm	Tarnow et al., 2003
	<4.0 mm	Grunder, 2004
Papilla between implant/pontic	<5.5 mm	Salama et al., 2004
Papilla between tooth/pontic	<6.5 mm	Salama et al., 2004
Papilla between pontic/pontic	<6.0 mm	Salama et al., 2004

(Adapted from Zetu & Wang[17], p.836).

tion process, bone to implant contact, and the biomechanical behavior of dental implants, without considering the esthetic aspect of implant-supported prosthesis. Palacci[27] was the first professional to address the esthetic issues found in the interproximal papillary regions.

Soft tissue manipulation before implant placement

Several techniques have been described in the literature to optimize the esthetics and function of implant-supported prostheses. Once distinct biological principles characterize each technique, they can be used in several steps of implant treatment.

Here we will describe each technique in chronological sequence, remembering that the same technique can be applied in different treatment phases with specific aims and results. The purpose is to show how to rebuild a more natural looking esthetics toward papillary soft tissue management, but always having in mind the need for surgical treatment of bone tissue aiming perfect implant placement.

Pre-surgical extraction phase

The first approach is conducted before tooth removal for implant insertion. Surgical maneuvers are used to augment soft and hard tissues, as well as techniques to enhance the recipient bed for implant placement, e.g., orthodontic forced eruption.[24-37]

The gingival margin is extruded in the coronal direction, without interfering with mucogingival line position, which in turn favors esthetics[42,43].

The root sealing[5,44] is another technique for soft tissue manipulation, but there is only an *in situ* gingival augmentation, which aids in primary intention of wound healing during extraction.

Clinical case 6

Fig. 6-34-1 – This 45-years old female patient presented with gingival recession at tooth 14 and root fracture at tooth 15. Note there is a thin attached mucosa in the same area.

Fig. 6-34-2 – Periapical radiograph of tooth 15. Distal bone loss is visible.

Fig. 6-34-3 – The fractured tooth was removed with a periotome and thus, the buccal and lingual bone walls, as well as the septum, were preserved.

Fig. 6-34-4 – Note tissue retraction at teeth 14 and 16.

Fig. 6-34-5 – A connective tissue graft was removed from the contralateral side. Observe primary closure through suture.

Fig. 6-34-6 – The connective tissue at the region of 14, 15 and 16.

Fig. 6-34-7 – The graft is stabilized by a resorbable suture.

Fig. 6-34-8 – Palatal flap coronally positioned, according to Tinti and Parma-Benfenati.

Fig. 6-34-9 – Palatal dissection is toward apico-coronal direction creating a partial thickness flap in another incision plane.

Fig. 6-34-10 – The flap covers the entire alveolus.

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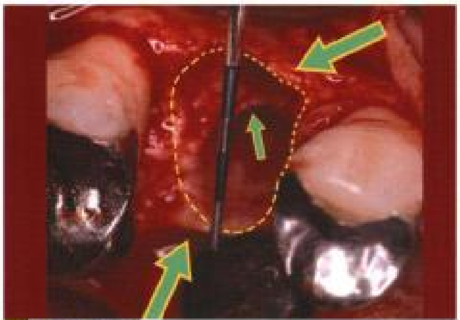

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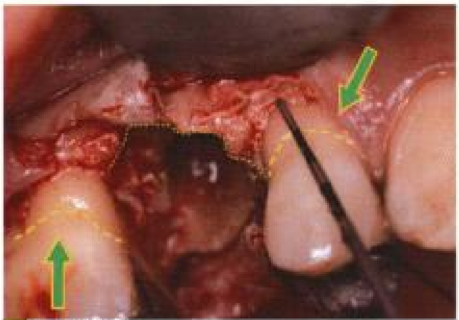

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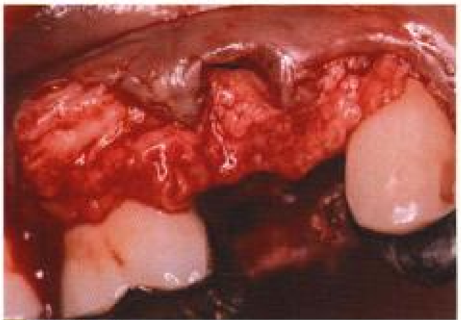

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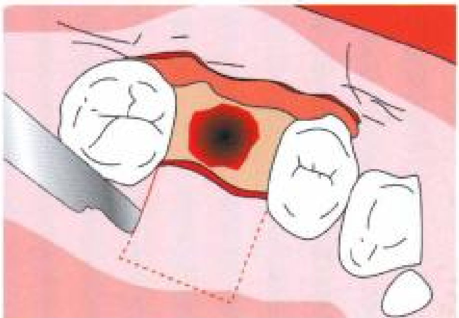

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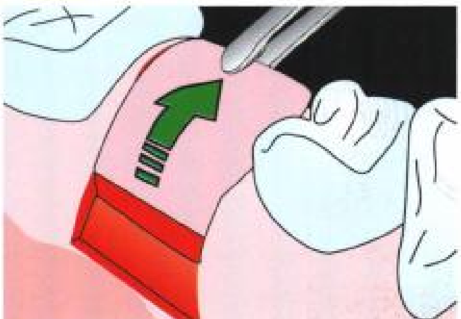

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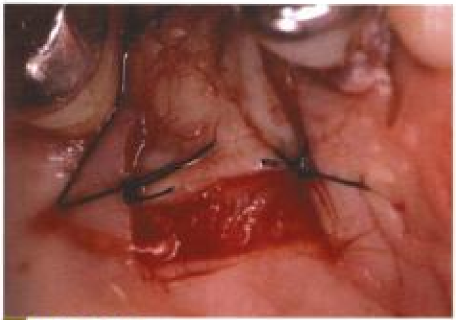
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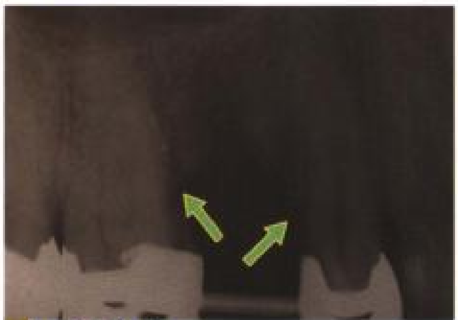
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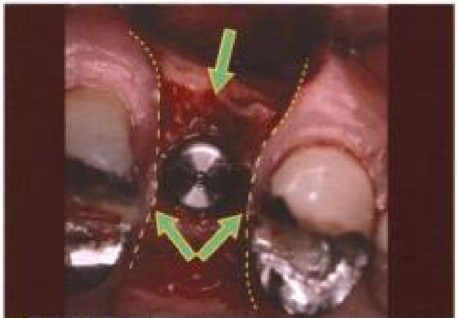
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Fig. 6-34-11 – Palatal flap sliding to coronal direction.

Fig. 6-34-12 – Observe primary closure of bilaminar flap. The buccal and palatal flaps aren't intension.

Fig. 6.34-13 – Three months after surgery. Observe excellent tissue healing.

Fig. 6-34-14 – Three months after tooth extraction. The alveolar socket was almost completely filled by blood clot.

Fig. 6-34-15 – Periapical radiograph after tooth extraction. The bone crest level was preserved.

Fig. 6-34.16 – Implant placement at 15 region. Note papillae preservation. There is a little defect at the buccal wall, but a bone graft is not necessary because the implant is inside the osseous envelope.

Fig. 6-34.17 – Suture. The incision was placed at the palatal side to protect the implant area.

Fig. 6-34.18 – Periapical radiograph 6 months.

Fig. 6-34-19 – Clinical aspect 6 months after implant placement. Observe excellent tissue healing.

Fig. 6-34-20 – Seven months after tissue conditioning with the provisional prosthesis. Procera copings on tooth 14 and the implant abutment 15. Observe papillary aspect and soft tissue cicatrization.

Fig. 6-34-21 – Metal-free single crowns on 14 and 15. Clinical aspect after 2 years.

6.34.21

Clinical case 7

Patient NLM, 56-years old, male. There is a root fracture on tooth 44.

Fig. 6-35-1 – Clinical aspect. Periodontal probe showing bone loss and the lack of keratinized tissue.

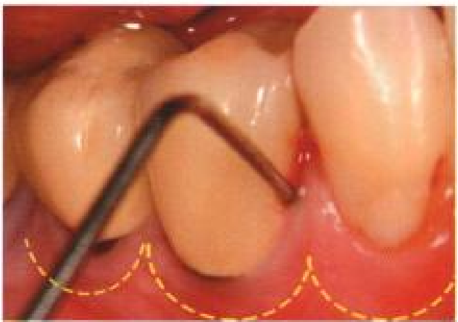
Fig. 6-35-2 – Periapical radiograph showing the lesion.

Fig. 6-35-3 – The tooth 44 was extracted with a periotome. Observe alveolar integrity.

Fig. 6-35-4 – Immediate implant placement.

Fig. 6-35-5 – Particulate autogenous bone graft from the mandibular torus.

Fig. 6-35-6 – Resorbable membrane (Resolut) over the implant and the bone graft.



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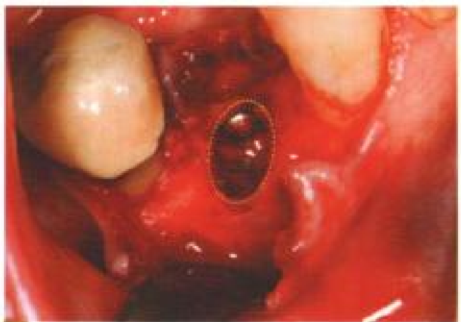

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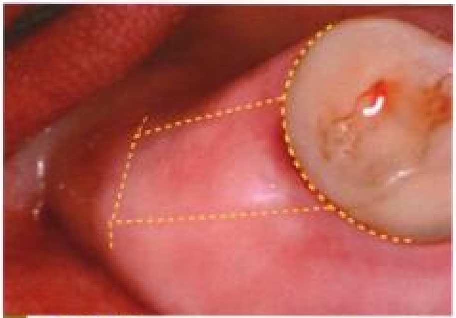
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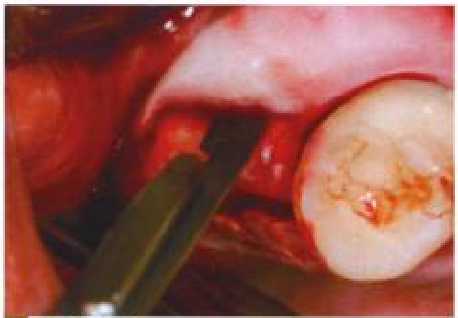
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Fig. 6-35-7 – Connective tissue graft removed from tuberosity region.

Fig. 6-35-8 – Flap design.

Fig. 6-35-9 – Observe flap thickness.

Fig. 6-35-10 – The graft is removed.

Fig. 6-35-11 – Flap closure.

Fig. 6-35-12 – The epithelial layer is removed.

Fig. 6-35-13 – The graft has been divided.

Fig. 6-35-14 – Part of the graft was made uniform.

Fig. 6-35-15 – Connective tissue graft under the membrane.

Fig. 6-35-16 – Suture.

Fig. 6-35-17 – Clinical aspect 5 months later (second surgical stage).

Fig. 6-35-18 – Circular punch.

Fig. 6-35-19 – Observe the thickness of keratinized mucosa.

Fig. 6-35-20 – Soft tissue removal to uncover the implant.

Fig 6-35-21 – Healing abutment connected without further suture.

Fig. 6-35-22 – Clinical aspect three months after soft tissue maturation. Observe the quantity and quality of keratinized mucosa over the implant.


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Clinical case 8

Patient APJ, 24-years old, male. Failure after orthodontic treatment and root fracture of tooth 15.

Fig. 6-36-1 – Clinical aspect. Soft and hard tissue deficiencies, as well as incorrect mesiodistal dimension at tooth 25 due to extraction of tooth 24. Observe gingival retraction at teeth 23 and 26.

Fig. 6.36.2 – Periapical radiograph of tooth 25.


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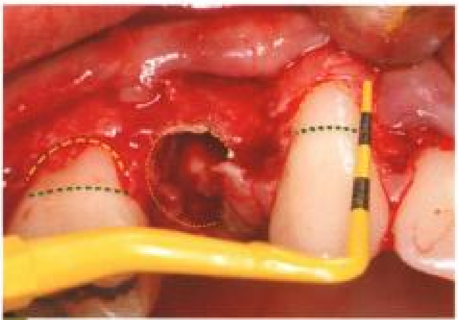
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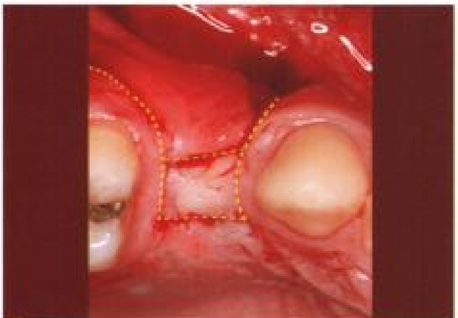
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Fig. 6-36-3 – Frontal view of the tooth 24. Observe soft and hard tissue deficiency.

Fig. 6-36-4 – The tooth 25 was extracted.

Fig. 6-36-5 – Connective tissue graft.

Fig. 6-36-6 – The connective tissue graft was stabilized with resorbable sutures.

Fig. 6-36-7 – Tension-free flap closure.

Fig. 6-36-8 – Three months after tissue healing. There is an improvement at the region of 24 and 26.

Fig. 6-36-9 – The incision was placed at the palatal side and papillary tissue preserved.

Fig. 6-36-10 – Observe that the alveolus was completely filled by blood clot.

Fig. 6-36-11 – The Summer's technique was used to prepare the alveolar socket and sinus lift.

Fig. 6-36-12 – Implant placement at 25 region.

Fig. 6-36-13 – Suture.

Fig. 6-36-14 – Six months after implant placement. A small soft tissue deficiency at the buccal site.

Fig. 6-36-15 – Second surgical stage. An incision was made at the palatal side, and the epithelium was removed near the buccal surface.

Fig. 6-36-16 – Partial thickness flap at the buccal surface.

Fig. 6-36-17 – The flap was divided at the buccal region and an intra-sulcular releasing incision made between the region of 23 and 26 for tissue undermining.

Fig. 6-36-18 – Schematic drawing. The epithelium was removed from the palatal surface.

Fig. 6-36-19 – Incision design. The connective tissue is folded over the buccal surface.

Fig. 6-36. 20 – The flap is positioned inside the tissue (Abrams'technique).

Fig. 6-36.21 – Occlusal view of tissue repositioning.

Fig. 6-36-22 – Schematic drawing of suture.


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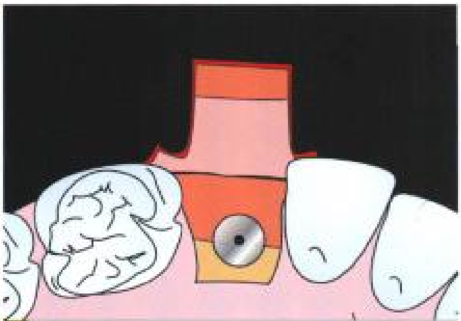
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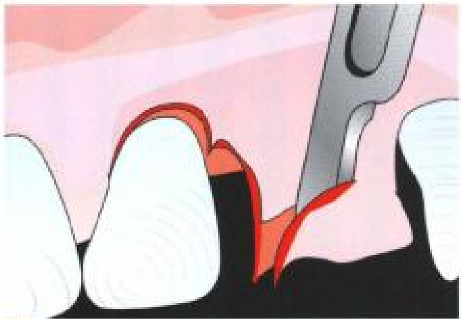
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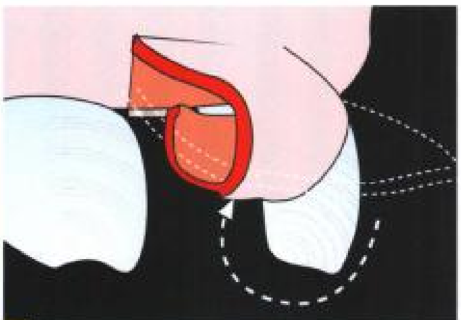
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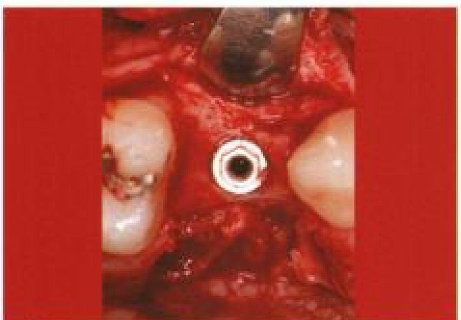
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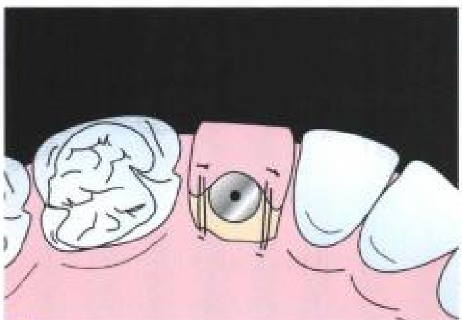
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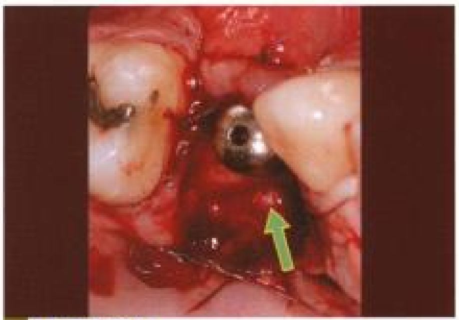

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Fig. 6-36-23 – Observe tissue volume obtained at the buccal surface.

Fig. 6-36-24 – At the palatal side, the bone becomes exposed and heals by second intention.

Fig. 6-36-25 – Tissue healing 20 days after surgery.

Fig. 6-36-26 – Soft tissue conditioning 4 months after provisional crown insertion. The osseous deficiency at the region of 14 was corrected.

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Clinical case 9

Patient VN, 47-years-old, female. The tooth 24 had a fracture and the patient was scheduled for implant surgery.

Fig. 6-37-1 – Periapical radiograph of tooth 24.

Fig. 6-37-2 – Root fragment.

Fig. 6-37-3 – The fragment was removed.

Fig. 6-37-4 – Suture.

Fig. 6-37-5 – Three months after healing, there is a defect at the buccal surface.

Fig. 6-37-6 – A free gingival graft was made to augment the soft tissue volume and the vestibular fornix.

Fig. 6-37-7 – Three months after grafting. Observe adequate volume of keratinized mucosa.

Fig. 6-37-8 – Implant placement at the 24 region. An implant thread is exposed.

Fig. 6-37-9 – Bone graft and Gore-Tex membrane.

Fig. 6-37-10 – Gore-Tex suture.

Fig. 6-37-11 – Tissue healing after 8 months.

Fig. 6-37-12 – Second surgical stage with healing abutment connected. Observe bone regeneration at tooth 24.

Fig. 6-37-13 – Impression transfer procedure. The soft tissue quality is fundamental.

Fig. 6-37-14 – Eight years after prosthesis delivery.


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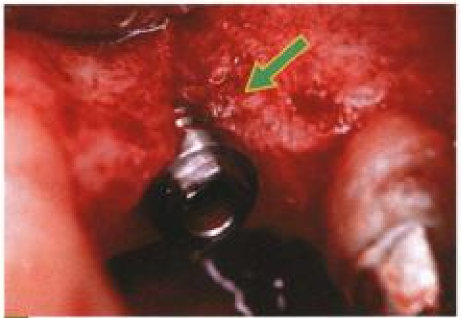
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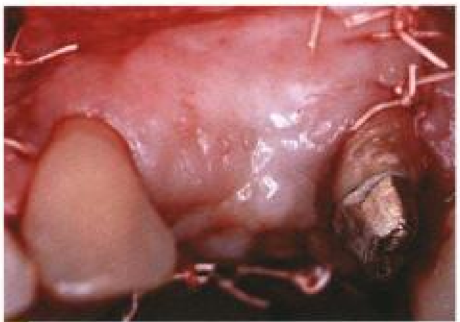
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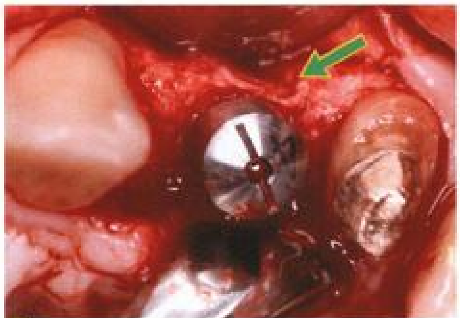
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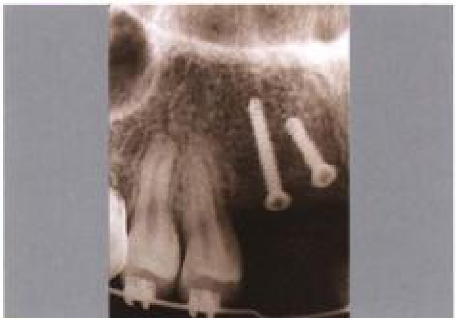
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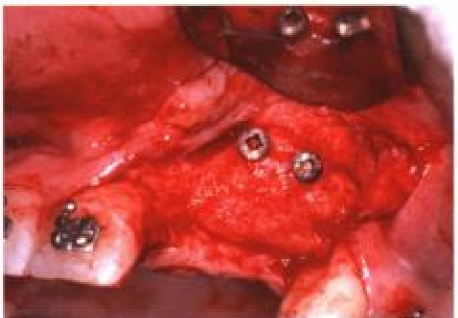
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Clinical case 10

Patient IP, 18-years old, female. This patient lost their teeth 13,22 and 23 due to incorrect orthodontic treatment. An interdisciplinary team composed by an orthodontist, buccomaxillofacial surgeon and periodontist evaluated the case. The proposed treatment planning was to finalize the orthodontic treatment, an iliac bone crest graft and implant placement at 13,22 and 23 regions.

Fig. 6-38-1 – Frontal view after orthodontic finalization (Courtesy of Dr. Onofre Mendes Neto). Observe soft and hard tissue deficiency.

Fig. 6-38-2 – Palatal view showing accentuated bone loss.

Fig. 6-38-3 – Lateral view. Observe extensive tissue loss, and the condition of teeth 21 and 24.

Fig. 6-38-4 – Panoramic radiograph evidencing bone loss.

Fig. 6-38-5 – Frontal view. Observe the lack of soft tissue at teeth 21,22,23 and 13.

Fig. 6-38-6 – Periapical radiograph of 22 and 23 regions four months after an iliac bone crest graft (Cortesy of Dr. Luis Henrique Marinho). Bone integration is evident.

Fig. 6-38-7 – Clinical palatal aspect after 4 months.

Fig. 6-38-8 – The tissue was excised to remove the lag screws and implant placement.

Fig. 6-38-9 – The screws are removed. Observe optimal bone integration in the receptor site.

Fig. 6-38-10 – Occlusal aspect after screw removal.

Fig. 6-38-11 – Implant placement at 22 and 23 regions.

Fig. 6-38-12 – Suture.

Fig. 6-38-13 – Four months after implant placement. Bone tissue is lacking at the distal of 21 and mesial of 24.

Fig. 6-38-14 – Receptor site preparation for a free gingival graft.

Fig. 6-38-15 – Free gingival graft stabilized with sutures.

Fig. 6-38-16 – One week postoperative results.

Fig. 6-38-17 – Three-week postoperative results. Soft tissue is not adequate. Observe that the healing abutment at 23 is showing through the thinned mucosa.

Fig. 6-38-18 – Periapical radiograph.

Fig. 6-38-19 – Two vertical releasing incisions were placed at the buccal surface. A running incision was made at the palatal side.

Fig. 6-38-20 – Incision design.


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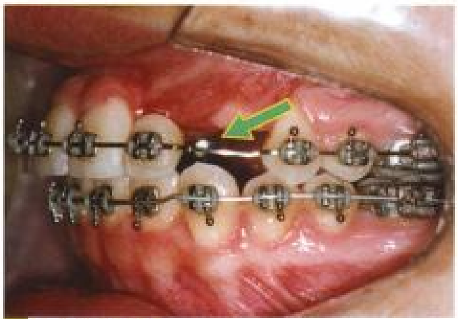
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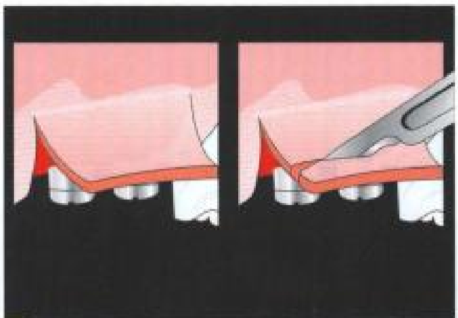
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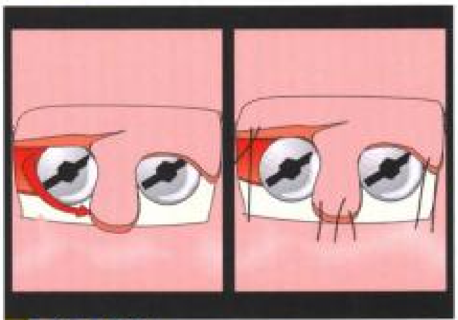
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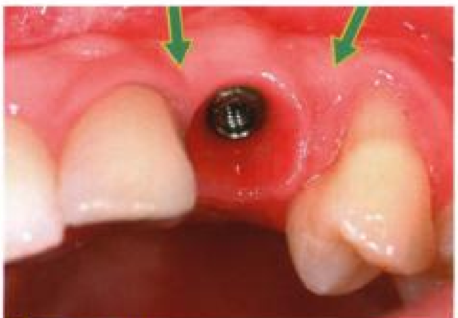
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Fig. 6-38-21 – A full-thickness flap was elevated from palatal to buccal side, and a partial-thickness flap was elevated from buccal to preserve the bone tissue and for suture stabilization.

Fig. 6-38-22 – Healing abutments are connected.

Fig. 6-38-23. Schematic drawing of flaps and suture.

Fig. 6-38-24 – The flap is incised and two soft tissue pedicles (fingers) are created and sutured around the healing abutments.

Fig. 6.38-25 – Palatal view. Bone at this region heals by second intention.

Fig. 6.38-26 – Lateral view. The flap was apically positioned and the central papilla preserved.

Fig. 6-38-27 – Postoperative aspect after three months.

Fig. 6-38-28 – Clinical aspect after 5 years. Soft tissue maturation is seen.

Fig. 6-38-29 – Porcelain fracture five years later (CerAdapt abutment).

Fig. 6-38-30 – Clinical aspect. The periimplant soft tissue shows excellent quantity and quality.

Fig. 6-38-31 – Final clinical aspect. Procera crown at the region of 23.

Fig. 6-38-32 – Clinical aspect three years later. Soft tissue homeostasis is seen.


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Clinical case 11

Patient SMFC, 56 years-old, female. The tooth 21 was lost and the patient scheduled for implant surgery.

Fig. 6-39-1 – Clinical aspect of tooth 21. The tooth has a brownish coloration, advanced bone loss and a poor esthetic prognosis.

Fig. 6-39-2 – Observe buccal bone loss.

Fig. 6-39-3 – the tooth was extracted with a periotome and the surrounding gingival tissue had the epithelium removed.

Fig. 6-39-4 – Frenectomy.

Fig. 6-39-5 – A partial thickness flap was made at the buccal portion of tooth 22 and laterally rotated to the region of 21.

Fig. 6-39-6 – Incision design and the laterally positioned flap.


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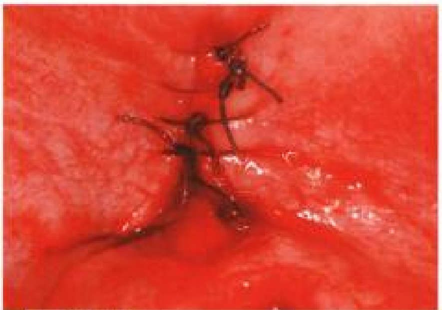
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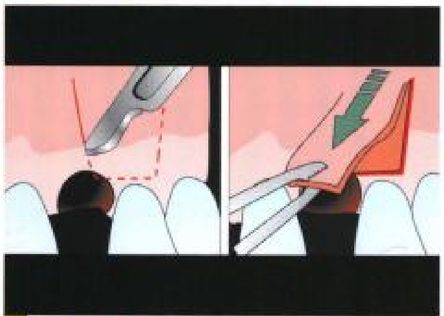
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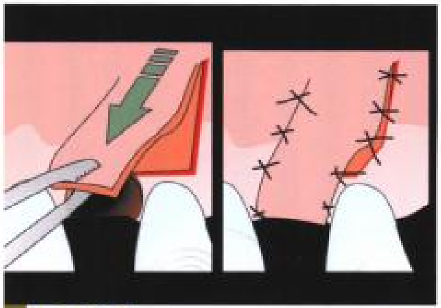
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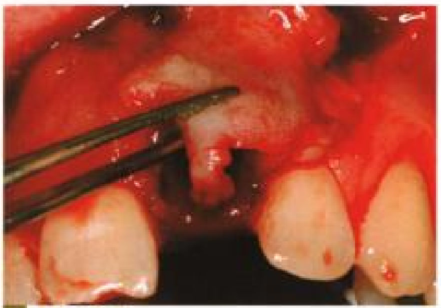
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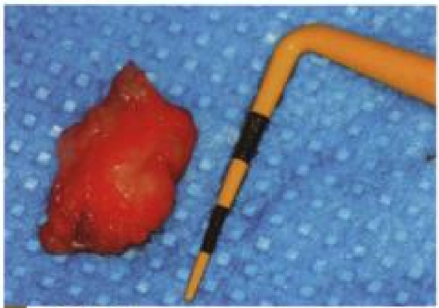
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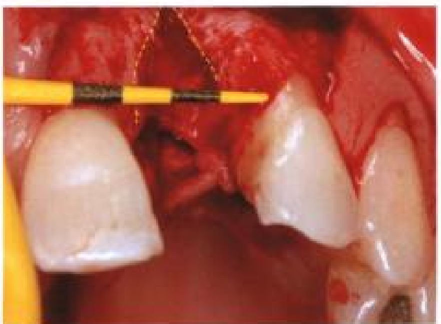
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Fig. 6.39-7 – Schematic drawing showing the technique.

Fig. 6.39-8 – The flap was divided and coronally positioned.

Fig. 6-39-9 – Connective tissue graft.

Fig. 6-39-10 – Connective tissue graft stabilized by sutures.

Fig. 6.39-11 – Suture aspect.

Fig. 6-39-12 – One week after suture.

Fig. 6-39-13 – Three month after tooth extraction. Observe the soft tissue quantity and quality at the region of 21.

Fig. 6.39-14 – Periapical radiograph.

Fig. 6-39-15 - Observe buccal and palatal bone loss.

Fig. 6.39.16 – Buccal bone loss, but still with the osseous crest intact.

Fig. 6-39-17 – Ideal implant position.

Fig. 6-39-18 – Particulate autogenous bone graft.

Fig. 6.39-19 – Gore-Tex membrane.

Fig. 6-39-20 – Gore-Tex suture.

Fig. 6-39-21 – Eight months after implant osseointegration.

Fig. 6-39-22 – Membrane removal. Observe guided bone regeneration.

Fig. 6-39-23 – Healing abutment and suture.

Fig. 6-39-24 – Early soft tissue conditioning with a provisional acrylic crown.


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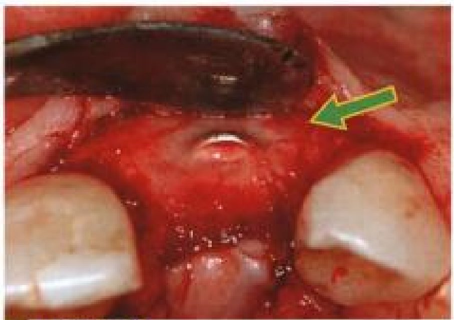
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Root sealing technique

This is an easy and user-friendly technique that aims to create or augment the band of keratinized gingiva over the most coronal radicular portion. Generally, this occurs with abutments indicated for extraction due to extensive caries, fracture, poor crown-to-root ratio, failure in the endodontic treatment, and that need to be replaced by a dental implant.

It promotes tissue formation that facilitates wound healing by first intention in immediate implant placement, thus reducing the risk of membrane exposure during GBR techniques, and so minimizes the need for other grafting procedures. Also, it reduces bone resorption soon after tooth extraction, keeping the cortical plates intact[5,44]. (Fig. 6.40).

Principles of surgical technique

The *in situ* gingival downgrowth occurs within 8-10 weeks[17] after the tooth had been reduced below the bone crest; that is when the body produces sufficient soft tissue to cover the "sealed" root.

Langer[44] in 1994 described this technique, which benefits from regenerative capacity of the gingival tissue over the ridge. After, the root will be replaced by a titanium fixture after 2-3 weeks. Potaschnick[5] believes in an 8-10 week period, while in my personal view 4-8 weeks are sufficient.

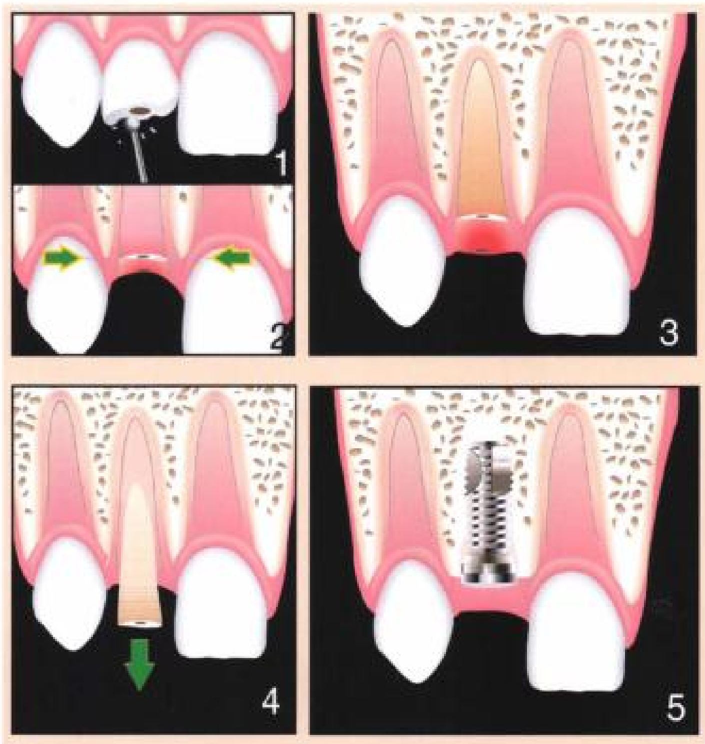

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Fig. 6-40.1-2 – Root fragment reduction to bone crest level. **3.** Four to six weeks is allowed to form an hyperplasic tissue that will cover the root. **4.** Root removal. **5.** Implant placement. There is enough soft tissue for primary healing intention.

Clinical case 12

Patient MAM, 45 years-old, female. Tooth 46 is fractured and an implant will be inserted.

Fig. 6.41.1 – Clinical aspect of fracture root of 46.

Fig. 6-41.2 – The root fragment was leveled to the bone crest.

Fig. 6-41-3 – An hyperplasic tissue was formed after six weeks.

Fig. 6-41-4 – Tooth extraction.

Fig. 6-41-5 – The buccal and lingual bone walls were preserved due to attraumatic extraction techniques.

Fig. 6-41-6 – The alveolar socket was filled with PRP (platelet-rich plasma).

Fig. 6-41-7 – A PDS II Johnson's tent was adapted to maintain the space.

Fig. 6-41.8 – The blood clot is in position.

Fig. 6-41-9 – PRP gel (fewer platelets) to protect the area.

Fig. 6-41-10 – Suture. Observe primary flap closure without tension.

Fig. 6-41.11 – One week later. Observe excellent tissue healing.

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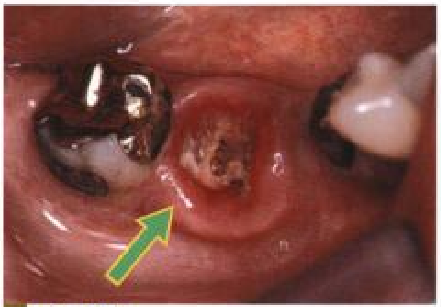

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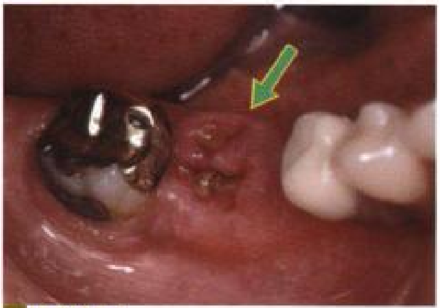

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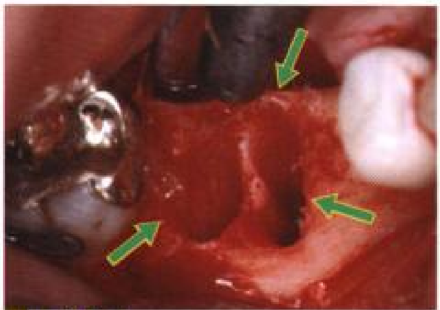

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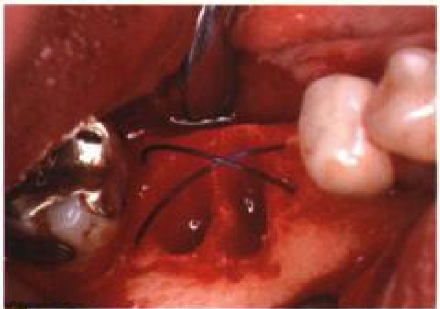

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Clinical management

- fabrication of a provisional prosthesis with sufficient space for tissue growth over the sealed root;
- under local anesthesia, the crown is cut to the gingival level, with the radicular portion at the level of the bone crest;
- vital abutments need previous endodontic therapy, since i mmediate implant placement is not indicated in cases of suppuration, granulation tissue or any type of infected lesion;
- the epithelial layer of this gingival tissue must be removed with a diamond bur to encourage tissue growth over the sealed root;
- the provisional prosthesis is inserted and necessary adjustments are made;
- 2-4 weeks are allowed for gingival proliferation over the radicular portion.

Surgical procedure: root removal after tissue proliferation

- a horizontal incision is placed at the palatal side of the ridge; vertical releasing incisions are made whenever necessary;
- a partial thickness flap is elevated to the buccal region;
- the root is carefully removed to avoid damaging the cortical plates;
- GBR with e-PTFE membrane is provided. Whether an autogenous bone graft is needed or not depends on the size of the defect;
- flap closure and suturing;
- the provisional prosthesis is inserted.

Advantages of root sepulture

- pediculated or free flaps are not necessary for primary alveolar socket closure;
- an extra gingival tissue can be obtained to correct soft tissue deformities;
- diminishes the likelihood of premature membrane exposure;
- diminishes the likelihood of postoperative soft tissue infection and membrane contamination;
- it maintains the healthy of cortical plates

During this phase, another bone wall defects can be treated by intra or extra-oral block bone grafts, orthodontic forced eruption, alveolar distraction osteogenesis, and sinus augmentation. Large osseous reconstruction also can be corrected by bone grafting techniques with further vestibuloplasty, or simply to create adequate conditions for implant insertion.

In addition, mucogingival surgeries can be made to improve the soft tissue condition, such as the coronal sliding and the palatally rotated flaps, aiming to seal the wound created after ridge augmentation. Besides, connective tissue or free gingival grafts can be performed to create or augment the band of keratinized tissue that will protect the implants and further permits a more esthetic emergence profile.

First surgical stage

Here, the implants are inserted. The surgeon has planned and executed some of the reconstructive surgeries for the hard and soft tissues. At this moment, the clinician can use GBR with or without bone grafts, eventually to cover some implant exposed thread, or to treat dehiscences or fenestrations.

Also, the soft tissue can be managed with connective tissue grafts, frenectomy, free gingival graft, coronally positioned flap, and palatally rotated flap. These are made to seal the wound margin and to avoid soft tissue dehiscence, which in turn would cause premature membrane or implant exposure and consequent failure.

Clinical case 13

This 35 year old female patient had lost his upper central incisors. Central teeth in this fixed partial prosthesis are too long due alveolar bone resorption and inadequate gingival tissue. A soft tissue augmentation procedure was suggested before implant placement to facilitate closure during surgical management and to improve the final esthetic outcome.

6.42.1

Fig. 6-42.1 – Clinical aspect from tooth 12 to 22.

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Fig. 6-42-2 – Palatal view of the same region.


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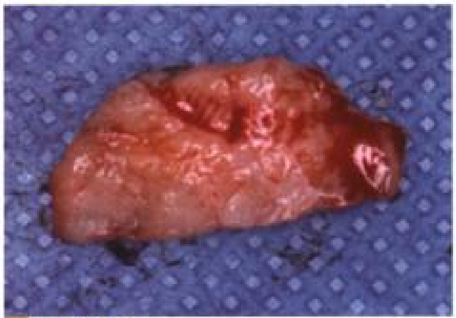
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Fig. 6.42.3 – After prosthesis removal, we can see the alveolar ridge atrophy and lack of gingival thickness.

Fig. 6.42.4 – Donor site. A connective tissue graft was removed from the palate region to augment the gingival thickness at the esthetic zone.

Fig. 6.42.5 – Connective tissue graft removed.

Fig. 6.42.6 – Occlusal view. The graft was inserted at the anterior region.

Fig. 6.42.7 – Suture.

Fig. 6.42.8 – After 4 months, adequate tissue thickness was achieved.

Fig. 6.42.9 – An incision was placed along the crest for implant placement and the two lateral incisors were removed.

Fig. 6.42.10 – Implant placement. The lack of bone tissue at the lateral incisor region is seen.

Fig. 6.42.11 – Autogenous bone graft was removed from the mandibular bone mandibular ramus to supply this deficiency.

Fig. 6.42.12 – Bone collector showing the amount of tissue removed from the mandibular ramus.

Fig. 6.42.13 – Close-up of autogenous bone.

Fig. 6.42.14 – The autogenous bone is adapted over the implants.

Fig. 6.42.15 – Membrane is placed over the graft and stabilized with screws.

Fig. 6.42.16 – Suture.

Fig. 6.42.17 – Aspect before second surgical procedure to uncover the implants and papilla regeneration.

Fig. 6.42.18 – A partial thickness flap is created in the palatal side to aid in papilla formation, while a full-thickness flap is created on the buccal side.

Fig. 6.42.19 – The connective tissue is removed from the palate region.

Fig. 6.42.20 – Periapical radiograph.

Fig. 6.42.21 – The flap is elevated to remove the membrane.

Fig. 6.42.22 – Now, there is sufficient bone volume and the implant threads are not exposed.


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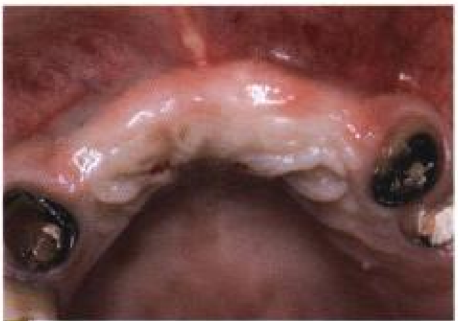
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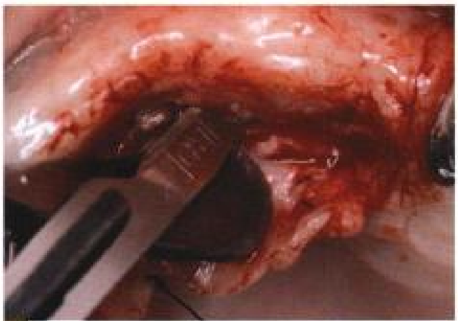
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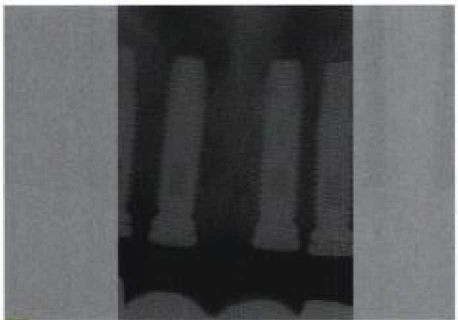
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Fig. 6.42.23 – Occlusal view of the surgical area with adequate bone thickness.

Fig. 6-42.24 – Occlusal view of the implants.

Fig. 6.42.25 – A new connective tissue graft was removed from the posterior palatal region and inserted at the anterior ridge.

Fig. 6.42.26 – Connective tissue removed.

Fig. 6.42.27 – Donor site area.

Fig. 6.42.28 – The healing abutments were inserted and the soft tissue sutured.

6.43.1

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Clinical case 14

Patient MGC, 56 years-old, female. She suffered the loss of teeth from 12 to 22 and a removable prosthesis was inserted. This patient was unhappy and was scheduled for implant treatment.

Fig. 6.43.1 – Periapical radiograph showing extensive bone loss in the anterior region.

Fig. 6.43.2 – Clinical aspect.

Fig. 6.43.3 – Observe extensive bone loss after tissue elevation.

Fig. 6.43.4 – The mental region was chosen as the donor area.

Fig. 6.43.5 – Bone graft removed.

Fig. 6.43.6 – The graft was adapted in the anterior region.

Fig. 6.43.7 – The bone blocks were stabilized by screws.

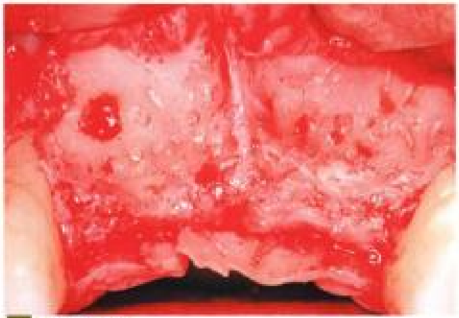
Fig. 6.43.8 – Particulate bone removed with a bone collector.

Fig. 6.43.9 – Empty spaces between the graft and the ridge are filled with particulate bone.

Fig. 6.43.10 – Suture.

Fig. 6.43.11 – Four months after bone grafting procedures.

Fig. 6.43.12 – Periapical radiograph showing bone regeneration and the stabilization screws.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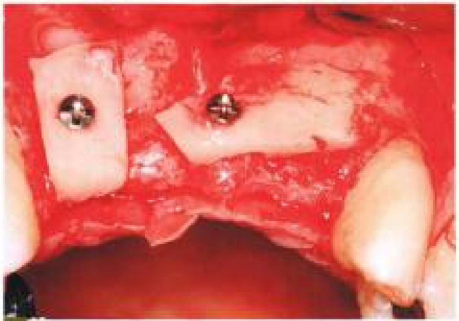
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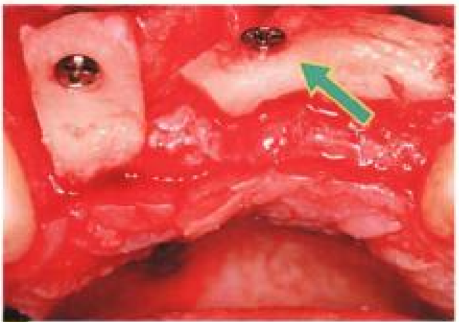
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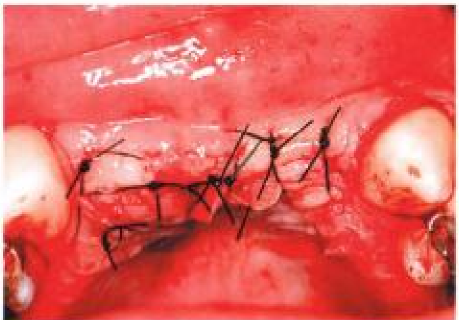
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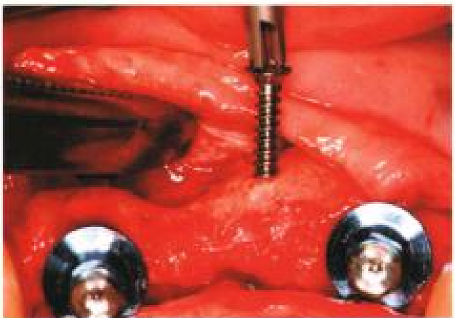
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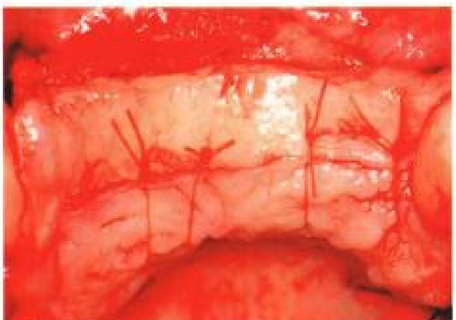
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Fig. 6.43.13 – Clinical aspect showing the absence of adequate hard and soft tissue in the anterior region.

Fig. 6.43.14 – An incision was made to remove the screws and install two implants.

Fig. 6.43.15 – There is a small resorption at the region of 21. Compare with Fig. 6.43.6

Fig. 6.43.16 – A 4 mm bone loss is observed at the occlusal view.

Fig. 6.43.17 – The implants were inserted at the region of 12 and 22. The stabilization screws were removed after implant insertion.

Fig. 6.43.18 – There is sufficient bone volume around the implants.

Fig. 6.43.19 – Free gingival graft removed from the right palatal aspect.

Fig. 6.43.20 – The graft is inserted at the anterior alveolar ridge.

Fig. 6.43.21 – Suture. Observe the amount of keratinized tissue after grafting.

Fig. 6.43.22 – Occlusal view after tissue suturing.

Fig. 6.43.23 – Tissue healing after four months.

Fig. 6.43.24 – The vestibular fornix was augmented. Teeth 13 and 23 need keratinized mucosa.

Fig. 6.43.25 – The receptor site is prepared.

Fig. 6.43.26 – Free gingival graft removed from the left palatal aspect.

Fig. 6.43.27 – The graft is adapted.

Fig. 6.43.28 – The graft did not cover the entire area. Observe the tooth 23.

Fig. 6.43.29 – The graft was incised to cover the left canine area.

Fig. 6.43.30 – Schematic drawing of the technique.

Fig. 6.43.31 – Schematic diagram showing soft tissue divisions.

Fig. 6.43.32 – Final suturing for graft stabilization.


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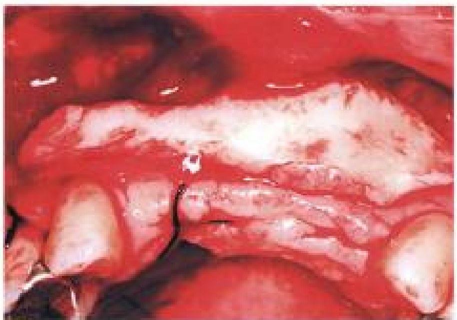
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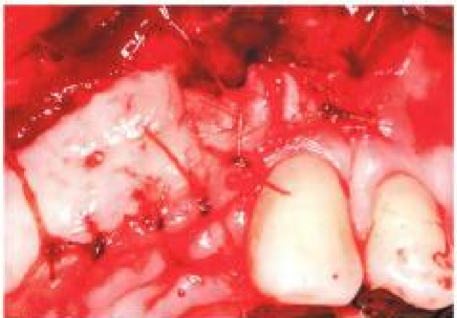
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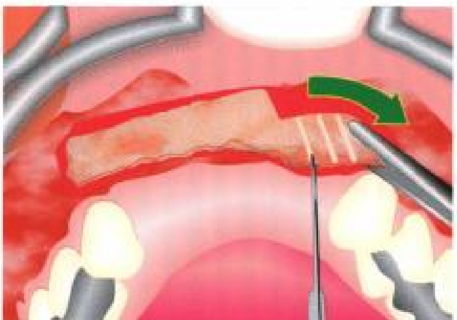
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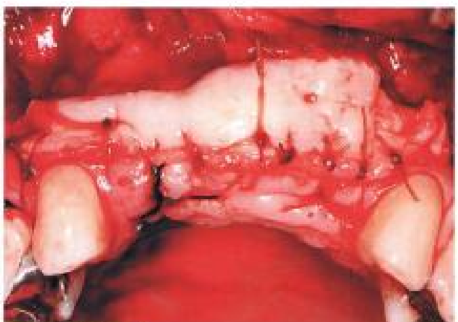
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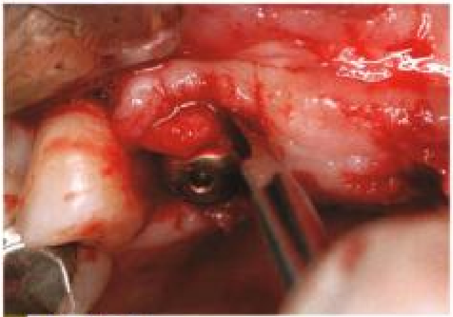
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Fig. 6.43.33 – Observe tissue healing three months later. Now there is adequate keratinized mucosa on both canines.

Fig. 6.43.34 – A circular punch was used to uncover the implants.

Fig. 6.43.35 – The epithelium around the implant was removed.

Fig. 6.43.36 – The healing abutment was connected and the pedicle was rotated to distal for papilla creation.

Fig. 6.43.37 – The same procedure was applied for both sides.

Fig. 6.43.38 – Fifteen days after surgery. Observe the healing abutments.

Fig. 6.43.39 – Impression transfer for provisional implant prosthesis.

Fig. 6.43.40 – Provisional acrylic prosthesis.

Fig. 6.43.41 – The soft tissue is conditioned by the provisional crowns.

Fig. 6.43.42 – Two months after tissue conditioning. The gingival contour at the implant site has been improved.

Fig. 6.43.43 – The provisional prosthesis was relined, there is adequate band of keratinized tissue over the canines, but soft tissue maturation is not completed. The patient has been under orthodontic treatment as well.

6.43.43

Clinical case 15

Patient DF, 16 years-old, female, student. The tooth 11 was lost during a car accident when she was 9 years-old. An implant surgery was scheduled after orthodontic treatment.

Fig. 6.44.1 – Clinical aspect. No papilla is present.

Fig. 6.44.2 – The periapical radiograph shows the localization of the nasopalatine duct, which prevents immediate implant placement.

Fig. 6.44.3 – Occlusal view. Observe the lack of bone tissue.

Fig. 6.44.4 – The neurovascular content of the nasopalatine duct was removed.

Fig. 6.44.5 – Particulate autogenous bone graft with a Gore-Tex membrane.

Fig. 6.44.6 – Gore-Tex suture.

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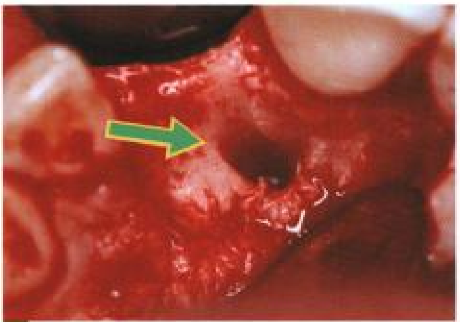

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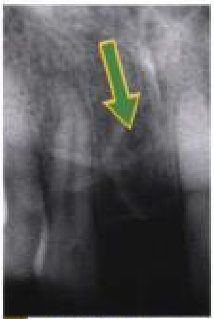
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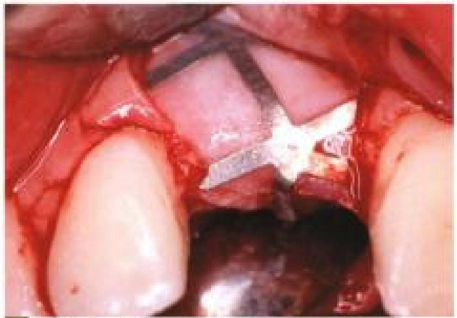
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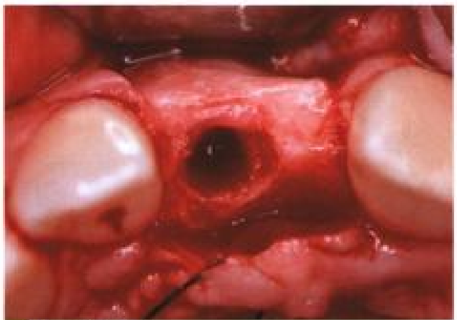
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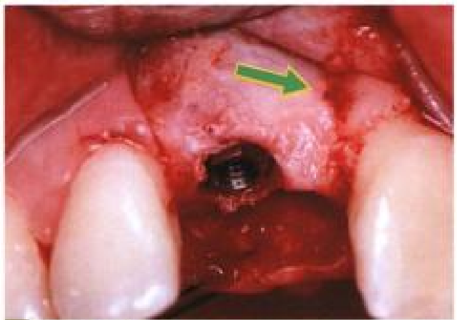
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Fig. 6.44.7 – Two months later. Observe unfavorable labial frenum attachment.

Fig. 6.44.8 – Frenectomy.

Fig. 6.44.9 – Suture.

Fig. 6.44.10 – Clinical aspect 8 months after guided bone regeneration.

Fig. 6.44.11 – Periapical radiograph of tooth 11. The nasopalatine duct is completely filled.

Fig. 6.44.12 – Incision for implant placement.

Fig. 6.44.13 – Membrane in position.

Fig. 6.44.14 – Membrane removal and alveolus instrumentation.

Fig. 6.44.15 – The implant is placed at the region of 11. There is a small bone deficiency near the midline.

Fig. 6.44.16 – Bone graft was placed at particulate autogenus bone in the midline region.

Fig. 6.44.17 – Suture.

Fig. 6.44.18 – Six months later. Observe excellent tissue quality.

Fig. 6.44.19 – Soft tissue punch in position.

Fig. 6.44.20 – there is no need for sutures.

Fig. 6.44.21 – Circular punch with soft tissue removed.

Fig. 6.44.22 – the cover screw is exposed.

Fig. 6.44.23 – The cover screw is removed.

Fig. 6.44.24 – The healing abutment was inserted.

Fig. 6.44.25 – Provisional acrylic crown.

Fig. 6.44.26 – Too much soft tissue is seen around the provisional crown.

Fig. 6.44.27 – The excess is removed by electrosurgery.


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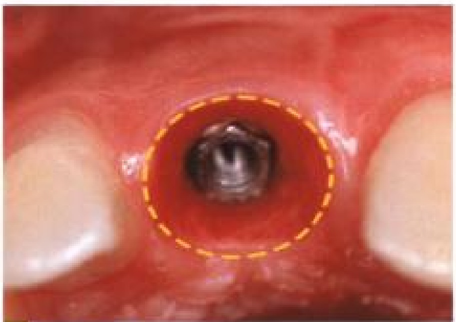
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Fig. 6.44.28 – Observe the final effect.

Fig. 6.44.29 – Three months after tissue conditioning with provisional crown.

Fig. 6.44.30 – Six months after tissue conditioning.

Fig. 6.44.31 – Frontal view. Papilla was formed adjacent to the implant.

Fig. 6.44.32 – Final soft tissue conditioning.

Between the first and the second surgical stages

At this stage, clinicians can use techniques to augment the band of keratinized mucosa aiming esthetics, papillae formation and protection against toothbrush trauma.[13]

Possible surgeries include: palatally rotated flap, soft tissue pouch, free gingival graft, connective tissue graft, interpositional or onlay combined grafts[21], and vestibuloplasty.[13]

The use of free gingival grafts and vestibuloplasty to augment attached mucosa has been studied in the literature. Krekeler et al.[60] installed plasma-sprayed implants on 26 patients. Seventeen patients received previous vestibuloplasty. Half of the implants were inserted in non-keratinized tissue. They concluded that no correlation exists between the attached gingival and plaque level, or with the probing depth. However, in sites with bacterial plaque formation, the lack of attached mucosa contributes to an increase in local inflammation and pocket formation.

Also, concomitant surgical procedures must not interfere with osseointegration process. Sometimes, exposed implant threads or fenestration/dehiscence defects are filled with bone particles. Moreover, the bone graft performed in the first phase was insufficient or had been lost due to postoperative complications that occurring after implant placement.

Clinical case 16

Patient NMA, 51 years-old, female. Treatment planning involves region from 14 to 17. Teeth 15 and 17 have a poor prognosis.

Fig. 6.45.1 – Periapical radiograph of the proposed area.

Fig. 6.45.2 – Panoramic radiograph three months after extraction of compromised teeth. Observe sinus pneumatization in the right area.

Fig. 6.45.3 – Periapical radiograph of the teeth 15 and 17. Pneumatization can be seen at the region of 16.

Fig. 6.45.4 – Incision design for sinus lifting. There is a shallow vestibule.

Fig. 6.45.5 – The exposed area.

Fig. 6.45.6 – A bone graft was removed from the tuberosity region.

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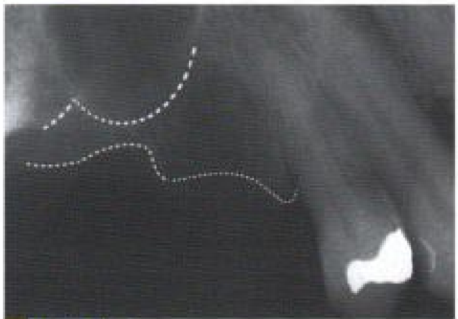

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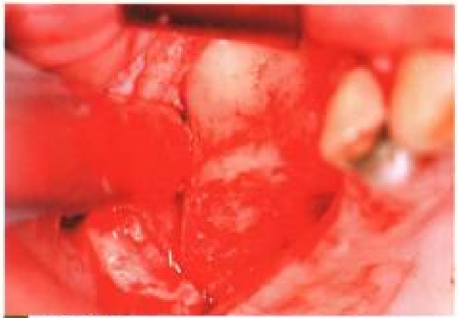
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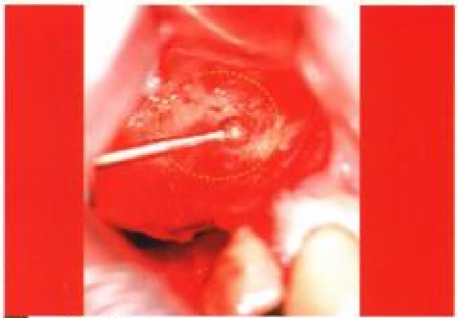
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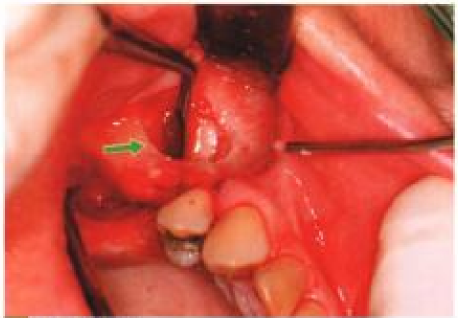
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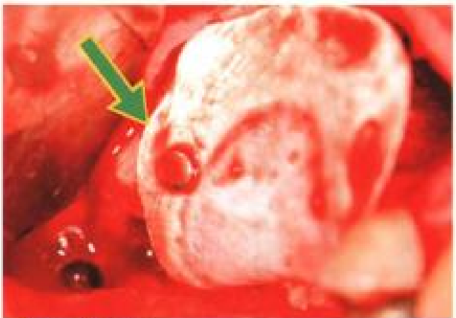
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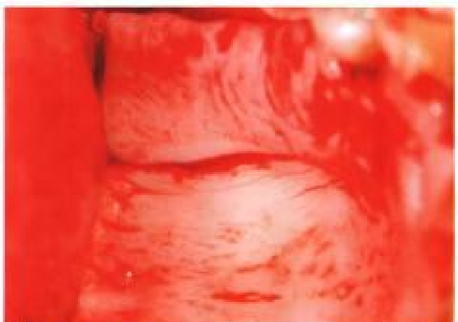
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Fig. 6.45.7 – The bone collector was used to remove bone from the posterior site.

Fig. 6.45.8 – A diamond bur to open a sinus window.

Fig. 6.45.9 – The sinus window is elevated without trauma.

Fig. 6.45.10 – The bone collector removes osseous tissue from the mental region.

Fig. 6.45.11 – Observe the amount of bone graft removed from the maxillary tuberosity, maxillary sinus wall, and mentonian region.

Fig. 6.45.12 – Immediate implant and filling of maxillary sinus with particulate autogenous graft.

Fig. 6.45.13 – The sinus window stabilized with a Gore-Tex membrane.

Fig. 6.45.14 – Six months after the sinus lifting procedure. There no buccal vestibule at the region of 15 and 17.

Fig. 6.45.15 – An incision was placed along the bone crest. Also, a partial thickness flap was created.

Fig. 6.45.16 – Two releasing and one horizontal incision were made at the palatal side to rotate the pedicle toward the coronal portion.

Fig. 6.45.17 – The tissue is moved to coronal.

Fig. 6.45.18 – The first suture line is at the deep of the vestibule.

Fig. 6.45.19 – Suture details.

Fig. 6.45.20. The flap was rotated from palatal to buccal region approximately 5 mm.

Fig. 6.45.21 – The alveolar ridge has deficiencies.

Fig. 6.45.22 – Panoramic view 8 months after the sinus lifting.

Fig. 6.45.23 – The maxillary sinus has healed completely.

Fig. 6.45.24 – Flap rotated from palatal to the buccal side.

Fig. 6.45.25 – Suture.

Fig. 6.45.26. Fifteen days after healing abutment connection.

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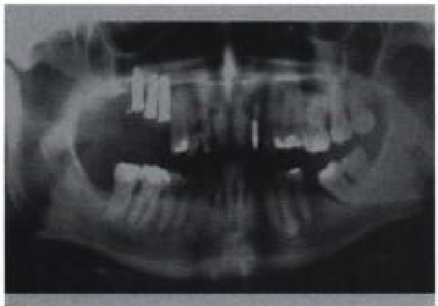

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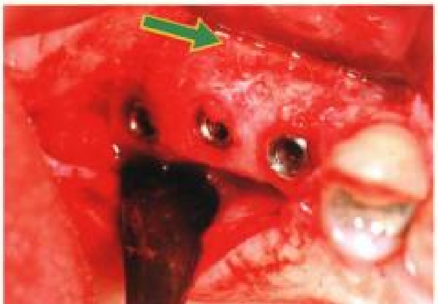

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Fig. 6.45.27 – Three months later. Observe vestibular depth and the quality of periimplant tissue.

Fig. 6.45.28 – Fixed prosthesis from implants at 15, 16 and 17 region after three years.

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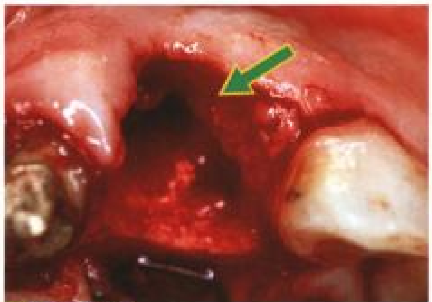

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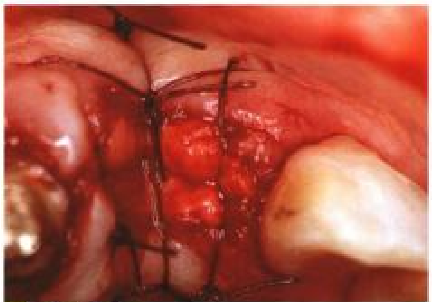

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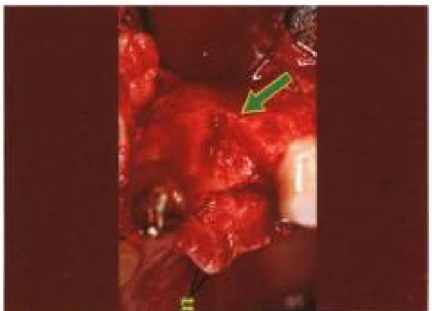


6.46.6

Clinical case 17

Patient HPR, 57years-old, female. The tooth 21 had a poor esthetic and functional prognosis

Fig. 6.46.1 – Unpleasant aspect of tooth 21. There is extensive bone loss.

Fig. 6.46.2 – Periapical radiograph of tooth 21. The osseous fenestration is seen after extraction.

Fig. 6.46.3 – After tooth extraction, observe bone loss.

Fig. 6.46.4 – connective tissue graft.

Fig. 6.46.5 – Three months after tooth extraction. The soft tissue was maintained.

Fig. 6.46.6 – Note extensive bone loss.

Fig. 6.46.7 – The implant was placed. The buccal surface was decorticalized and a healing abutment (2 mm-height, 4 mm-diameter) was connected to augment the soft tissue profile.

Fig. 6.46.8 – Particulate autogenous bone graft.

Fig. 6.46.9 – Gore-Tex membrane stabilized by screws.

Fig. 6.46.10 – Gore-Tex suture.

Fig. 6.46.11 – Clinical aspect 8 months after tissue healing. A tissue deficiency is seen and no papilla is present.

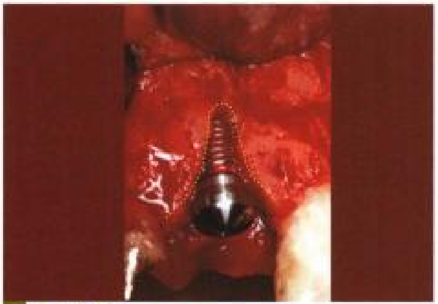
Fig. 6.46.12 – Periapical radiograph 8 months after implant insertion.

Fig. 6.46.13 – Membrane removal.

Fig. 6.46.14 – Clinical aspect showing bone growth over the implant at 22 region.

Fig. 6.46.15 – Before and after guided bone regeneration.

Fig. 6.46.16 – Occlusal view of the implant site. Note the hard tissue formed at buccal and interproximal regions.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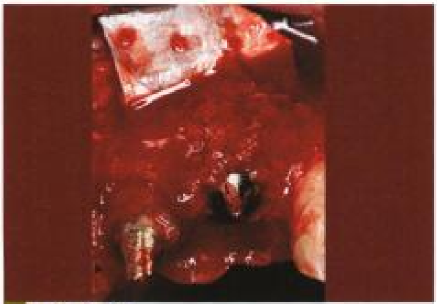
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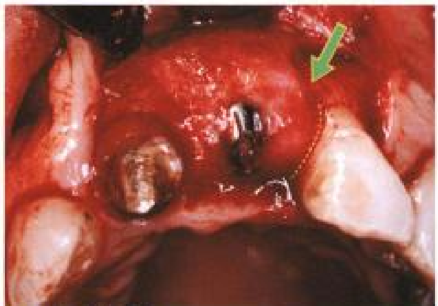
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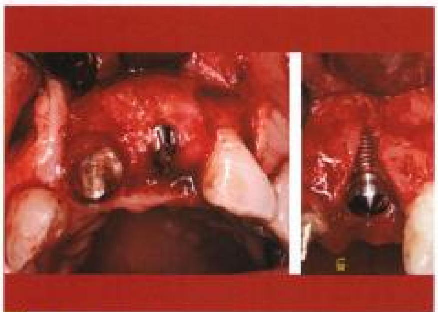
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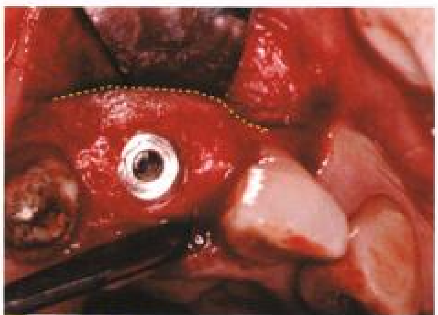
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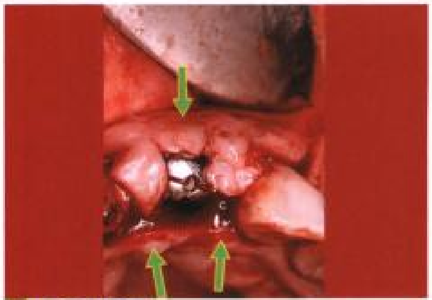

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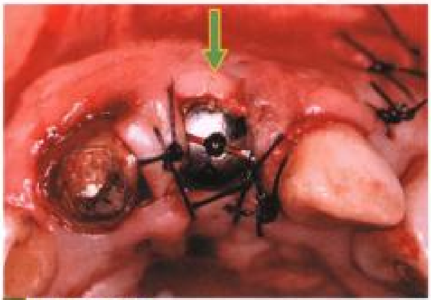

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Fig. 6.46.17 – A palatal incision was made and the full-thickness flap divided in mesial and distal fingers for papilla regeneration. The healing abutment is 1 mm below the gingival margin.

Fig. 6.46.18 – Stabilization sutures for interproximal tissues.

Fig. 6.46.19 – One month after healing connection.

Fig. 6.46.20 – Soft tissue conditioning with provisional crown.

Fig. 6.46.21 – One month after tissue conditioning.

Fig. 6.46.22 – Five months after soft tissue maturation, with progressive relining of the acrylic crown. Observe implant transfer post for impression.

Fig. 6.46.23 – Occlusal final view. Observe the quantity and quality of mucosal tissue with gingival contours similar to the adjacent tooth.

Fig. 6.46.24 – Seven years after prosthesis delivery. The patient shows excellent esthetics.

Clinical case 18

Patient VV, 59 years-old, female. She had a fixed prosthesis from teeth 34 to 36 that fractured on occasion.

Fig. 6.47.1 – Periapical radiograph showing root fracture at tooth 36.

Fig. 6.47.2 – The root fragments were extracted.

Fig. 6.47.3 – After granulation tissue removal, observe bone loss.

Fig. 6.47.4 – A Resolut membrane protected de coagulum.

Fig. 6.47.5 – Gore-Tex suture.

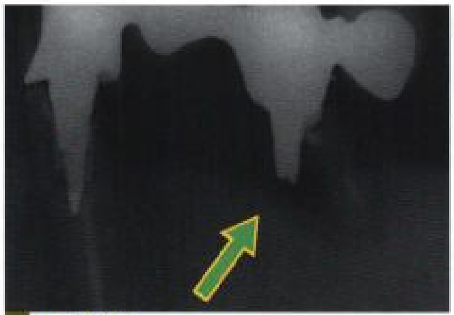
Fig. 6.47.6 – Three months after tissue healing. There is no keratinized mucosa.

Fig. 6.47.7 – The receptor site has been prepared for a free gingival graft.

Fig. 6.47.8 – Free gingival graft to augment the band of keratinized mucosa and the buccal vestibule.

Fig. 6.47.9 – Implant placement. Observe bone regeneration 6 months later.

Fig. 6.47.10 – Periapical radiograph 4 months later.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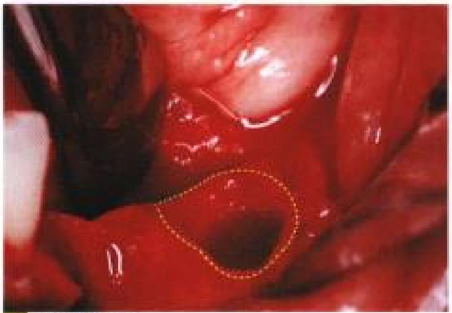
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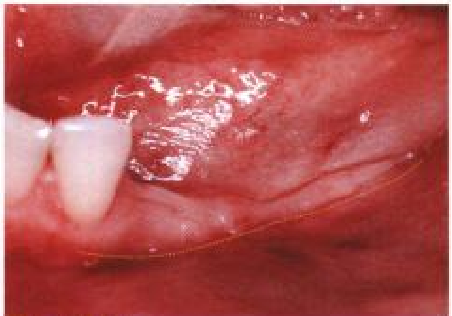
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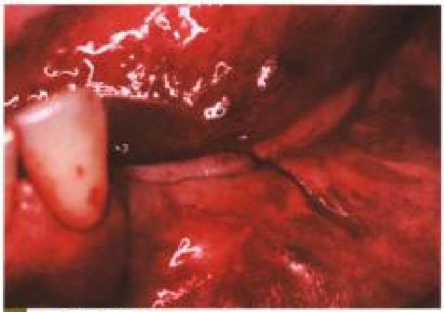
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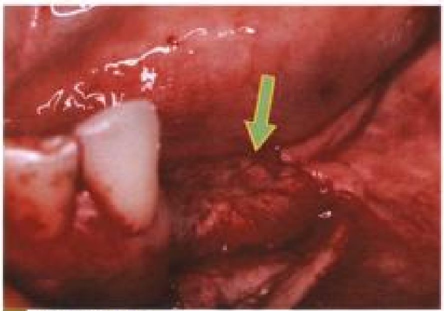
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Fig. 6.47.11 – Seven months after the free gingival graft surgery. Now there is adequate keratinized tissue.

Fig. 6.47.12 – two vertical releasing incisions were placed and a partial thickness flap were rotated from lingual to buccal site.

Fig. 6.47.13 – Observe that the flap was divided.

Fig. 6.47.14 – The flap was apically positioned and sutured.

Fig. 6.47.15 – Three months later. Observe soft tissue around healing abutments.

Fig. 6.47.16 – Four months after soft tissue maturation. Note the quantity and quality of keratinized mucosa.


6.48.1


6.48.2

Clinical case 19

Patient NPM, 47 years-old, female. The premature tooth loss led to complete denture prosthesis insertion. The patient felt unhappy with her actual esthetics.

Fig. 6.48.1 – Computerized Tomography scan showing severe maxillary resorption.

Fig. 6.48.2 – Clinical aspect. Observe maxillary osseous atrophy.

Fig. 6.48.3 – Clinical aspect. An iliac crest block graft was inserted. (Cortesy of Dr. Hugo Nary Filho).

Fig. 6.48.4 – Graft removed from the iliac crest.

Fig. 6.48.5 – Clinical aspect 6 months later. Observe the lack of buccal vestibule and keratinized mucosa.

Fig. 6.48.6 – Panoramic radiograph. Good bone integration is observed.

Fig. 6.48.7 – The stabilization screws were removed. There is sufficient alveolar ridge after the surgery.

Fig. 6.48.8 – The complete prosthesis was relined trying to the a buccal fold.

Fig. 6.48.9 – Three months later. There is no buccal fold yet.

Fig. 6.48.10 – Clinical aspect four months after tissue maturation. Incision design for implant placement.

Fig. 6.48.11 – Ten implants were inserted. Observe parallelism among them.

Fig. 6.48.12 – Clinical aspect 4 months later. Buccal fold is not observed.


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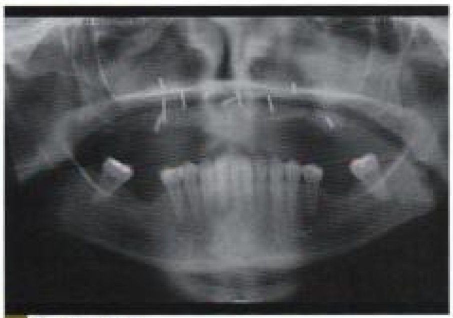
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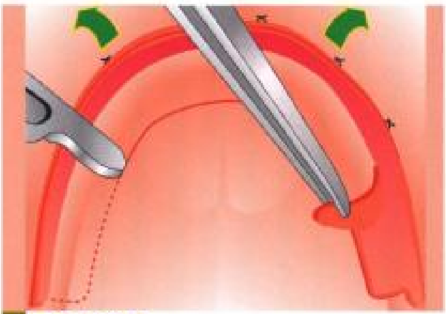
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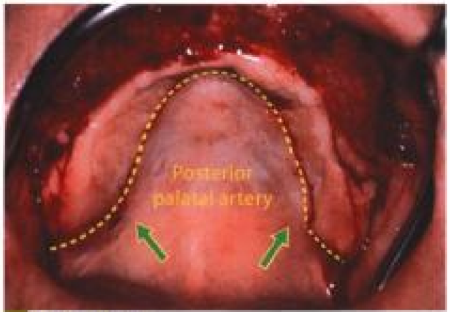

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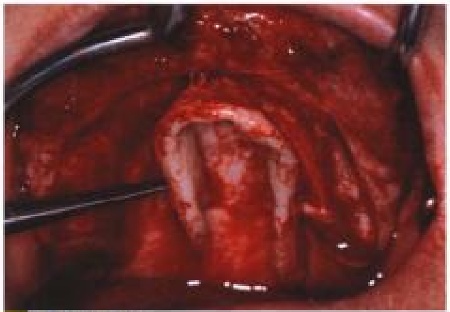
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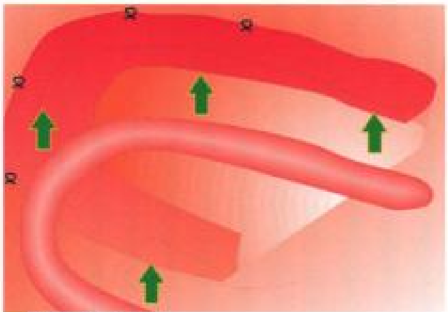
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Fig. 6.48.13 – A partial thickness flap was elevated and the vestibuloplasty performed.

Fig. 6.48.14 – Schematic drawing for flap design and free gingival grafting procedure.

Fig. 6.48.15 – The palatal area is delimitated to remove the free gingival graft.

Fig. 6.48.16 – The tissue is removed from 17 to 27 region.

Fig. 6.48.17 – Free gingival graft.

Fig. 6.48.18 – Schematic drawing of graft removed.

Fig. 6.48.19 – The free gingival graft is stabilized by sutures.

Fig. 6.48.20 – Schematic diagram showing graft stabilization.

Fig. 6.48.21 – A complete denture prosthesis is inserted to protect the grafted area.

Fig. 6.48. 22 – Clinical aspect 1 month later. Observe that a buccal fold was formed and the quantity and quality of keratinized tissue.

Second surgical state

Now, the healing abutments are connected. Early protocols aimed to expose the top of implants, evaluate osseointegration condition and to install abutments with enough length to fabricate dental prosthesis. However, this step has received great attention due to the esthetic requirements for the soft tissue in the anterior region. Gingival contour, thickness and the amount of attached tissue can be managed to enhance long-term periimplant performance.

The second surgical stage is directed toward soft tissue management and papilla formation. Available techniques include: use of a circular punch, roll technique (Abrams envelop[7]), apically positioned flap, free gingival graft, and papilla formation strategies.

Possibilities on second surgical stage

- adequate soft tissue thickness to the abutment height contour;
- remove bone growth over healing abutment;
- bone contouring to enhance emergence profile;
- observe direct seating of healing abutments;
- to preserve, create or enhance the amount of keratinized mucosa through plastic periodontal periimplant surgeries;
- to improve soft tissue adaptation around healing abutment;
- to improve final esthetics with adequate flap design to create papillary tissue and good emergence profiles.

Clinical case 20

Patient AA, 72 years-old, male. An implant surgery was indicated for posterior lower region (35-37).

Fig. 6.49.1 – Clinical aspect showing the lack of keratinized mucosa and buccal vestibule.

Fig. 6.49.2 – Three implants were inserted in the regions of 35, 36, and 37.

Fig. 6.49.3 – Four months later. The cover screws are showing through the thinned mucosa, which denotes the lack of attached tissue.

Fig. 6.49.4 – Periapical radiograph, four months after implant insertion. Observe bone healing.


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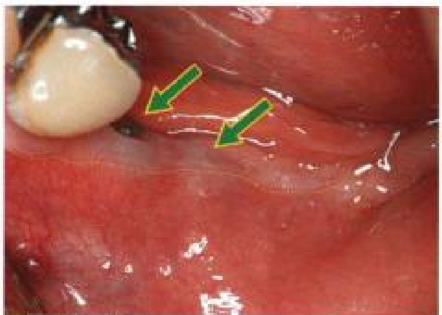
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Fig. 6.49.5 – A free gingival graft was planned in the posterior region with the aim to augment the keratinized mucosa.

Fig. 6.49.6 – A partial thickness flap was elevated.

Fig. 6.49.7 – Free gingival graft removed from the palatal region.

Fig. 6.49.8 – The healing abutments were inserted.

Fig. 6.49.9 – The graft was positioned and stabilized by suturing around the healing abutments.

Fig. 6.49.10 – Tissue healing after three months.

Fig. 6.49.11 – Observe the excellent aspect of the soft tissue.

Clinical case 21

Patient SVF, 51 years-old, female. A fixed prosthesis was lost in the region from 25 to 28.

Fig. 6.50.1 – Observe the soft tissue deficiency. The teeth 25 and 27 had been scheduled for extraction.

Fig. 6.50.2 – Periapical radiograph. Distance from the alveolar ridge to the floor of the maxillary sinus is 7 mm.

Fig. 6.50.3 – Root fragments of teeth 25 and 27 were removed, and the sinus floor was elevated with the Summers' technique.

Fig. 6.50.4 – Immediate implant placement at 25 region. There is a fenestration on the buccal aspect.

Fig. 6.50.5 – Guided bone regeneration on teeth 25 and 26. Particulate autogenous bone graft and Gore-Tex membrane.

Fig. 6.50.6 – Gore-Tex membrane stabilized over the cover screw.

Fig. 6.50.7 – Connective tissue graft removed from tuberosity area.

Fig. 6.50.8 – Suture. The connective tissue graft was placed for primary flap closure.

Fig. 6.50.9 – Clinical aspect 8 months later. Observe the lack of keratinized mucosa on the region of 25 and 26.

Fig. 6.50.10 – Periapical radiogaph 8 months later. Observe excellent bone healing on the 26 region after sinus floor lifting.


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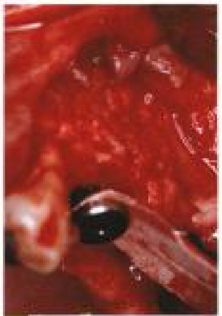
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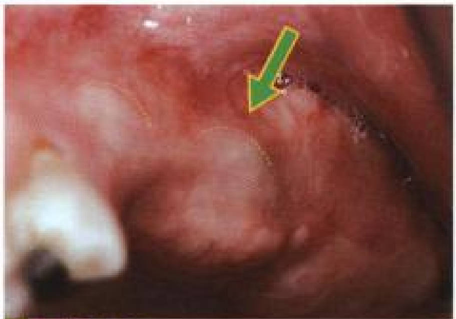
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Fig. 6.50.11 – Two vertical releasing incisions were placed on the buccal aspect to remove the membrane. The papillary tissue was preserved.

Fig. 6.50.12 – A full thickness flap was apically positioned.

Fig. 6.50.13 – Three months after tissue healing with transmucosal abutments.

Fig. 6.50.14 – Three months after tissue healing with the emergence profile transmucosal component. Observe the quantity and quality of keratinized tissue.


6.51.1


6.51.2


6.51.3


6.51.4

Clinical case 22

Patient SM, 67 years-old, female. Osseointegrated implants were scheduled in the lower posterior region.

Fig. 6.51.1 – Second surgical stage. There is a buccal frenum and a shallow vestibule.

Fig. 6.51.2 – Periapical radiograph 4 months later implant placement.

Fig. 6.51.3 – Two vertical releasing incisions were placed at the buccal aspect and one incision made from lingual to buccal.

Fig. 6.51.4 – The flap was divided and apically positioned.

Fig. 6.51.5 – Flap suture.

Fig. 6.51.6 – Two months after healing and impression transfer procedures.

Fig. 6.51.7 – Definitive prosthesis six years later. There is an excellent attached mucosa around the porcelain crowns.


6.51.5


6.51.6


6.51.7

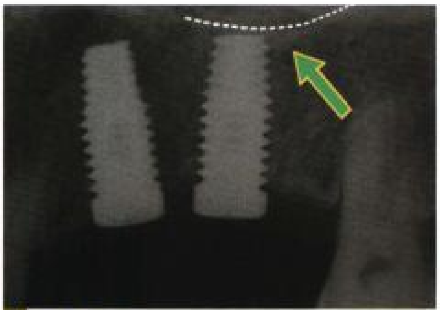
Clinical case 23

Patient WB, 28 years-old, male. Advanced periodontal disease on teeth 25 and 26. Six months later, two implants were inserted after the Summers' technique.

Fig. 6.52.1 – Eight months after implant insertion. The cover screw is showing through the thinned mucosa.

Fig. 6.52.2 – Periapical radiograph showing excellent bone healing after sinus lifting procedure.


6.52.1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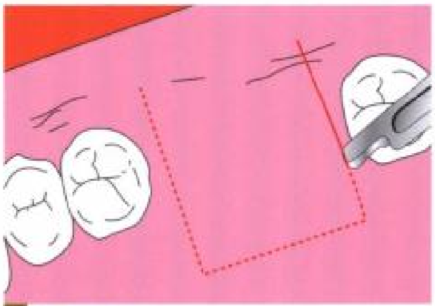
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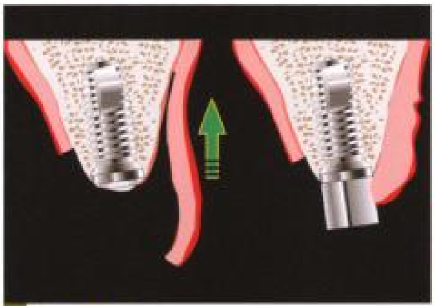
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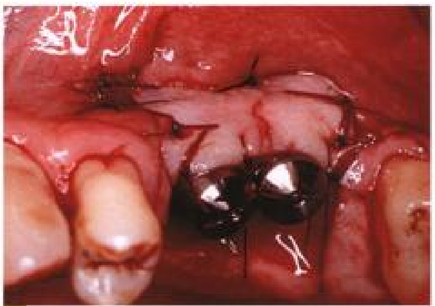
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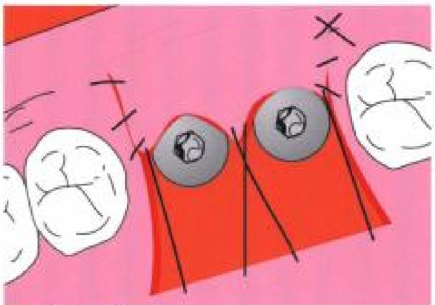
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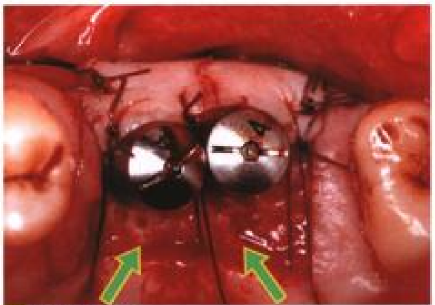
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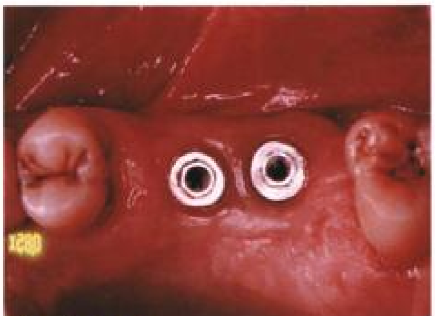
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Fig. 6.52.3 – A full thickness flap was elevated from palatal to the alveolar crest, followed by a partial thicknes flap in the buccal region.

Fig. 6.52.4 – Observe that the healing abutment and the partial thickness flap on the buccal aspect. The periosteum is indicated here.

Fig. 6.52.5 – Incision design.

Fig. 6.52.6 – Schematic drawing. The flap is moved in a apical direction.

Fig. 6.52.7 – Clinical view. The palatal flap is moved to the buccal position.

Fig. 6.52.8 – The flap is sutured and apically stabilized.

Fig. 6.52.9 – Suture design.

Fig. 6.52.10. The palatal surface is exposed to heal by second intention.

Fig. 6.52.11 – Three months after soft tissue maturation. Observe complete mucosal regeneration.

Fig. 6.52.12 – Note the amount of keratinized mucosa on the palatal and vestibular surfaces.

Clinical case 24

Patient IGSM, 54 years-old, female. The teeth 26 and 27 were lost due advance periodontal disease. An implant surgery was indicated.

Fig. 6.53.1 – Periapical radiograph 8 months after sinus lifting.

Fig. 6.53.2 – There is a shallow vestibule at the second surgical stage.

Fig. 6.53.3 – Schematic drawing of incision design.

Fig. 6.53.4 – The flap was rotated from palatal to buccal surface.

Fig. 6.53.5 – there is only soft tissue attachment at the buccal area.

Fig. 6.53.6 – The flap is incised at the palatal portion.

Fig. 6.53.7 – The flap was divided.

Fig. 6.53.8 – The flap is maintained by the muscular pedicle.

Fig. 6.53.9 – Now, the flap is divided.

Fig. 6.53.10 – Schematic drawing. The flap is apically stabilized.


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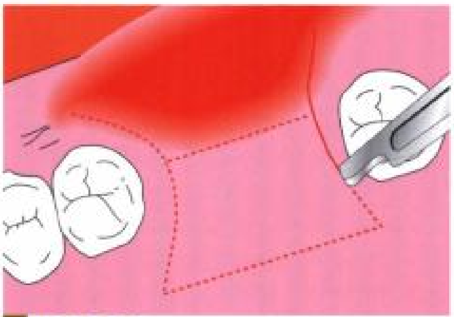
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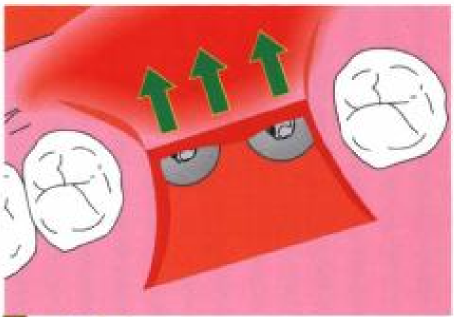
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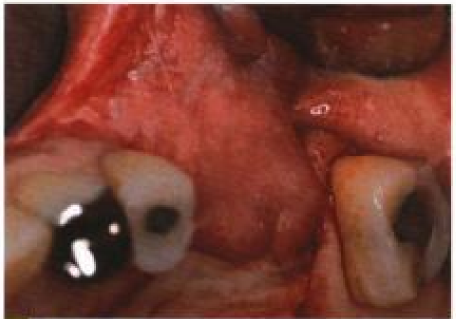
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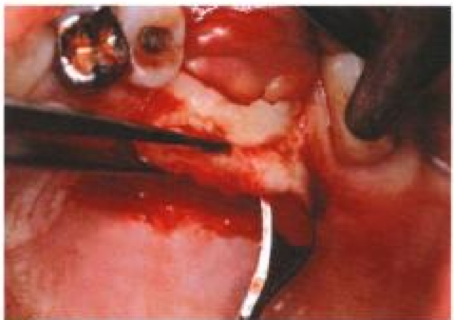
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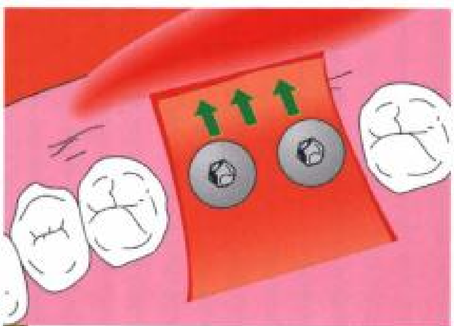
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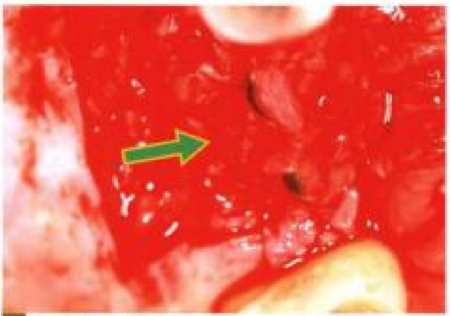
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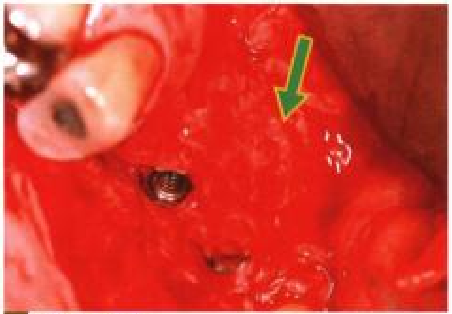
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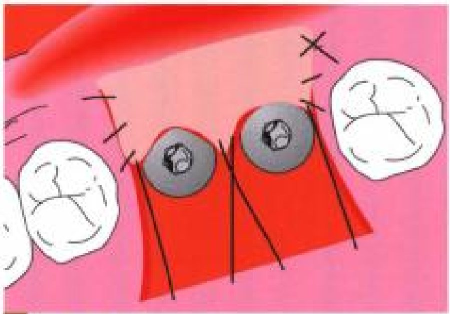
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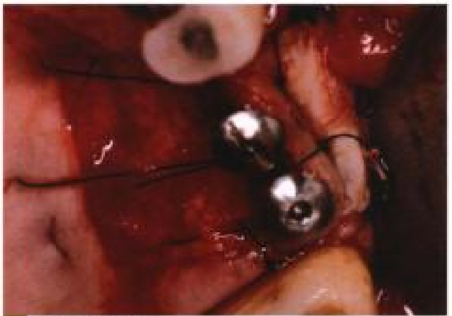
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Fig. 6.53.11 – A partial thickness flap is elevated on the palatal surface.

Fig. 6.53.12 – The flap was apically positioned (divided at the buccal aspect).

Fig. 6.53.13 – Healing abutment connection.

Fig. 6.53.14 – Schematic drawing of sutures.

Fig. 6.53.15 – Suture. Buccal view.

Fig. 6.53.16 – Suture. Palatal view.

Fig. 6.53.17 – Three years after prosthesis delivery. Observe the quantity and quality of keratinized mucosa.

Fig. 6.53.18 – Observe the restoration three years later.

Surgical techniques for implant uncovering – second surgical stage

Soft tissue circular punch

First, the cover screw must be localized with the aid of the surgical template. After, the overlying soft tissue is removed with the circular punch, the implant is exposed and the abutment connected. Due to its circular configuration, the instrument helps in soft tissue conditioning and papillae formation. Main indications for this procedure are well-positioned implants with sufficient periimplant tissue quantity and quality.

The soft tissue punch is contra-indicated when:

The soft tissue is too thick and the punch cannot be well-adapted;

The implant is below the bone crest, which prevents the punch from reaching the proposed site; here, it is necessary to remove the bone over the cover screws through the use of curettes or similar devices.

After the cover screw have been released, the clinician can remove the bone around the implant with a low rotation bur (bone profiler) at 200-300rpm, which further permits perfect seating of the healing abutment.

Papilla formation in the second surgical stage

Several techniques have been described to minimize tissue recession and improve periimplant healing. An adequate amount of keratinized mucosa around implants could be important to maximize esthetic outcomes, at the same time that prevents inflammatory process and trauma to the tissues.

Now we will describe some techniques to manage the soft tissue and create papilla around implants.

Nemcovsky et al. technique [45]

It is indicated for single implants, with interproximal papillae on adjacent teeth. On the other hand, it is not recommended in the lack of keratinized gingiva or when the flap must be apically positioned.

Description:

A U-shaped incision is made in the gingival sulcus of adjacent teeth and continues from the facial aspect to the healing abutment localization at the palatal area. Now, a full-thickness flap is elevated. Then, interproximal papillae are denuded to receive this flap.

The healing abutment is replaced with a new transmucosal component. Now, an incision is placed at the middle of flap creating two fingers. Each finger is dislocated to their respective mesial and distal areas. Each half is placed over the denuded papilla and secured with vertical monofilament 4-0 or 5-0 sutures.


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Clinical case 25

Patient LB, 28 years-old, female. Tooth 11 is lost. An implant surgery was scheduled.

Fig. 6.54.1 – Initial periapical radiograph. There is soft and hard tissue loss. Orthodontic forced eruption is indicated.

Fig. 6.54.2 – Clinical aspect.

Fig. 6.54.3 – Six months after the orthodontic forced eruption. Now, soft and hard tissue is improved.

Fig. 6.54.4 – Tooth extraction. Observe the lack of bone buccal wall.

Fig. 6.54.5 – The implant was placed.

Fig. 6.54.6 – Bone graft removed from the retromolar area.

Fig. 6.54.7 – Particulate autogenous bone graft from the retromolar area.

Fig. 6.54.8 – The graft is adapted over the implant. Also, a resorbable membrane is inserted.

Fig. 6.54.9 – Suture.

Fig. 6.54.10 – Four months later there is soft tissue loss, with the cover screw showing through the thinned mucosa.

Fig. 6.54.11 – The bone graft is integrated, and a connective tissue graft was adapted over it.

Fig. 6.54.12 – Frenectomy was performed simultaneously to the graft procedure.

Fig. 6.54.13 – The graft is sutured.

Fig. 6.54.14 – Six months later, the cover screw is exposed. There was large soft tissue shrinkage at the buccal area.

Fig. 6.54.15 – Periapical radiograph after 6 months. Observe complete bone healing.

Fig. 6.54.16 – The receptor site is prepared for a free gingival graft. The cover screw as replaced by a transmucosal component.

Fig. 6.54.17 – Free gingival graft stabilized by sutures.

Fig. 6.54.18 – Postoperative view after 3 weeks.

Fig. 6.54.19 – Four months after soft tissue maturation. There is soft tissue deficiency at buccal and interproximal regions.

Fig. 6.54.20 – The graft region, from palatal to buccal side.

Fig. 6.54.21 – Schematic drawing of incisions.

Fig. 6.54.22 – The flap is divided to augment the soft tissue area and to provide adequate pedicle nutrition.


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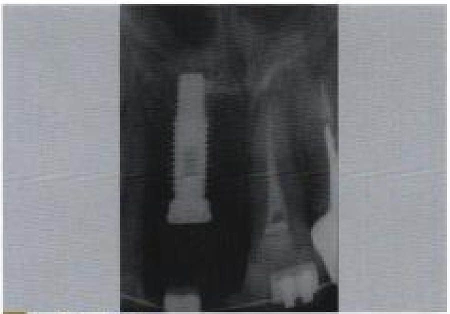
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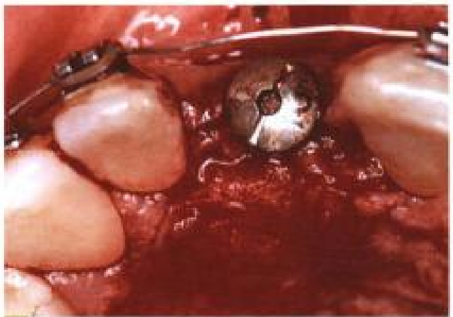
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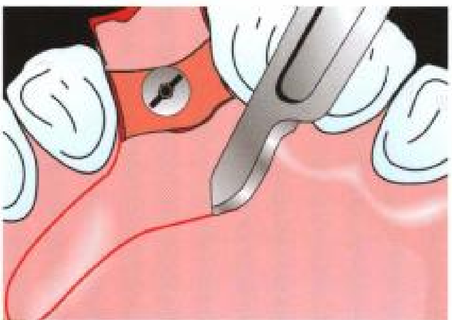
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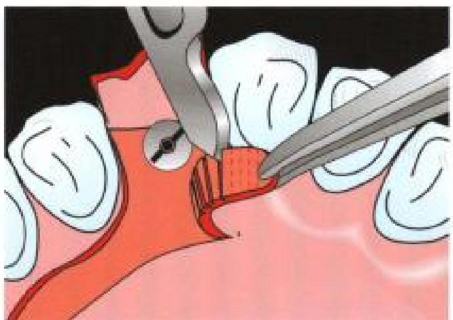
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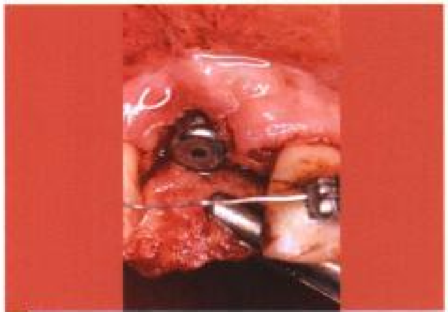
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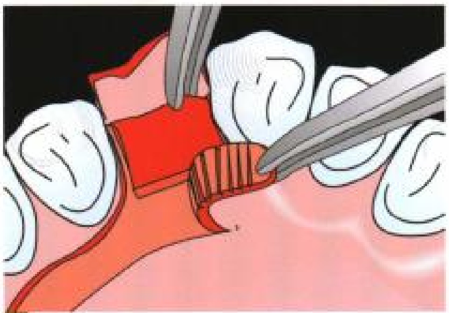
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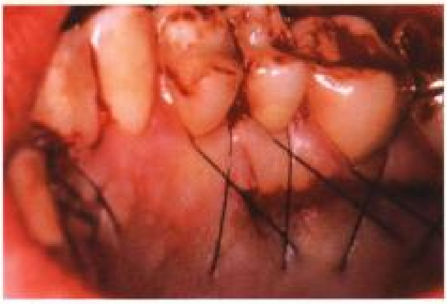
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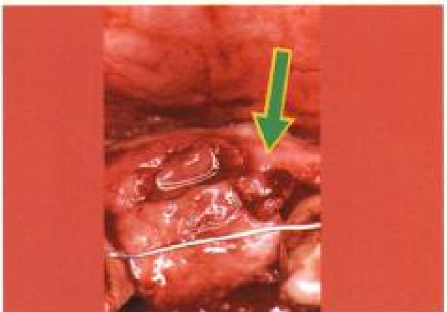
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Fig. 6.54.23 – Pediculated flap.

Fig. 6.54.24 – Pediculated flap over the buccal area.

Fig. 6.54.25 – The soft tissue removed was insufficient for primary wound close.

Fig. 6.54.26 – The tissue was divided several times to augment the proposed area.

Fig. 6.54.27 – Now, the pedicle is widened.

Fig. 6.54.28 – Suturing at the donor site. Observe primary closure.

Fig. 6.54.29 – Connective tissue graft removed from the palatal region.

Fig. 6.54.30 – Connective tissue graft interposed to augment the soft tissue profile at the region of 21.

Fig. 6.54.31 – Suture is placed. Observe tension-free flaps with primary closure.

Fig. 6.54.32 – Postoperative view 15 days later.

Fig. 6.54.33 – Postoperative view 3 months later. Observe the soft tissue quantity and quality over the implant.

Fig. 6.54.34 – Palatal view.

Fig. 6.54.35 – A circular punch is used.

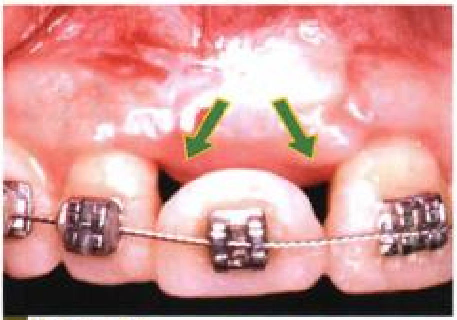
Fig. 6.54.36 – A soft tissue pouch is removed.

Fig. 6.54.37 – Healing abutment connected.

Fig. 6.54.38 – Six months after soft tissue conditioning with a provisional acrylic crown. There is enough keratinized buccal and interproximal tissue.

Fig. 6.54.39 – An excellent periimplant condition is seen after soft tissue conditioning.

Fig. 6.54.40 – Overview of several treatment steps taken.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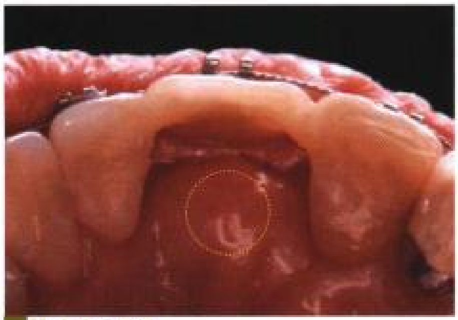
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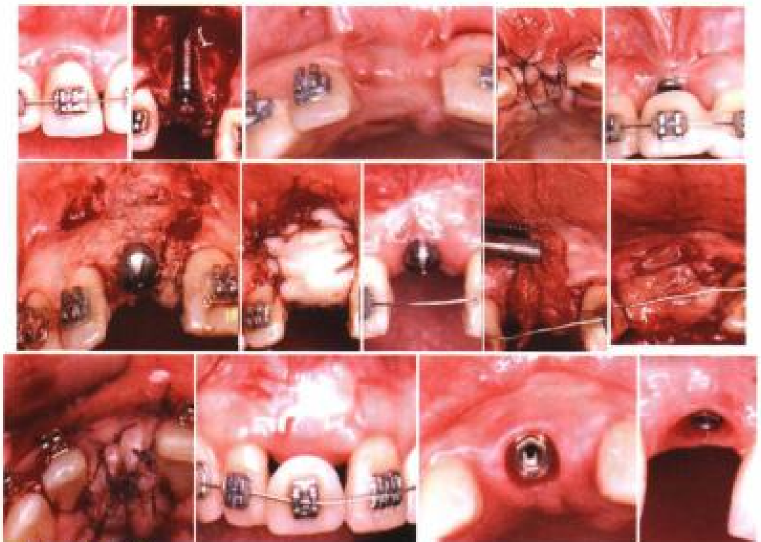
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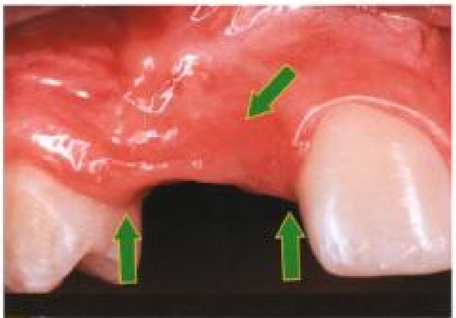

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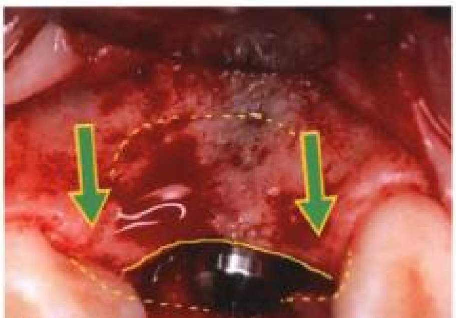

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Clinical case 26

Patient SL, 23 years-old, female. After several surgeries for orthodontic treatment, the patient had a removable prosthesis in the region of teeth 12 and 13. Orthodontic treatment was finalized and the patient is scheduled for implants.

Fig. 6.55.1 – Periapical radiograph when the patient was 10 years-old. An endodontic treatment was performed in tooth 12. The tooth 13 is unerupted.

Fig. 6.55.2 – The endodontic treatment had no success and was extracted.

Fig. 6.55.3 – Clinical aspect of removable prosthesis. She was very upset with her esthetics.

Fig. 6.55.4 – Panoramic radiograph.

Fig. 6.55.5 – Clinical aspect. Observe the lack of tissue in height and thickness. Inadequate space for implant placement (teeth 12 and 13).

Fig. 6.55.6 – Observe bone loss due to extraction of teeth 12 and 13.

Fig. 6.55.7 – An implant was planned at the region of 13.

Fig. 6.55.8 – The implant was placed. The alveolar ridge was expanded by the Summer's technique.

Fig. 6.55.9 – Observe the lack bone tissue in height and thickness.

Fig. 6.55.10 – Particulate autogenous bone graft removed from the retromolar area. At the same time the tooth 48 was removed.

Fig. 6.55.11 – Titanium reinforced Gore-Tex membrane stabilized by screws.

Fig. 6.55.12 – Gore-Tex suture.

Fig. 6.55.13 – Panoramic radiograph after 8 months. Observe bone regeneration (detail at the inset).

Fig. 6.55.14 – Clinical aspect 8 months later (second surgical stage).

Fig. 6.55.15 – Observe excellent membrane integration and the canine contour at the buccal surface.

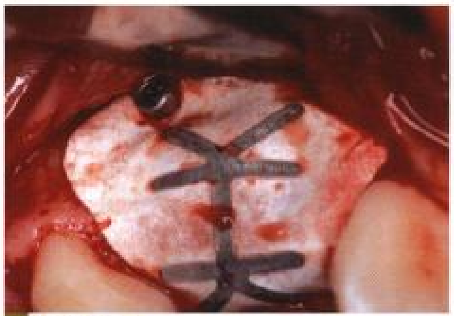
Fig. 6.55.16 – Membrane removal. Observe soft tissue augmentation over the transmucosal component.

Fig. 6.55.17 – Soft tissue removal over the membrane.

Fig. 6.55.18 - Suture.

Fig. 6.55.19 – One month after soft tissue conditioning with provisional acrylic prosthesis for papilla creation.

Fig. 6.55.20 – Provisional prosthesis. Acrylic resin will be added at the region of 12 to create papillary tissue.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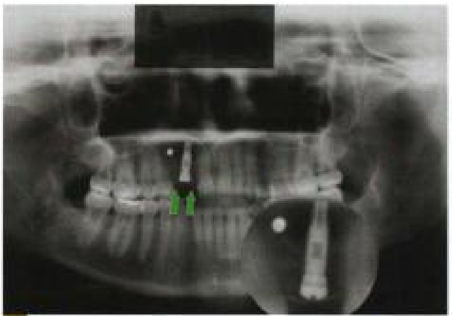
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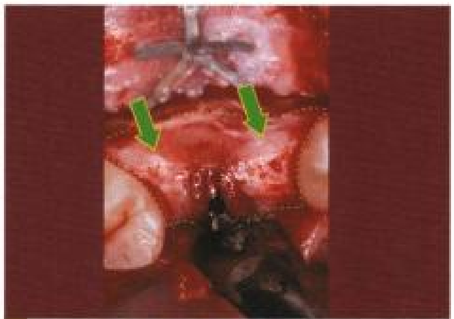
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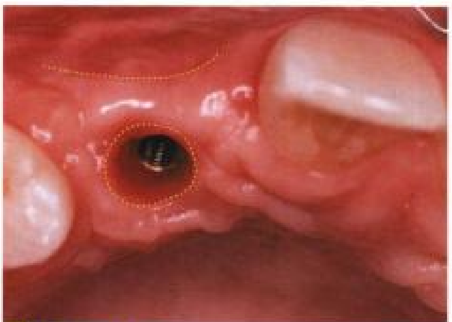
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Fig. 6.55.21 – The relining process can be seen at the intaglio surface of element 12.

Fig. 6.55.22 – Papilla was formed through tissue compression with provisional prosthesis.

Fig. 6.55.23 – Impression transfer procedure. Papillary tissue was formed.

Fig. 6.55.24 – Try-in of metal infra-structure. Soft tissue maturation after one year.

Fig. 6.55.25 – Clinical aspect after 5 years.

Fig. 6.55.26 – Clinical comparison during treatment.

Tinti and Parma Benfenati[46] technique

This technique is indicated when more than two adjacent implants are needed.

Description:

A linear incision is placed 5 mm apart from mesial and distal sites. When there is adjacent tooth to implant situation, an intrasulcular incision is made. No more incisions are made.

After, a full-thickness flap is elevated, healing abutments are exposed and substituted for trasmucosal components.

The flap is rotated to the labial side. Gore-Tex monofilament sutures (3i/WL Gore) are placed 5 mm above the palatal aspect. After 4-5 weeks, gingivectomy is made at the labial side to provide papilla configuration. When there is insufficient keratinized tissue, the flap is extended to the palatal area, providing adequate masticatory mucosa.

Palacci[47] technique

Palacci was the first surgeon to highlight his concerns on interproximal esthetics for the anterior maxillary region.

Description:

The papilla regeneration technique begins with a linear incision placed at the palatal-lingual aspect of the cover screws, followed by vertical releasing incisions in a buccal and divergent direction to allow better blood supply to the flap. It is important to preserve the gingival cuffs at neighboring teeth. A full-thickness flap is elevated in the buccal direction.

The cover screws are removed and the proper abutments connected to the implants. A semilunar bevel incision is made in the buccal flap towards each abutment, starting at the distal aspect of the most mesially located implant. The pedicles are disengaged and rotated 90 degrees toward the palatal side to fill in the interimplant space. This simulates new periimplant papillae. Tissues are sutured at the interproximal region without tension in the pedicles.

This technique can be used either for single or multiple implants in both arches.

Use of healing abutments with emergence profile for papilla formation

It comprehends several techniques to warrant maintenance of keratinized tissue, providing its excellent distribution over buccal, interproximal and palatal areas. Control of soft and hard tissue positions allow clinicians to better visualize final esthetic outcomes.

Use of customized healing abutments (EP- emergency profile)

Once the second surgical stage is finished, the soft tissues will need 6-8 weeks for wound healing and maturation. Thus, a stable gingival margin is obtained and restorative prosthetic procedures can be advanced. To supply an increasing esthetic demand of patients, industry has provided new components that can mimic the appearance of natural teeth. Thus, the second surgical stage is fundamental because the size, shape and diameter of the healing abutment will determine success or failure.

Many professionals feel frustrated because they could not provide adequate esthetics in the past. Today, the emergence profile can be shaped by healing abutments with progressive diameters. Clinicians will find in the market healing abutments with 5, 6, and 7.5 mm to match the desired perimeter. Similarly, different sizes are available so that the healing is 1-2 mm above the gingiva to prevent tissue inflammation.


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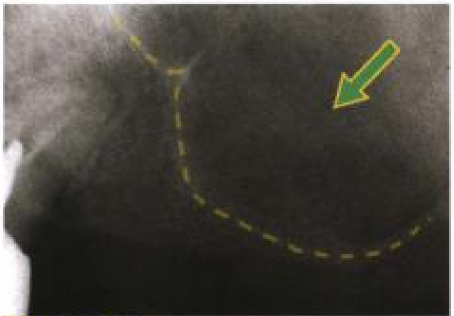
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Clinical case 27

This 70 year-old patient was indicated for implant placement at the anterior and posterior upper left quadrant. He had a removable prosthesis.

Fig. 6.56.1 – Panoramic radiograph. Treatment planning included tooth 21 extraction, sinus lifting at the upper left quadrant, and implant placement at tooth 24 – The patient wants to maintain the tooth 23.

Fig. 6.56.2 – The tooth 12 that will replaced by an implant.

Fig. 6.56.3 – Tooth 22 removed.

Fig. 6.56.4 – Alveolar socket after tooth extraction. Interproximal papillae and bone walls were preserved.

Fig. 6.56.5 – An acrylic provisional pontic at the region of 22.

Fig. 6.56.6 – Periapical radiograph showing sinus pneumatization.

Fig. 6.56.7 – Incision placed at the buccal surface for sinus lifting and bone graft procedures.

Fig. 6.56.8 – A full thickness flap is elevated at the maxillary sinus area. The sinus mucosa is exposed.

Fig. 6.56.9 – A spherical bur delimitated the sinus bone window.

Fig. 6.56.10 – The sinus window is elevated. The sinus membrane is perforated.

Fig. 6.56.11 – A resorbable membrane (Bioguide) was placed at the roof of the maxillary sinus.

Fig. 6.56.12 – The bone graft was removed from the mentonian region with a trephine bur.

Fig. 6.56.13 – Particulate bone and Bio-Oss.

Fig. 6.56.14 – Particulate autogenous bone graft filling the maxillary sinus.

Fig. 6.56.15 – The implant placed at the region of 25.

Fig. 6.56.16 – Resorbable membrane (Bioguide) adapted over the bone wall of maxillary sinus.

Fig. 6.56.17 – Suture.

Fig. 6.56.18 – Eight months after maxillary sinus lifting.

Fig. 6.56.19 – Observe bone loss at the region of tooth 21. There is a lack of keratinized mucosa at the posterior region, as well as at the tooth 25.

Fig. 6.56.20 – Periapical radiograph eight months later. The root of tooth 23 is too distal. The maxillar sinus is filled with bone.


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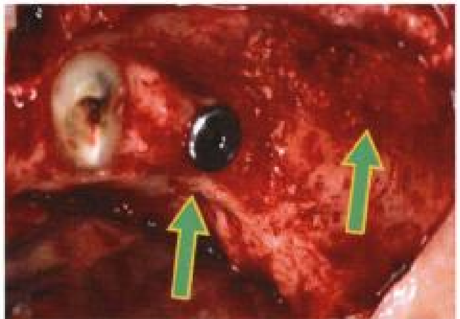
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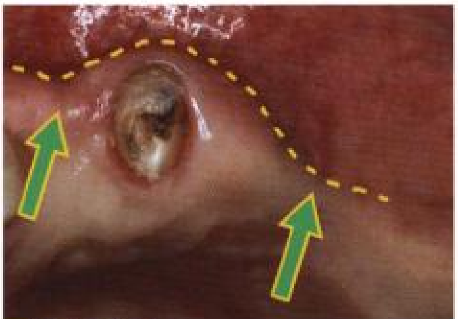
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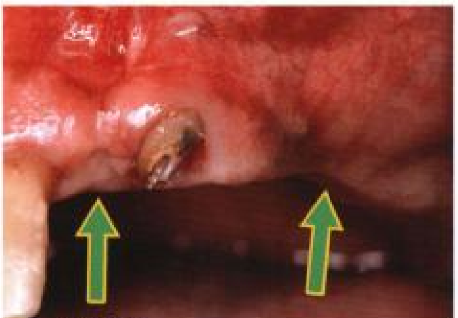
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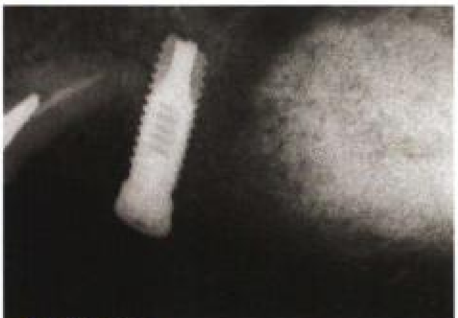
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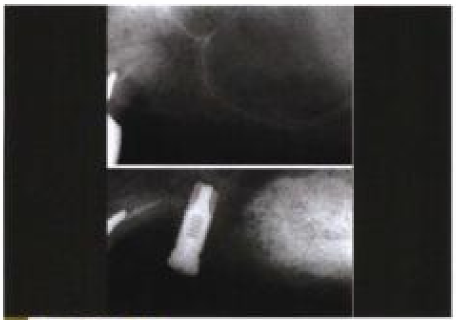
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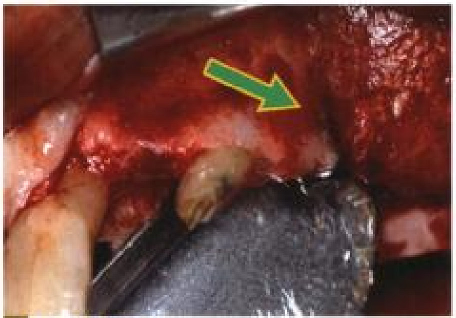
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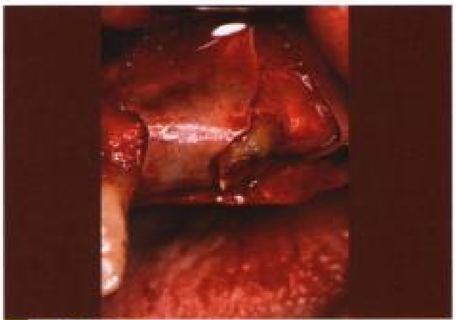
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Fig. 6.56.21 – Periapical radiographs before and after sinus lifting. Observe bone gain at the site.

Fig. 6.56.22 – Periapical radiograph 8 months later at the same region.

Fig. 6.56.23 – Implant placement at 21 region. There is implant thread exposure at 25 region.

Fig. 6.56.24 – An implant will be placed at 22 region. Observe the sinus lifting region.

Fig. 6.56.25 – Implant placement at 22 region. The alveolar ridge was split by the Su mmer's technique .Green-stick fracture at the buccal wall.

Fig. 6.56.26 – Autogenous bone graft and resorbable membrane around the 22 region.

Fig. 6.56.27 – Receptor site preparation for implant placement at region 26 and 27. The alveolar sockets were prepared by the Summers' technique.

Fig. 6.56.28 – Implant placement at 26 and 27 region.

Fig. 6.56.29 – Alveolar extraction socket at 23.

Fig. 6.56.30 – Root fragment.

Fig. 6.56.31 – Palatal donor site of the connective tissue graft that will be placed at the 23,24 and 25 region.

Fig. 6.56.32 – Connective tissue removed.

Fig. 6.56.33 – Implant placed at the 23 region. Six months after bone regeneration the buccal aspect is augmented at 25 implant.

Fig. 6.56.34 – Connective tissue graft.

Fig. 6.56.35 – Tissue graft over the implant to augment the band of keratinized tissue. This step is important for papilla creation.

Fig. 6.56.36 – Gore-Tex suture.

Fig. 6.56.37 – Periapical radiograph six months after implant insertion at 22,23, and 25 region.

Fig. 6.56.38 – Periapical radiograph six months after implant insertion at 26 and 27 region.

Fig. 6.56.39 – Six months after implant and graft surgeries. There is adequate keratinized tissue but no vestibule.

Fig. 6.56.40 – Two vertical releasing incisions were placed at the buccal aspect with dental papilla preservation. The flap is divided at the palatal site.


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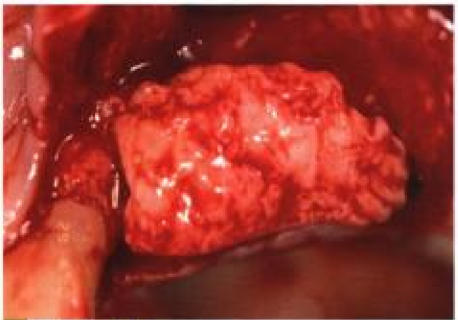
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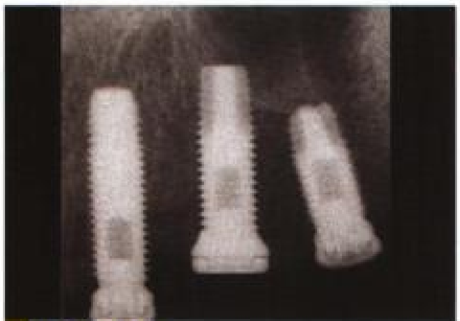
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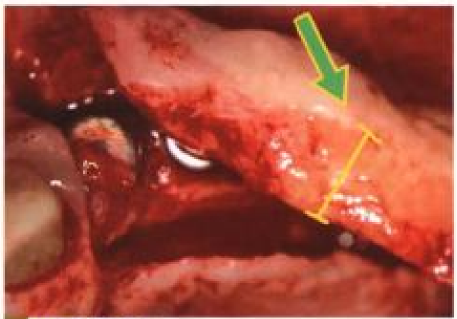
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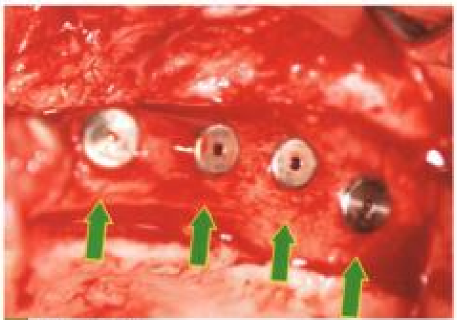
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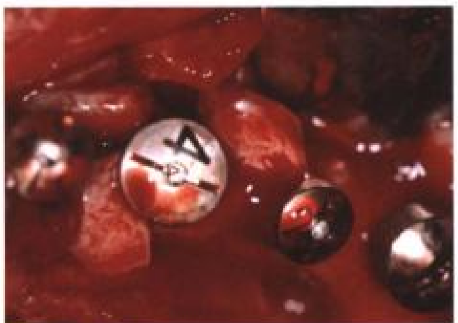
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Fig. 6.56.41 – Incision aspect at the palatal site. A too thickness mucosa is present.

Fig. 6.56.42 – Partial- and full-thickness flap are elevated on palatal and buccal aspect, respectively. The flap will be folded over the buccal site to augment the mucosal thickness around the cover screws.

Fig. 6.56.43 – The soft tissue is elevated for transmucosal connection.

Fig. 6.56.44 – Note excellent implant cicatrization.

Fig. 6.56.45 – Fourteen months after sinus lifting. There is no implant thread exposure.

Fig. 6.56.46 – Second surgical stage.

Fig. 6.56.47 – Connective tissue graft removed from the tuberosity region.

Fig. 6.56.48 – Abrams' envelop design.

Fig. 6.56.49 – Tissue graft adapted around the healing abutments to make papila.

Fig. 6.56.50 – Adequate soft tissue at the buccal aspect and around the abutments.

Fig. 6.56.51 – Suture design.

Fig. 6.56.52 – Gore-Tex suture stabilizing soft tissue graft around the abutments.

Fig. 6.56.53 – Occlusal view of sutures.

Fig. 6.56.54 – Periapical radiograph to confirm the connection of impression transfer components. Observe bone quality.

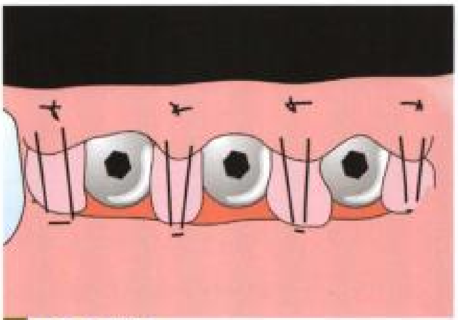
Fig. 6.56.55 – Master cast fabricated.

Fig. 6.56.56. Occlusal view at the implant region. Observe the quantity and quality of soft tissue obtained.

Fig. 6.56.57 – Observe periimplant papilla aspect and the vestibule.

Fig. 6.56.58 – Observe the quantity and quality of soft tissue at periimplant region.

Fig. 6.56.59 – Periapical radiograph 2 years after prosthesis delivery.



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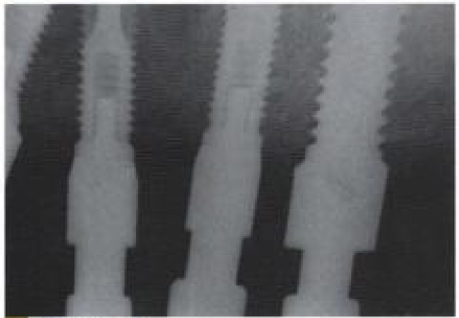

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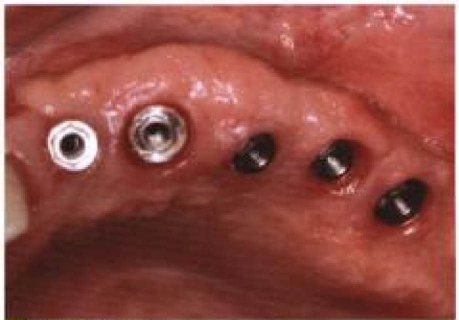

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Fig. 6.56.60 – Buccal view after 5 years.

Fig. 6.56.61 – Occlusal view 5 years later.


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Clinical case 28

Patient mm, 54 years-old, female. Root fracture at tooth 21. An implant was scheduled.

Fig. 6.57.1 – Clinical aspect. Apical fistulous tract.

Fig. 6.57.2 – Root extraction and fracture exposition.

Fig. 6.57.3 – Extraction was performed with a periotome. The soft tissue (papillae) was maintained.

Fig. 6.57.4 – PRP gel.

Fig. 6.57.5 – The alveolar socket was filled with PRP.

Fig. 6.57.6 – Gel-like aspect of PRP.

Fig. 6.57.7 – Final aspect of alveolar socket.

Fig. 6.57.8 – Suture.

Fig. 6.57.9 – Clinical aspect 2 days after extraction.

Fig. 6.57.10 – Two months after tooth extraction.

Fig. 6.57.11 – Periapical radiograph.

Fig. 6.57.12 – Bone defect at buccal side.

Fig. 6.57.13 – Surface-treated implant embedded in PRP and autogenous bone.

Fig. 6.57.14 – A PRP gel and an autogenous bone graft were placed after implant insertion.

Fig. 6.57.15 – Gore-Tex suture.

Fig. 6.57.16 – Radiograph 6 months after implant placement.

Fig. 6.57.17 – There is a bone deficiency at the buccal site.


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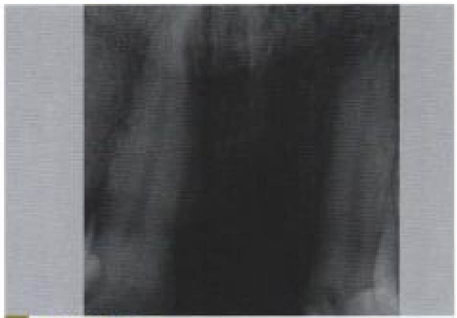
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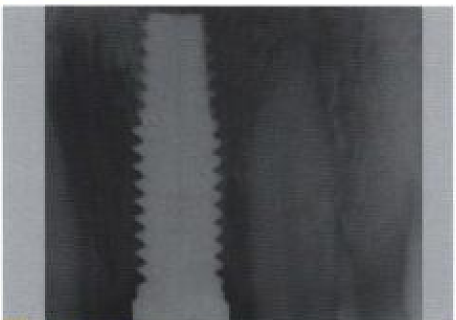
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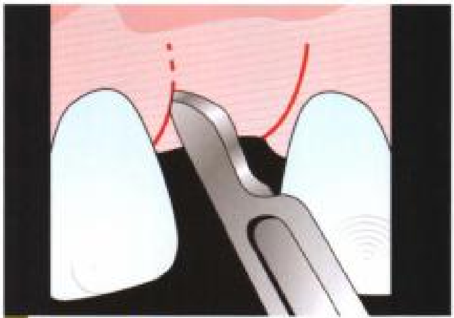
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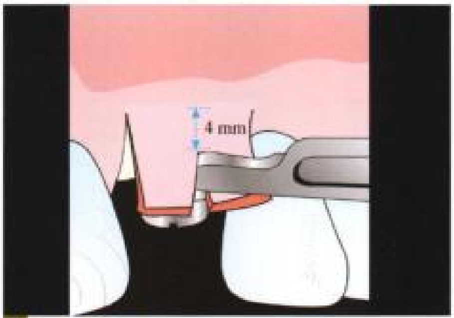

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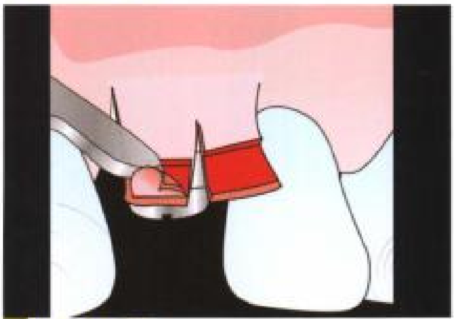
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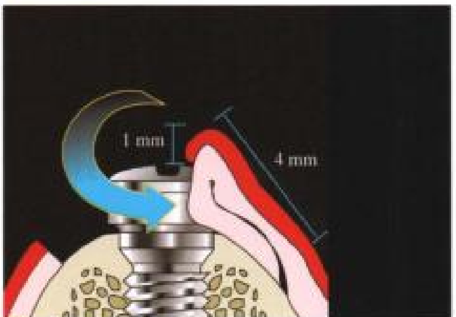

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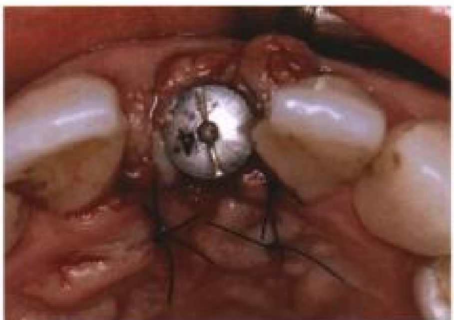
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Fig. 6.57.18 – Incision design.

Fig. 6.57.19 – An incision was placed at the midportion of the flap to preserve the keratinized mucosa.

Fig. 6.57.20 – Epithelial layer removal at the palatal site.

Fig. 6.57.21 – Incision placed at the palatal site.

Fig. 6.57.22 – The flap was rotated to the buccal site.

Fig. 6.57.23 – Observe bone regeneration at the buccal aspect.

Fig. 6.57.24 – Observe that the flap pedicle was folded over the buccal aspect and divided around its mesial and distal portions.

Fig. 6.57.25 – The flap was coronally positioned and an incision placed at midportion.

Fig. 6.57.26 – Now, the epithelial layer was removed and the flap moved to create papillae.

Fig. 6.57.27 – Suture. Observe tissue augmentation at the buccal aspect.

Fig. 6.57.28 – Fifteen days later.

Fig. 6.57.29 – Six months after soft tissue conditioning.

Fig. 6.57.30 – Clinical aspect 5 years later. Observe soft tissue stability.


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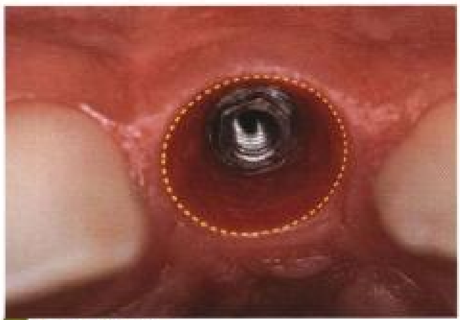
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Clinical case 29

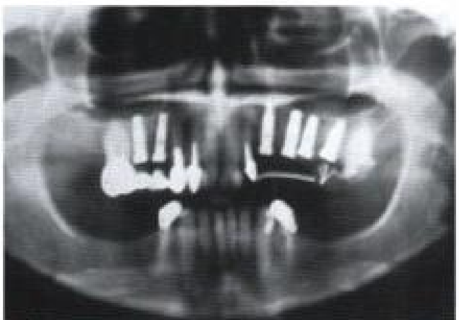
This 50 year-old female patient had the implants installed from 24 to 26 region. (Courtesy of Prof. Alber Barbosa Barbara, Rio de Janeiro, Brazil)

Fig. 6.58.1 – Panoramic radiograph.

Fig. 6.58.2 – Clinical aspect 6 months after implant placement.

Fig. 6.58.3 – Incision design.

Fig. 6.58.4 – The incision is placed at the palatal site to uncover the implants and the buccal aspect is moved approximately 5 mm.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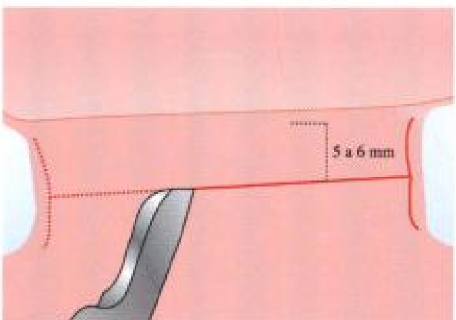

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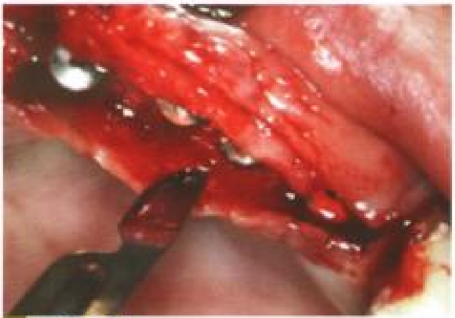
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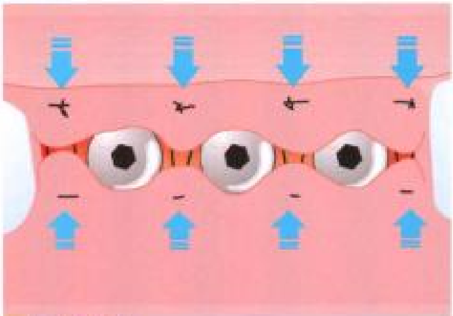
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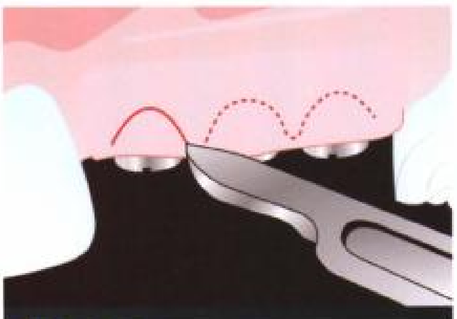
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Fig. 6.58.5 – Connective tissue graft removed from the palatal region inserted at the buccal flap.

Fig. 6.58.6 – After healing abutment connection, soft tissue pedicles were inserted between the implants.

Fig. 6.58.7 – there is approximately 5 mm of soft tissue around the abutment.

Fig. 6.58.8 – Suture for tissue stabilization over the transmucosal components.

Fig. 6.58.9 – Incision design.

Fig. 6.58.10 - Occlusal view.

Fig. 6.58.11 – Buccal view of sutures.

Fig. 6.58.12 – Clinical aspect 6 weeks after second surgical stage.

Fig. 6.58.13 – Incision design to create an scalloped gingival architecture.

Fig. 6.58.14 – Clinical view of scalloped incision.

Fig. 6.58.15 – Final aspect of gingival architecture.

Fig. 6.58.16 – Clinical aspect 4 weeks later.

Fig. 6.58.17 – Schematic drawing of adequate gingival architecture.

Fig. 6.58.18 – Soft tissue maturation 4 weeks later. Observe papillae formation.

Fig. 6.58.19 – Papillary clinical aspect (Tinti and Benfenat Technique).


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Clinical case30

Patient JP, 23 years-old, female. The patient was hit several shots on region of the face and one of them hit the area of 12 to 23 teeth. It was indicated to implant reconstruction.

Fig. 6.59.1 – Right lateral view. This patient needs orthodontic treatment for occlusal correction and tooth alignment.

Fig. 6.59.2 – Frontal view. Observe extensive bone loss in height and thickness, as well as the root fragments.


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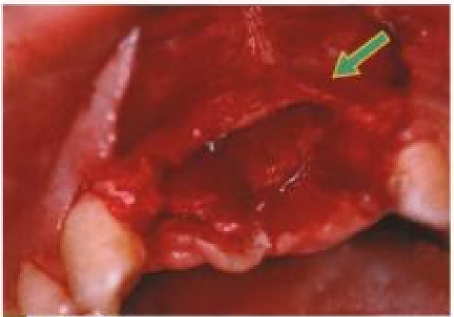
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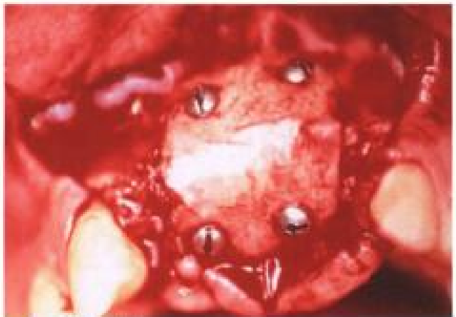
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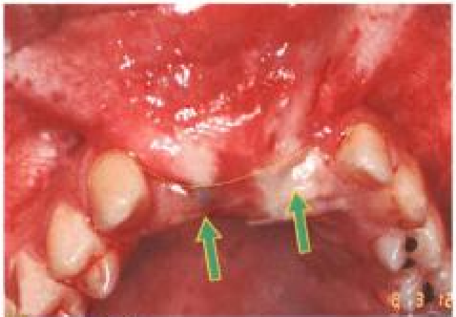
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Fig. 6.59.3 – Left lateral view.

Fig. 6.59.4 – Occlusal radiograph. Observe extensive bone loss.

Fig. 6.59.5 – Frontal aspect.

Fig. 6.59.6 – Extra-oral iliac bone graft (Courtesy of Dr. Luís Henrique Marinho).

Fig. 6.59.7 – Bone graft stabilized with four screws. Attempts to gain bone height and thickness.

Fig. 6.59.8 – Clinical aspect 4 months later. Observe showing through of the stabilization screw.

Fig. 6.59.9 – Occlusal radiograph 4 months later. Observe excellent integrity of bone tissue.

Fig. 6.59.10 – Neither the keratinized mucosa nor the vestibule are present. Soft tissue aspect.

Fig. 6.59.11 – Incision placed at the surgical site.

Fig. 6.59.12 – The stabilization screws are removed.

Fig. 6.59.13 – The flap was apically sutured.

Fig. 6.59.14 – An acrylic stent in an attempt to keep the vestibuloplasty results.

Fig. 6.59.15 – Three months later. No vestibule was created.

Fig. 6.59.16 – Free gingival graft to gain keratinized mucosa and vestibule. The tissue was apically positioned.

Fig. 6.59.17 – Tissue healing after 15 days.

Fig. 6.59.18 – Three months later. Observe the quantity and quality of the soft tissue.

Fig. 6.59.19 – An incision is made at the palatal site.

Fig. 6.59.20 – Palacci's technique. Observe excellent bone regeneration.

Fig. 6.59.21 – The cover screws are removed and the healing abutments connected.

Fig. 6.59.22 – Schematic drawing with the flap moved to the buccal site.


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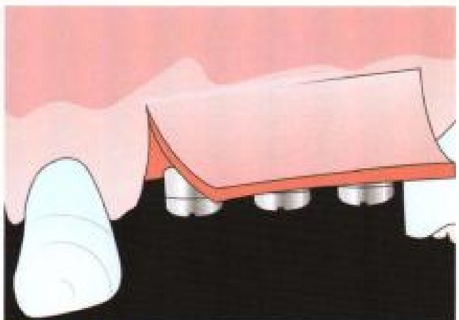
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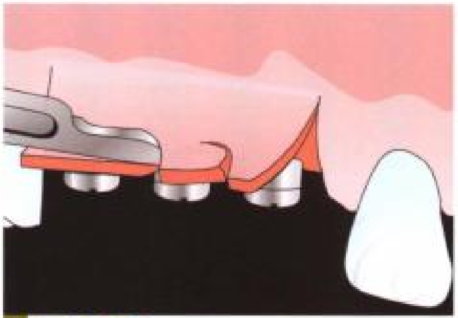
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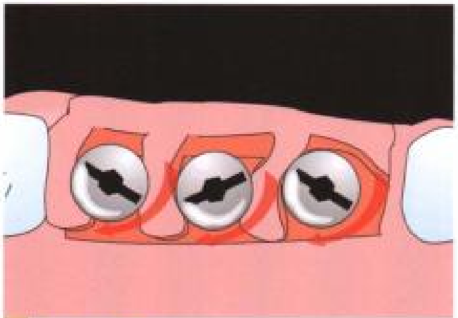
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Fig. 6.59.23 – The flap was moved to the buccal site. Observe flap height through the abutments.

Fig. 6.59.24 – Incision design for papilla creation.

Fig. 6.59.25 – C incision with flap rotated to the distal portion.

Fig. 6.59.26 – The flaps are interposed between the implants.

Fig. 6.59.27 – Palacci's technique.

Fig. 6.59.28 – Suture for graft stabilization.

Fig. 6.59.29 – The implant at 21 is incorrect but was left in position.

Fig. 6.59.30 – A flap was created to cover the implant.

Fig. 6.59.31 – Suture.

Fig. 6.59.32 – Three months later. Provisional prosthesis installed for soft tissue conditioning at implant sites 11 and 21.

Fig. 6.59.33 – One year after soft tissue conditioning.

Fig. 6.59.34 – Occlusal view of implant sites 11 and 12, and soft tissue compression at 21 region. Note the quality and quantity of keratinized mucosa and vestibule of oral cavity.

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Clinical case 31

Patient LS, 36 years-old, female. Apical abscess at root 36. two apicectomies had been performed and the tooth was scheduled for extraction.

Fig. 6.60.1 – Periapical radiograph.

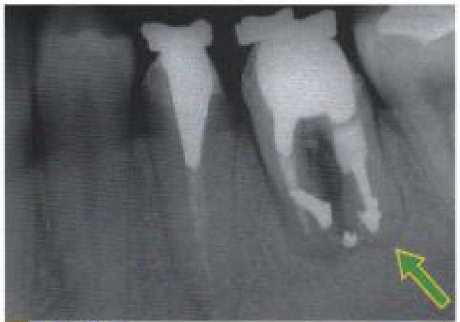
Fig. 6.60.2 – Observe localized bone loss at apical portion of tooth 36.

Fig. 6.60.3 – Alveolar portion after tooth extraction. There is an extensive bone loss.

Fig. 6.60.4 – A titanium-reinforced Gore-Tex membrane was placed around the defect.

Fig. 6.60.5 – Suture. The membrane was exposed.

Fig. 6.60.6 – Three months after tooth extraction, the patient had the membrane exposed.



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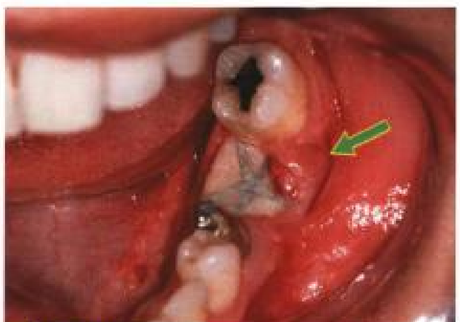

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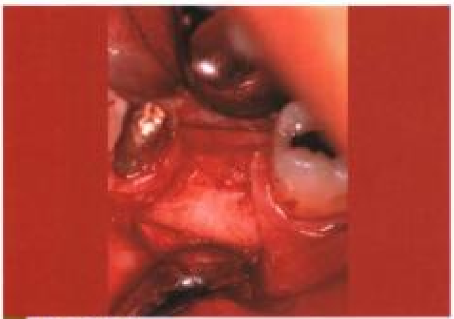
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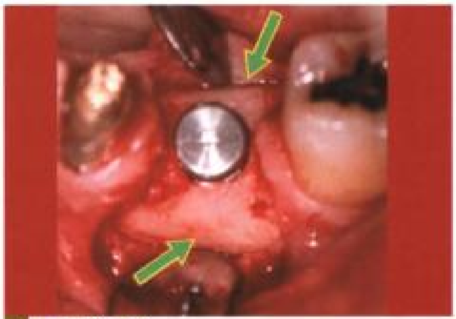
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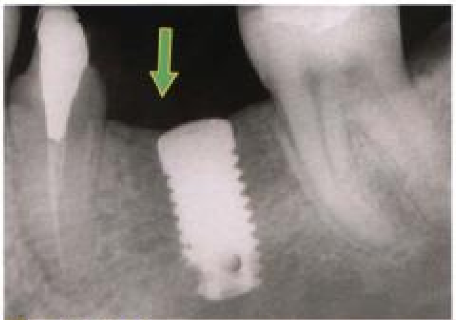
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Fig. 6.60.7 – The Gore-Tex membrane is removed.

Fig. 6.60.8 – Three months after soft tissue maturation.

Fig. 6.60.9 – Flap creation and papilla preservation before implant placement at region 36. Observe excellent bone regeneration.

Fig. 6.60.10 – Large diameter implant placed. Preservation of buccal and lingual walls is seen.

Fig. 6.60.11 – Suture.

Fig. 6.60.12 – Periapical radiograph four months later. Observe bone over the implant.

Fig. 6.60.13 – Clinical view. The bone can be seen over the implant top.

Fig. 6.60.14 – Bone profile.

Fig. 6.60.15 – The surrounding bone is removed.

Fig. 6.60.16 – Detailed view after bone removal.

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Fig. 6.60.17 – EP healing abutment (5 mm x 7.5 mm).

Fig. 6.60.18 – Three months later. Observe the quantity and quality of soft tissue around the implant.

Fig. 6.60.19 – Clinical view after three years. There is excellent esthetics around the implant crown.

Undoubtedly, this was the most important step taken by 3I Innovations to improve esthetics around periimplant tissues.

Main advantages of the Emergence Profile abutment

- It provides guided tissue healing and more esthetic restorations
- It can be found in three anatomic dimensions: 5,6, and 7.5 mm
- Numbers on the top of the component means abutment height, diameter and the emergence profile.
- A well-polished titanium surface to facilitate soft tissue adaptation

Also, the dentist has now impression copings, implant analogs, and prosthetic components with different diameters. This is very important to improve communication with dental technicians.

Another technique consists in fabrication of provisional crowns to conditioning the papillary tissue. Jemt[48] suggested that this could preserve papilla and guide the soft tissue to the interproximal space. It was concluded that soft tissue conditioning with provisional crowns was faster than with healing abutments.

After second surgical stage and definitive prosthesis insertion

Jemt & Lekholm[49] measure changes in buccal and proximal tissue volumes after local bone grafting and single-implant treatment. Ten patients were provided with buccal bone grafts 6 months prior to implant treatment in central upper incisor regions. Following a healing time of 6 months, abutments and single-implant crowns were installed and followed up for 2 years. They observed that a significant reduction of the buccal crest volume was observed in the grafted area before abutment connection. However, a significant increase of tissue volume was noticed at the subsequent crown placement, followed by a second but slow reduction of the volume during the following 2 years of function. The interdental papillae increased significantly in volume ($p<0.05$) during the first year, almost completely filling up the embrasure areas after 2 years. They concluded that placement of the abutment cylinder and the crown seems to play a more important role for reestablishing the tissue volume at the implant-supported single crowns.

It must be pointed out that in this phase is still possible to create the keratinized tissue that was lost due to gingival recession after prosthesis delivery through a free or bilaminar connective tissue graft that will optimize esthetics.

Healing control after second surgical stage

A second study by Tarnow et al.[2,19] classified the gingival tissue

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6.61B

Fig. 6.61A – Measurements were made with a probe inserted at the gingival crest and secured against the healing abutment coronal portion.

Fig. 6.61B – Measurements were made during healing period.

around implants after surgery to determine its stability. Sixty-three implants in eleven patients were evaluated. The soft tissue characteristics were observed during one and two-stage protocols for osseointegrated implants (Fig. 6.61). Analyses were conducted at one week, 1, 3, 6, 9 months and one-year. Eighty percent of soft tissue sites shown buccal recession. In this way, a 3-month period is reco mmended before abutment connection or impression making. The results demonstrated recession trends over one year. After 3 months, mesio-buccal recession slightly increased from 0.75 mm to 0.85 mm, stabilizing after one year. Coronal migration was observed in the first postoperative week due to inflammation and swelling. Thus, impressions taken one week after abutment connection would compromise esthetic results.

Mean mesio-buccal recession value was of 1.05 mm (from 0.88 mm of coronal migration (first week) to 1.05 mm of buccal recession (one year later)). Most recessions were observed three months after the second stage surgery. For this, the clinical protocol must consider 1 mm of tissue recession. Thus, impression and abutment selection have to be made only three months after soft tissue healing.

Periimplant soft tissue complications

Although Implantology has presented elevated success rate over the years, some complications can be seen. These occur soon after implant placement, during the osseointegration period, between the first and second surgical stage, after the second surgical stage or even during abutment connection.[51,52]

Common related problems include: screw loosening, abutment dislodgement and rotation, as well as esthetic complications.[53,54]

Also, periimplantitis can be seen with or without bone loss.[55,56] Other findings include gingivitis and an increase in probing depths due to bacterial plaque[57], gingival overgrowth due to abutment material, provisional or definitive prosthesis[52], gingival recession due to toothbrushing trauma, exposure of the implant threads[52,55,58], which according to Adell et al.[59] can irritate the mucosa and lead to gingivitis.


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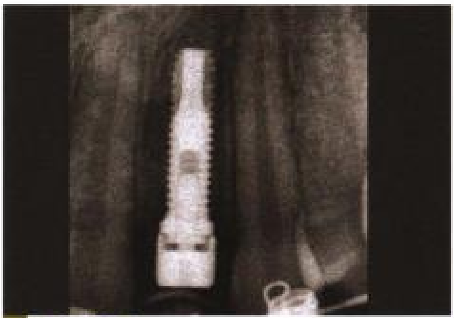
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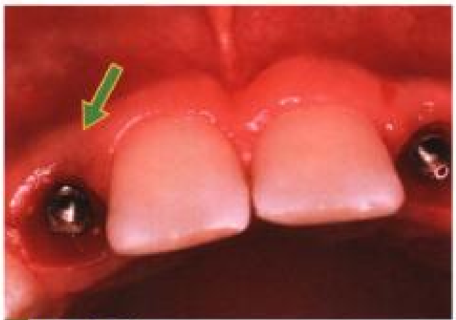
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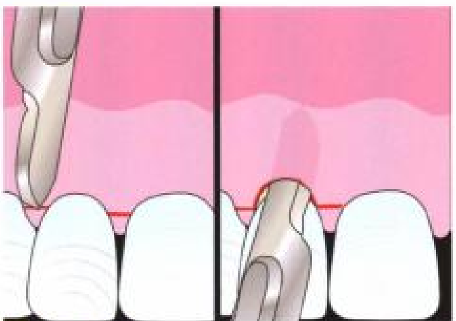
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Clinical case 32

Patient RP, 17 years-old, female. Congenital absence of teeth 12 and 22. Orthodontic treatment was made to create adequate room for implant insertion (Courtesy of Prof. Onofre Mendes Neto).

Fig. 6.62.1 – Periapical radiograph at region 21.

Fig. 6.62.2 – Periapical radiograph at region 22 showing excellent bone regeneration.

Fig. 6.62.3 – Clinical gingival aspect of element 12 with soft tissue conditioning by an acrylic provisional crown.

Fig. 6.62.4 – Clinical gingival aspect of element 22 with soft tissue conditioning by an acrylic provisional crown.

Fig. 6.62.5 – Soft tissue is adequate around the provisional prosthesis.

Fig. 6.62.6 – Three months later. No papilla is seen at the mesial of element 12.

Fig. 6.62.7 – Schematic drawing for tooth crown lengthening at elements 13,11,21,23,24 and 25.

Fig. 6.62.8 – Study dental casts before and after surgery.

Fig. 6.62.9 – Incision design. Papillae are preserved.

Fig. 6.62.10 – Zenith creation at teeth 11 and 21. Once again, papilla was preserved.

Fig. 6.62.11 – Osteotomy placed at the canine with an Ochsenbin's microchisel.

Fig. 6.62.12 – Connective tissue removed from the palatal region.

Fig. 6.62.13 – The connective tissue graft is inserted under the bilaminar flap.

Fig. 6.62.14 – The graft is stabilized over the region of 12.

Fig. 6.62.15 – Gingivoplasty at teeth 11 and 21. Papilla was preserved.

Fig. 6.62.16 – Gingivoplasty at teeth 23,24, and 25.

Fig. 6.62.17 – Sutures at teeth 14,13,12,11. Observe tissue volume gained at tooth 12.

Fig. 6.62.18 – Sutures at teeth 23,24, and 25.

Fig. 6.62.19 – Seven months after tissue conditioning with an acrylic provisional prosthesis at tooth 12. The soft tissue has a healthy aspect.

Fig. 6.62.20 – Seven months after tissue conditioning with an acrylic provisional prosthesis at tooth 22. The soft tissue has a healthy aspect.


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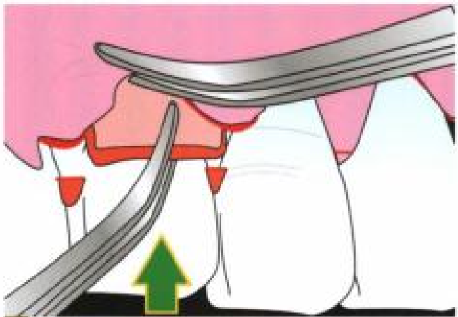
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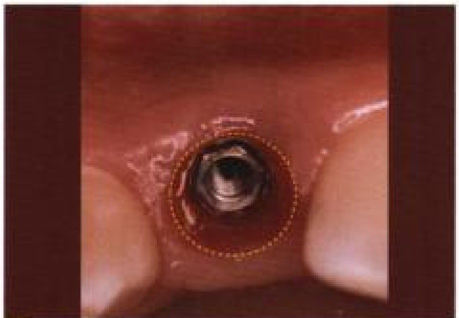
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Fig. 6.62.21 – Metal-free definitive prosthesis at tooth 21. Observe excellent esthetics.

Fig. 6.62.22 – Metal-free definitive prosthesis at tooth 22. Observe excellent esthetics.

Fig. 6.62.23 – Final aspect. Excellent dentogingival harmony is seen.

Fig. 6.62.24 – Initial case when the patient had 12-years old.

Fig. 6.62.25 – Patient's smile. Clinical aspect three years later. This patient has a high smile line.

CONCLUSION

The treatment planning is fundamental to maintain and stabilize the interproximal tissue.

Osseous deficiencies can be treated with grafting techniques: block grafts, interproximal grafts, alveolar distraction osteogenesis, orthodontic extrusion, and GBR. Adequate height and thickness for the keratinized tissue is essential around the implants, which guarantees the gingival contour. Also, the attached mucosa is fundamental to the final esthetic appearance of implant-supported restorations, often represented by metal-free crowns. Also, papillary formation can be anticipated and treated as soon as the periimplant soft tissue condition is diagnosed.

The papillae can be created or augmented through mucogingival surgeries shown in this chapter.

We saw in this chapter that plastic gingival surgeries can improve the final esthetic outcome and, even when the desired result is not achieved, an artificial gingiva will be adequate for prosthesis delivery.

The soft tissue conditioning is still a new and exciting area, and more long-term studies on papilla regeneration and grafting techniques are necessary.

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7

THODONTIC
ATMENT IN
LANTOLOGY

INO MELGAÇO / JOSÉ BERNARDES DAS NEV
MU NOJIMA / LUIZ FELIPE DE MIRANDA C
CUNHA GONÇALVES NOJIMA

Orthodontic Treatment in Implantology

RELATIONSHIP BETWEEN ORTHODONTICS AND IMPLANTOLOGY

The oral rehabilitation treatment involves interplay between prosthodontics, periodontics, restorative dentistry, endodontics, buccomaxillofacial surgery, implantology, and the orthodontic treatment as well. Concise participation of each discipline during the diagnostic process is fundamental. Some cases can involve alterations such as mal-positioning teeth, dentomaxillary discrepancies, periodontal alterations or severe tooth destruction.

Orthodontic treatment can improve periodontal conditions, tooth alignment, provide space for prosthetic elements or implants, upright inclined teeth or improve root parallelism.[1,2] The aims of orthodontic treatment involve esthetic and functional rehabilitation of the stomatognathic system, with emphasis on periodontal health and long-term stability.[3,4] However, some problems can be present during orthodontic treatment such as mechanical problems, lack of collaboration of the patients and anchorage limitations, which now can be improved by osseointegrated implants used as rigid anchorage elements.

Nowadays, osseointegrated implants not only replace lost teeth but also serve as absolute anchorage for tooth movement.

BASIC PRINCIPLES

Some terms and aspects discussed here must be first understood by the general practitioner integrated to a multidisciplinary team.

Anchorage

To understand the significance of anchorage, we must be familiar to the Newton's Third Law of Motion: "For every action, there is an equal and opposite reaction". In Orthodontics, this principle is easy to understand when an orthodontic device exerts a retraction force in the anterior teeth and the posterior ones tend to move in mesial direction (Fig. 7.1).

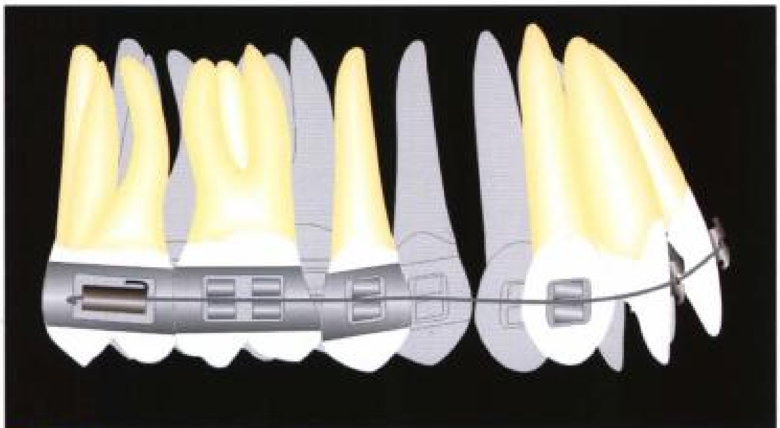
Proffit & Fields[4] define anchorage as resistance to an undesired tooth movement. Sometimes, mesialization of posterior teeth is not desirable, but when it occurs, anchorage is lost. In these situations, orthodontists can increase anchorage using several techniques as extra-oral anchorage (which requires patient collaboration), and the osseointegrated implants or mini-implants.

Direct anchorage

Direct anchorage occurs when the force is directly applied between the implant and the tooth that needs to be moved. Mini-implants or implants with prosthetic indications are the most common examples. As the implant provides a more rigid fixation to the alveolar bone, the desired movement is enhanced and the collateral effect of tooth mesialization is not observed. However, forces of this type can only be applied after complete osseointegration (Fig.7.2).

Indirect anchorage

It occurs when the orthodontic force is derived from a tooth that is stabilized by an implant or mini-implant. For example, when an implant is placed in the palatal region to immobilize the permanent upper molars while the anterior teeth are retracted (Fig. 7.3).



7.1

Fig. 7.1 – Newton's Third Law of Motion applied to Orthodontics. Retraction forces applied to the anterior teeth are equal and opposite to mesialization forces on posterior teeth.

7.2A-B

Fig. 7.2 – Direct anchorage principle. **A**- Osseointegrated implant in position. **B**- Implant prosthesis and the orthodontic fixed appliance ready for second molar uprighting.

7.3A 7.3B 7.3C

Fig. 7.3 – Indirect anchorage principle. **A** – upper first premolars extraction to retract anterior teeth. **B** – The upper molars are fixed to the palatal implant, which provides additional resistance to mesialization of these teeth. **C**- Finalized retraction of anterior teeth without anchorage loss.

OSSEOINTEGRATED IMPLANTS AND ORTHODONTICS

Esthetics has been a concern for patients with implant-supported prosthesis in extensive oral rehabilitation cases. In most of these cases, previous orthodontic treatment has been mandatory. Mal positioned teeth can compromise occlusion, periodontal health and maintenance, as correct implant placement and final treatment outcomes.

Two situations can occur considering the relationship between orthodontics and implantology: orthodontic treatment before dental implant placement or simultaneous to initial rehabilitation procedures.

Orthodontic treatment before dental implant placement

Orthodontics can improve final outcomes by correction of interdental spaces, root parallelism, bone and gingival remodeling, molar uprighting, tooth rotation, intrusion, cross-bite correction, and Spee's curve leveling. Thus, the goal of orthodontic treatment is to achieve normal occlusal parameters.

Adequate space for implant placement is fundamental. Soft tissue esthetics is enhanced when mesiodistal dimensions favors implant selection.[6-8] In most cases, space provision must occur through bodily movement (translation) to achieve root parallelism.

Congenital absence of teeth requires adequate spacing for implant placement. Several factors must be considered, such as initial and final occlusal relationships, available bone, position and form of adjacent teeth, treatment costs, and patient's expectations[4,9]. Clinical case 1 reports congenital absence of upper lateral incisors in a male patient. The treatment planning aimed osseointegrated implants and implant-supported prostheses. Redistribution of the anterior space and better tooth intercuspidation was the goal of orthodontic movement. In the first phase, only tooth crowns were moved and root parallelism was not achieved, contra-indicating implant placement. In the second phase, root positions were corrected and ideal axial inclinations were achieved, thereby allowing three-dimensional implant placement (Fig.7.4).

In some cases of tooth loss due to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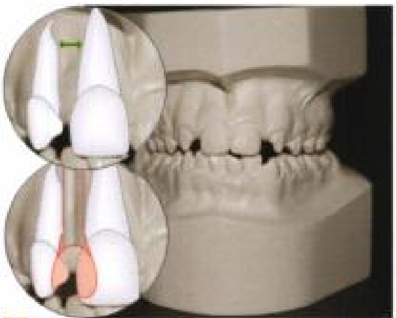
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Clinical case 1

Patient JW, 13-years-old, male. Congenital absence of the upper lateral incisors (12 and 22).

Fig. 7.4.1 to 7.4.3 – Occlusion after first orthodontic treatment. Adequate spacing was not provided yet for implant placement.

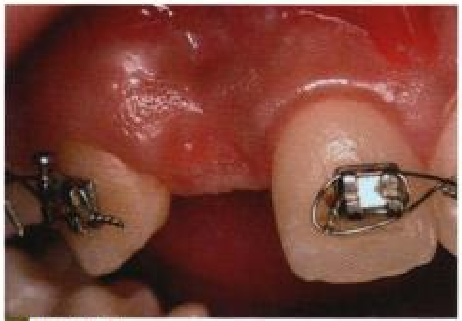
Fig. 7.4.4 – Schematic diagram showing the lack of minimal space for implant placement.

Fig. 7.4.5 – Panoramic radiograph showing absence of interdental spaces for implant installation.

Fig. 7.4.6 to Fig. 7.4.8 – A new orthodontic treatment was conducted. After one year, adequate interdental space was provided in both right and left sides. Clinical aspect of bone atrophy in the proposed implant sites.

Fig. 7.4.9 – Panoramic radiograph evidencing adequate interdental spaces.

Fig. 7.4.10 and 7.4.11 – Incision for implant placement. Bone defects in the implant sites.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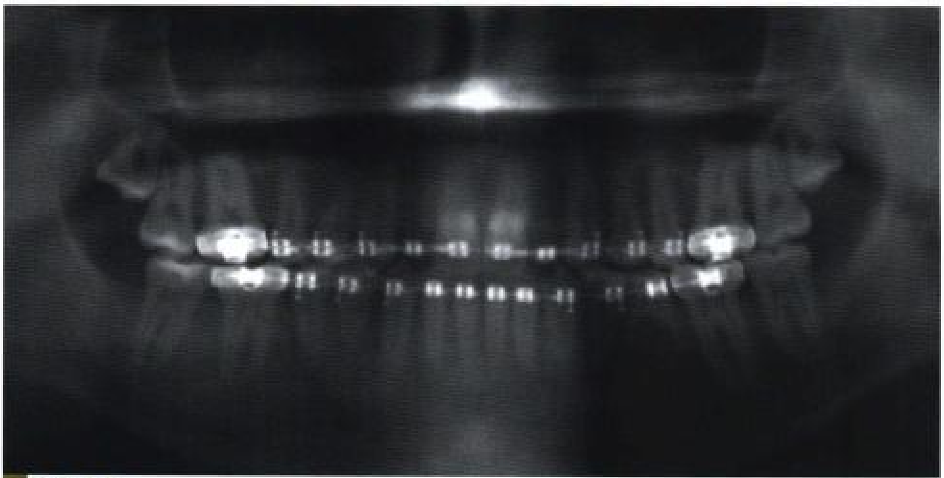
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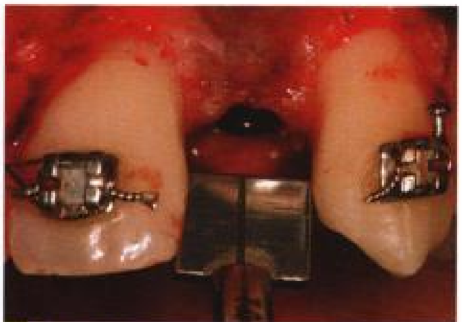
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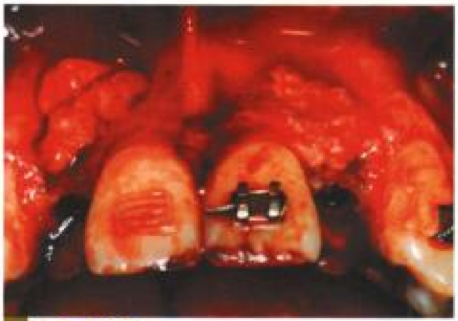

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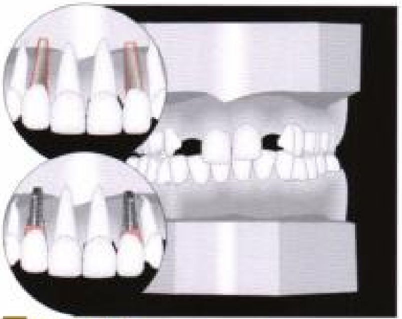

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Fig. 7.4.12 – Occlusal view. Observe implant positions.

Fig. 7.4.13 – Connective tissue graft in the 12 region and bone graft in the 22 region.

Fig. 7.4.14 – Final esthetic aspect. Procera crowns on teeth 12 and 22.

Fig. 7.4.15 – Schematic diagram of ideal implant positions.

Fig. 7.4.16 and 7.4.17 – Clinical aspect six months later. Excellent soft tissue quality was achieved and papillae can be seen between the crowns and the implants. (*Second phase of orthodontic treatment is courtesy of Dr. Múcio Rodrigo Reis Brito*).

dentoalveolar trauma and/or related pathologies, orthodontics can provide better final results. In these cases, migration of adjacent teeth compromises implant-supported prosthetic rehabilitations. Clinical Case 2 shows a patient (Fig.7.5) involved in a car accident with avulsion of tooth 11 and pulp necrosis on tooth 21. A removable prosthesis was made to replace tooth 11 without considering the principles of esthetics and function. Tooth alignment and space redistribution was extremely necessary before implant placement.

The loss of posterior teeth (e.g.,

Clinical case 2

Fig. 7.5.1 to 7.5.3 – Initial aspect. Patient's smile. A removable prosthesis was made to replace the avulsioned tooth. Observe the lack of esthetics and function.

Fig. 7.5.4 – Inadequate space for implant placement can be observed.

Fig. 7.5.5 and 7.5.6 – Diagram showing what happens when the implant and crown are made without considering the excessive mesio-distal dimension (red).

Fig. 7.5.7 – Tooth realignment will provide adequate crown size and implant position.

Fig. 7.5.8 – Orthodontic treatment. Two provisional pontics were placed at the region of 11.

Fig. 7.5.9 – The interdental space was adequate for implant placement.

Fig. 7.5.10 – Periapical radiograph showing bone deficiency before implant placement. (*Orthodontic treatment courtesy of Dr. Eliseu Félix Barros*).


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7.5.10

first permanent molar in the lower arch) is a serious problem found in the adult population. It implies in occlusal and periodontal deleterious conditions, including mesial tipping, angular bone defects, distal inclination of anterior teeth, extrusion of antagonist teeth, and also food impaction.[10] In these cases, oral rehabilitation can be a challenge since some basic requirements such tooth stability, abutment parallelism, and the periodontal health are lacking. Besides, premature occlusal contacts may be present. The use osseointegrated implants provided more conservative, definitive, and comfortable solutions. However, a multidisciplinary treatment planning is fundamental for implant success.

After premature loss of first lower molar, new situations can occur according to the space found in dental arches. It is possible to upright the second molar closing or opening space. The first option is not always possible. In these cases, the objective is to create adequate space for implant placement and prosthetic crowns with adequate dimensions. Several studies in the literature have sustained this treatment philosophy[3,4,10-12]

The clinical case 3 (Fig.7.6) exemplifies the situation described before, where premature loss of posterior teeth (lower first molar) resulted in the mesial inclination of the second molar. As the adjacent teeth are healthy, a fixed partial prosthesis is not the better option. On the other hand, the mesiodistal dimension is not adequate for implant placement. So, the second molar was uprighted and a space created.

The correction of rotated teeth is

7.6.1

Clinical case 3

Premature loss of the lower first molar with subsequent mesialization of the second molar.

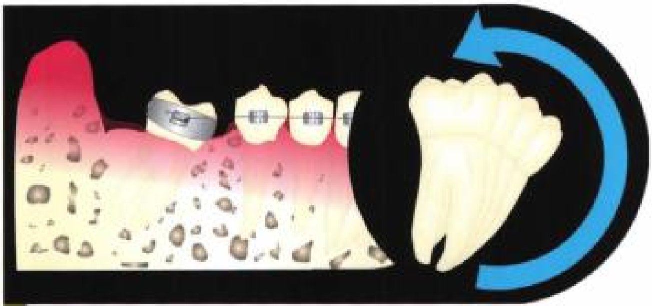
Fig. 7.6.1 – A fixed appliance was placed to upright the lower second molar.

Fig. 7.6.2 – Final stage with adequate mesio-distal space for implant placement.

Fig. 7.6.3 and 7.6.4 – Schematic diagram of tooth movement.

Fig. 7.6.5 – Implant and prosthesis in the desired positions.

7.6.2



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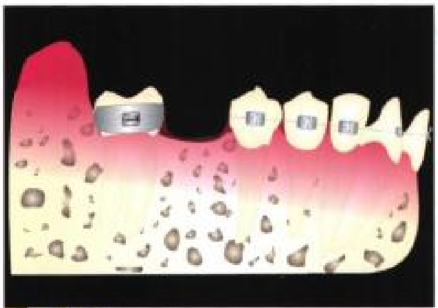

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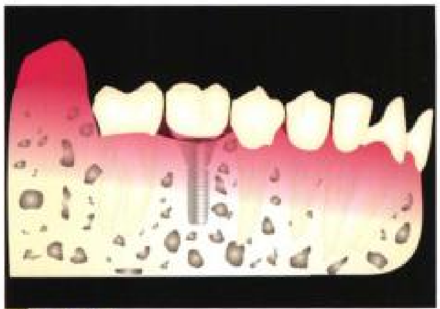

7.6.5

another important factor[3,4,13-15]. Several authors relate that alignment of rotated teeth is important for better occlusal contacts and force distribution in the periodontal structures. Rotated teeth present incorrect contact points with narrowing of the interdental space and reduction of the alveolar crest height. Bone destruction due to periodontal alterations would be a serious problem in these situations[13,15]. In addition, rotated teeth occupies more space than necessary in dental arches[3,4,14].

The clinical case 4 (Fig.7.7) illustrates agenesis of tooth 43, diastema in the lower anterior dentition, mesial inclination of tooth 44 and 90 degree rotation of tooth 45. The proposed orthodontic treatment aimed alignment and leveling of the upper and lower arches with a fixed appliance. The space for implant placement was achieved through correction of rotated tooth 45 and mesialization of tooth 44.


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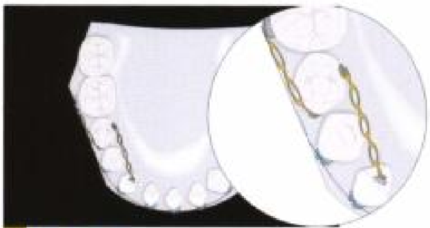
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Clinical case 4

Fig. 7.7.1 – Initial malocclusion, right lateral view.

Fig. 7.7.2 – Initial malocclusion, frontal view.

Fig. 7.7.3 – Initial malocclusion, left lateral view.

Fig. 7.7.4 – Occlusal view of the study cast. Observe 90-degree rotation on tooth 45.

Fig. 7.7.5 – Schematic diagram showing mechanism for tooth aligment.

Fig. 7.7.6 – Position of the alastiks created a binary system to facilitate tooth movements.

Fig. 7.7.7 – Final tooth position.

Fig. 7.7.8 – An adequate space is provided for implant placement.

Fig. 7.7.9 – Periapical radiograph showing root parallelism between premolars.

Fig. 7.7.10 – Implant surgery.

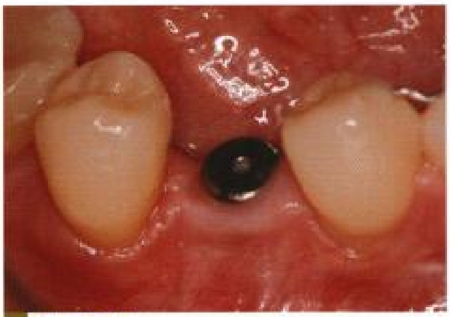
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Fig. 7.7.11 – Observe excellent soft tissue healing. Attached gingival was created.

Fig. 7.7.12 – Definitive prosthesis in position.

Fig. 7.7.13 – Panoramic radiograph showing case finalized.

Fig. 7.7.14 – Occlusal view of the inferior arch after treatment. (*Orthodontic treatment by Dr. Hector Ricardo Ariza Diaz*).

Another important potential benefit of orthodontics is bone remodeling and enhancement of gingival contours achieved through tooth movements.[16-19] Orthodontic extrusion in teeth affected by periodontal disease can modify the bone contour at the cervical region, with the gingival margin and the alveolar bone following tooth extrusion. Generally, the gingival margin of extruded teeth is more coronal than the adjacent gingival margins. Initially, this treatment was proposed to gain bone and soft tissue in areas of further implant placement.[18-20-23]

When an extrusive force is applied to the tooth, it generates tension resulting in the stretch of periodontal ligament fibers. Then, the osteoblasts secrete bone matrix where the ligament is being tensed.[3] Besides, orthodontic extrusion improves the emergence profile for implants and crowns, increasing the adjacent soft tissue thickness.[25,26]

The literature has emphasized that adequate position of gingival margins in the anterior region is fundamental for esthetics.[7,27-29] These specified patterns state that the gingival margins of upper central incisors must be equal and 1mm coronal to the cemento-enamel junction. The gingival margins of the canines must be at the same height of the upper incisors, and the lateral incisors should be 1-2mm more coronal[7,28,29] (Fig.7.8). Orthodontic movements can contribute to the achievement of these esthetic parameters.

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Fig. 7.8 – Adequate positioning of gingival margins in the esthetic zone.

The clinical case 5 (Fig.7.9) describes how orthodontic treatment can be effective in bone remodeling. The patient LBS, 22-years-old, suffered a dentoalveolar trauma. A clinical crown lengthening was performed in the region of tooth 11, resulting in bone loss and gingival recession. Also, the root length was inadequate. The treatment planning consisted of orthodontic traction with further implant placement. A fixed appliance was installed and the slow traction of the central incisor was done aiming to provide vertical bone gain and coronal repositioning of soft tissue, once tooth extraction following immediate implant placement would further compromise the esthetic. Besides, grafting at this area cannot guarantee adequate bone height. Thus, orthodontic forced eruption was the best option.

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Clinical case 5

Fig. 7.9.1 – initial clinical aspect showing inadequate gingival margins at tooth 11 due to the alveolar traumatism.

Fig. 7.9.2 – The level of root fracture is seen (biologic distance is compromised).

Fig. 7.9.3 – Periapical radiograph of tooth 11 and root canal preparation for orthodontic forced eruption.

Fig. 7.9.4 – A provisional crown was cemented and a fixed appliance was set. Orthodontic movement has initiated.

Fig. 7.9.5 and 7.9.6 – The cervical margin of tooth 11 followed the orthodontic movement.

Fig. 7.9.7 – Periapical radiograph of tooth 11 during forced eruption.

Fig. 7.9.8. and 7.9.9 – Periodontal surgery to retrieve the biologic width and to correct the gingival contours.

Fig. 7.9.10 – A new provisional crown was fabricated to guide the soft tissue conditioning.

Fig. 7.9.11 – Clinical aspect 6 months after crown cementation.

Fig. 7.9.12 and 7.9.13 – Tooth extraction and implant placement. Observe the quantity and quality of soff tissue, as well as its preservation.

Fig. 7.9.14 – Procera abutment in position.


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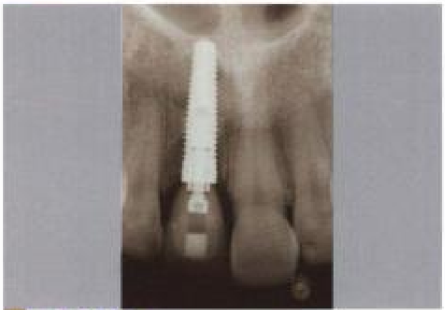
7.9.17


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Fig. 7.9.15 – Clinical aspect after soft tissue conditioning with the provisional crown.

Fig. 7.9.16 – Procera metal-free crown. Observe periimplant health.

Fig. 7.9.17 – Final periapical radiograph.

Fig. 7.9.18 – Final clinical aspect. *(Clinical case courtesy of Dr. Adauto de Freitas Junior (surgery), Dr. Dario Adolfi (prosthodontics) and Dr. Juliana de Oliveira R. Abi Faraj (orthodontics).*

Definitive osseointegrated implant placement before orthodontic treatment aiming final prosthetic rehabilitation

The use of osseointegrated implants can improve final orthodontic outcomes through enhancement of force and mechanics. Several works have attested the efficacy of osseointegrated implants as anchorage devices for all types of tooth movements. In some situations, the limits of orthodontic treatment demands this option.[30-36]

Historical review: implants as orthodontic anchorage elements

The use of implants as orthodontic anchorage was initially related in 1945 by Gainsforth & Higley[37]. The authors utilized metallic screws in the mandibular ramus of dogs for orthodontic movement. The force applied resulted in loosening of these screws after 16-31 days. The potential use of implants for orthodontics was later studied by Linkow[38,39] in 1969 and 1970, who described the use of blade implants as anchorage elements to retract anterior teeth. However, the author did not evaluate long-term stability of these implants.

Sherman[40], in 1978, evaluated the effectiveness of six vitreous carbon implants under loading during orthodontic movement in dogs. He observed that only 2 of the 6 implants were stable at the end of the treatment. At the same time, Turley, Shapiro & Moffett[41] performed a longitudinal study with ceramic implants placed in the maxillary bone of monkeys. Forces near to 425grams were applied with the aim to separate the palatal raphe. The authors related that orthopedic expansion was achieved only in 1 of 3 tested animals. Such outcome was attributed to screw loosening and inflammation at implant site. Since then, a common finding was the lack of long-term stability in bone fixation.

However, in 1964, Brånemark et al.[42] described the phenomenon of osseointegration. They conducted studies with endosseous implants in dogs and concluded that the implants were stable for more than 5 years, without signs of damage or tissue reaction, even when submitted to excessive loading.

Roberts et al.[30], in 1984, described the stability and resistance of titanium screws to applied forces. These implants were placed in the femur of rabbits and submitted to loadings near 100gf, sustained for 4-8 weeks. The authors concluded that the titanium implant had a great potential for orthodontic anchorage.

Since then, the literature has presented several papers[31,45,46] concerning on the orthodontic-implantology relationship. At the end of the 80s, some studies already discussed the titanium implant applications (Brånemark system) as a source of rigid anchorage for orthodontic movements[32,47]. Nowadays, an increasing overwhelming of studies have shown that the implants not only serve as abutments for implant prosthesis, but also as orthodontic anchorage[33,35,36,48-52].

More recently, new perspectives in the implant horizons for orthodontic anchorage are represented by the mini-implants[5,53,55]. There is a number of possibilities for implant sites due to its reduced size. Also, developments on biomaterials provide biodegradable substances that can used in the form of mini-implants to avoid a second surgical stage[56-58].

Planning

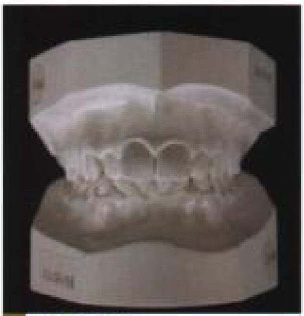
The major problem concerning osseointegrated implants that will serve as abutments for fixed prosthesis after being used for orthodontic anchorage is to determine its ideal position before treatment begining. In these situations orthodontic treatment must foresee the final tooth positions and also determine[5] where the implants must be placed. Once the treatment is finalized, the implants would be found at their ideal locations[59-61].

The clinician can anticipate the final tooth positions through the diagnostic set-up, in which the dental casts are used to "simulate" the correction of the malocclusion. The teeth are individualized and separated from the base of the gypsum cast, and further repositioned with wax to correct the initial malocclusion (Fig.7.10)[3,4,62,64].

The next case involves a 64-year old patient with poor esthetics and mastication problems, involving a multidisciplinary approach, such as: periodontal treatment, osseointegrated implants, fixed prostheses, endodontics, orthodontics, and restorative treatment.

A multidisciplinary approach is the key for treatment success. Initially, implant placement was planned at the begining of the orthodontic treatment, and each phase is detailed in the next paragraphs.

A complete radiographic set (periapical, panoramic, bitewings, TMJ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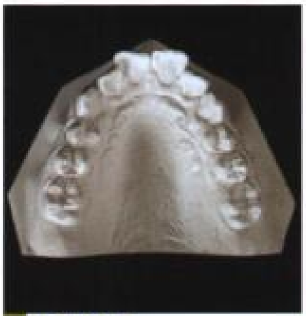
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Fig. 7.10.1. to 7.10.3 – Dental casts showing malocclusion at frontal, upper and lower occlusal views.

Fig. 7.10.4. and 7.10.5 – The teeth were individually removed from the base of the cast.

Fig. 7.10.6 to 7.10.8 – Repositioned teeth to simulate final outcomes in the orthodontic treatment. In this case, extraction of 4 premolars was necessary.

and lateral cephalometric analysis), as well as photographs and the study dental casts, were requested for a comprehensive case planning. The patient presented Angle's Class II Malocclusion, Division I, associated with dentoalveolar biprotrusion. On the right upper quadrant, teeth 16,13, and 11, as well as teeth 15,14, and 12 served as abutments and pontics of an extensive fixed prosthesis. On the upper left quadrant, teeth 23 and 25 (24 as pontic). On the lower left quadrant, teeth 35 and 36 (36 as pontic). Teeth 17,45,46 and 47 were absent. The upper right first molar showed excessive bone loss and its extraction was planned. The lower inferior anterior teeth presented diastema. Periapical radiographs showed horizontal bone loss and an angular bone defect at the mesial of 13. There was a thinned alveolar crest at the 12 region, preventing implant placement (Fig.7.11).

The initial treatment consisted in removal of inadequate restorations, periodontal pocket elimination of the infection sites, as well as extraction of tooth 16. The pontics were removed from the upper arch, and a removable provisional prosthesis was made to establish temporary esthetics and function. Then, a computerized tomography was performed and new study casts obtained (Fig.7.12).

To visualize final tooth positions, a diagnostic set-up was conducted, and the new study casts were duplicated. Now, three pairs of dental casts were obtained: the first reproducing the initial occlusal relationships without any intervention, the second designated to set up construction and the third (copy of the second) which will serve to fabricate the surgical stent (Fig.7.13).

In the second situation, only tooth to be aligned were removed from the base of the cast and correctly positioned. The remaining teeth will serve as reference points (Fig.7.14).

After the set-up phase, a diagnostic wax-up was made to evaluate form, position, anterior- posterior relationships and inclination of the teeth to be replaced. The cervical contour of these teeth were delimitated with an indelible pencil in the pink wax. The best locations for implant placement were determined (Fig.7.15).However, diagnostic setup was not performed in the upper right first molar area due to the lack of bone for implant placement, according to the CT exam (Fig.7.16). Thus, a bone graft was planned to improve local conditions.

Now, the ideal locals for implant placement, determined on the set-up model need to be transferred to the third pair of models (where the surgical stent will be made). The base of the cast and the not modified structures serve as references to transfer the desired points (3 measures for each point) from one cast to another using a digital caliper (Fig.7.17); justifying the need for identical bases on the study models[61]. Next, possible areas for implant placement are evaluated by clinicians with the aid of CT and panoramic radiographs. Two situations can prevent implant placement: lack of sufficient bone and the presence of teeth in the proposed regions. In the later, previous orthodontic treatment or changes during treatment planning can be necessary.

Now, metallic tubes that will guide burs in the correct anterior- posterior and bucco-lingual directions during surgery can be installed in the orthodontic set-up. After, the teeth to be replaced are waxed-up (cervical contours helps to determine the extent of anterior- posterior and buccolingual dimensions). The aim of this procedure is to facilitate surgery and implant placement in a more precise position. It is important to have in mind that such inclinations are defi-


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Fig. 7.11.1. to 7.11.3 – Frontal, right and left lateral views of malocclusion.

Fig. 7.11.4 – Observe extensive bone loss on tooth 16 (prosthesis abutment).

Fig. 7.11.5 to 7.11.9 – Dental study model in frontal, right and left lateral, upper and lower occlusal views.

Fig. 7.11.10. to 7.11.12 – Periapical radiographs showing angular bone defect on mesial of 13, which also compromises region 12. Lower anterior teeth with horizontal bone loss.

Fig. 7.12.1 to 7.12.4 – Intra-oral aspect after the diagnostic phase: frontal, right and left lateral views, respectively.

Fig. 7.12.5. to 7.12.8 – Intra-oral aspect after removable prosthesis insertion: frontal, right and left lateral views, respectively.

Fig. 7.12.9. to 7.12.11 – New study casts after the diagnostic phase.


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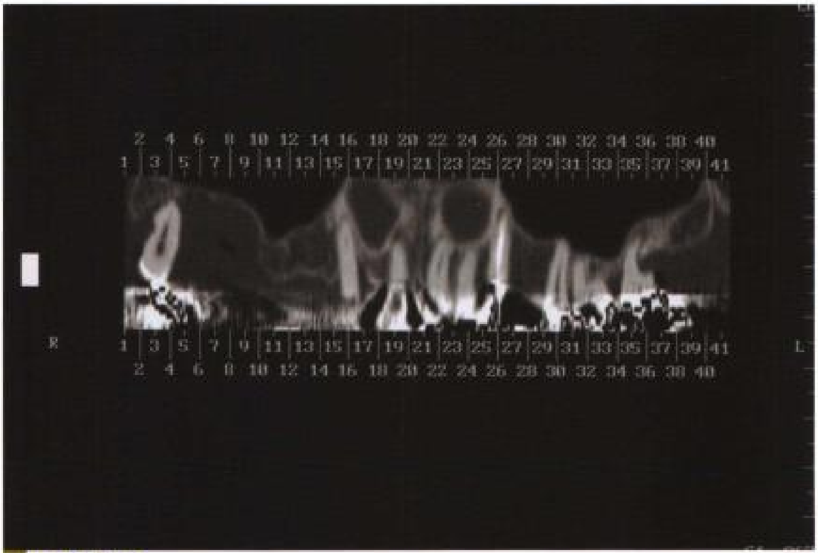

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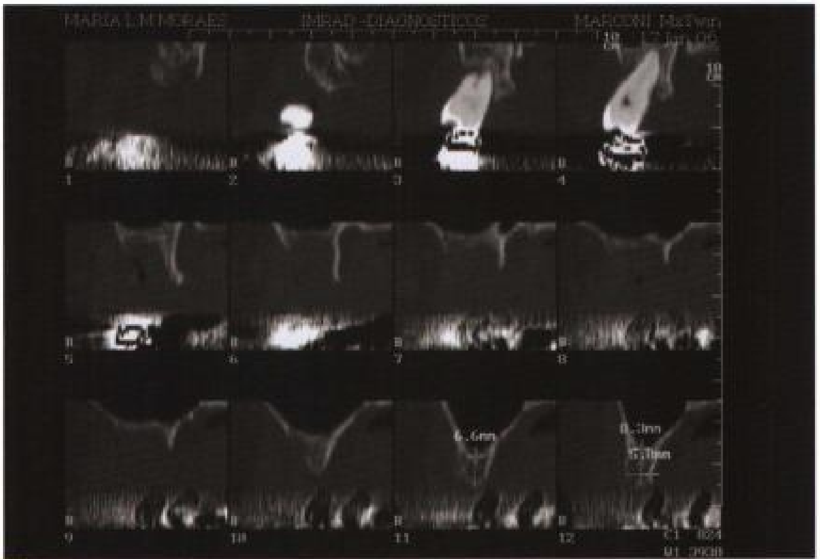

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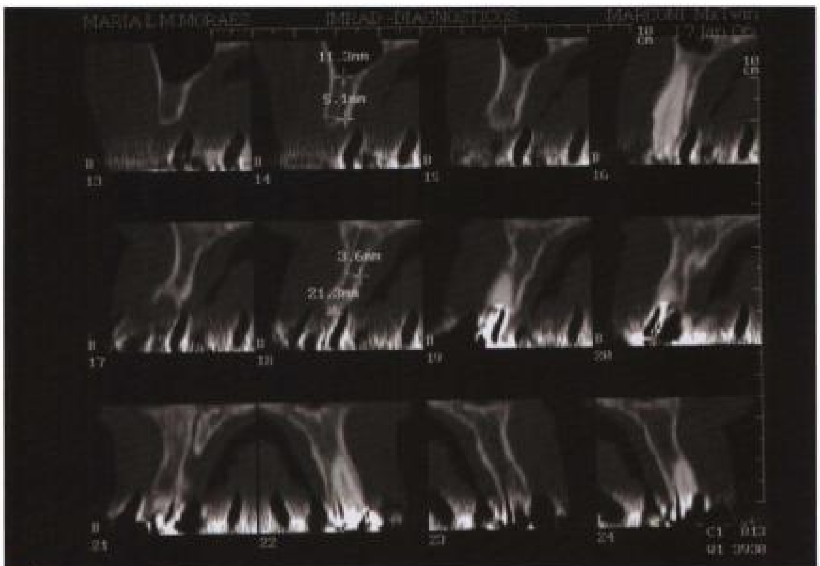

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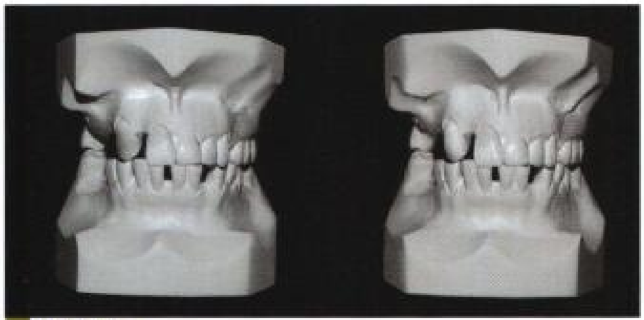
Fig. 7.12.12 to 7.12.14 – TC showing bone width were the implants will be inserted.

Fig. 7.12.13A – Initial study model before diagnostic phase.

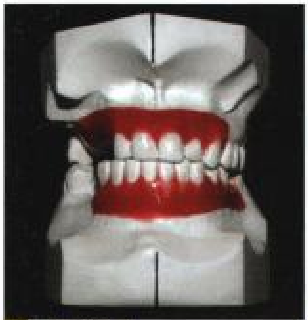
Fig. 7.13B – New pair of study models after diagnostic phase and its replica.

7.13A

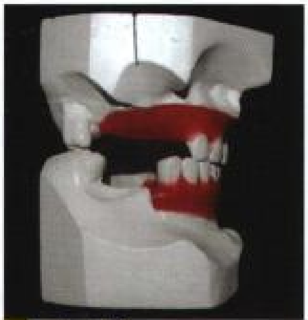


7.13B

Fig. 7.14.1. to 7.14.5 – Tooth set-up: frontal, right and left views, as well as upper and lower occlusal, respectively. The upper right canine was repositioned in the upper lateral incisor position.



7.14.1



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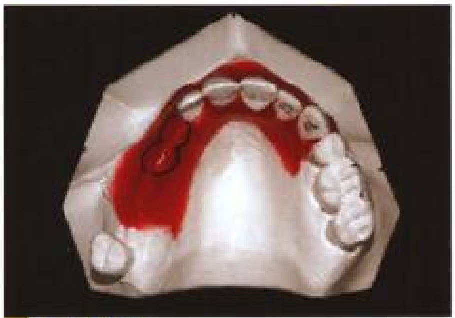
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Fig. 7.15.1 to 7.15.3 – Diagnostic set-up showing the tooth size and ideal proportions of the teeth to be replaced.

Fig. 7.15.4. and 7.15.5 – The diagnostic teeth removed to delimitate their cervical contours.

Fig. 7.15.6 and 7.15.7 – Ideal implant sites are marked with a pencil.


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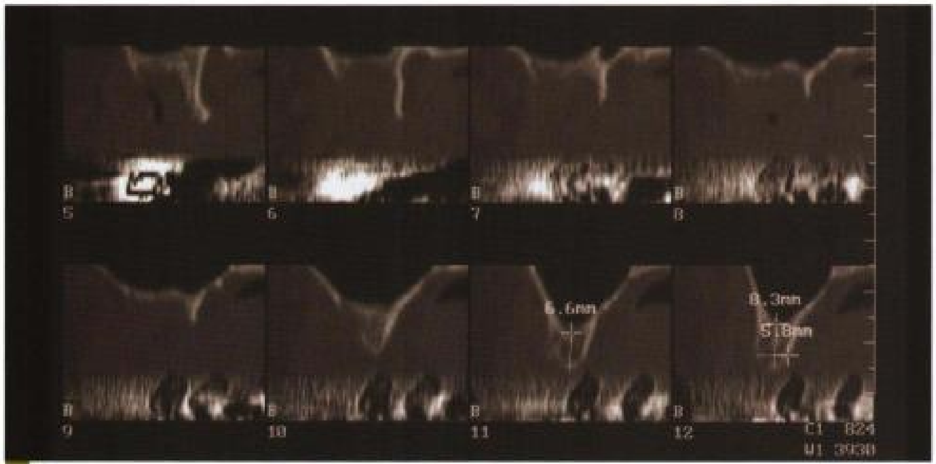
7.16.2

Fig. 7.16.1 – TC showing maxillary bone with coronal slices (1 to 13).

Fig. 7.16.2 – Detailed view of Fig. 7.16.1, slices 5 to 10.

Fig. 7.16.3 – Coronal slices show bucco-lingual thickness at the 16 region. Bone loss is seen in slices from 5 to 10.



7.16.3

Fig. 7.17.1 – Predetermined points in the set-up for implant placement.

Fig. 7.17.2 to 7.17.7 – A digital gauge is used to transfer the desired points to the model where the surgical stent will be made. Three measurements were made. The metallic points must be positioned at the same references in the study casts.

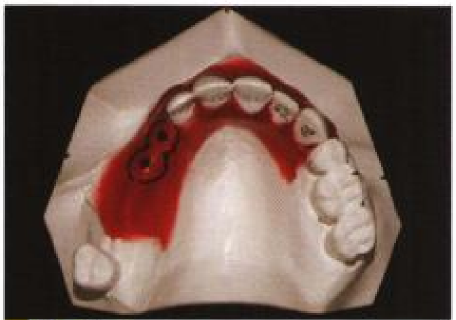


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Fig. 7.17.8 – The first point is transferred.

Fig. 7.17.9 and 7.17.10 – The same procedure is done to transfer the other points (upper and lower arches).


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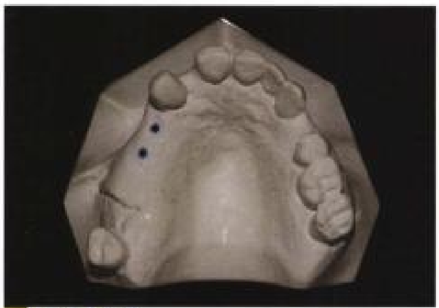
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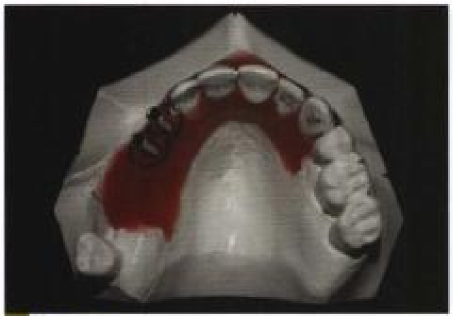
ned with the multidisciplinary team, and depends on bone quantity verified in the CT exam (Fig.7.18).

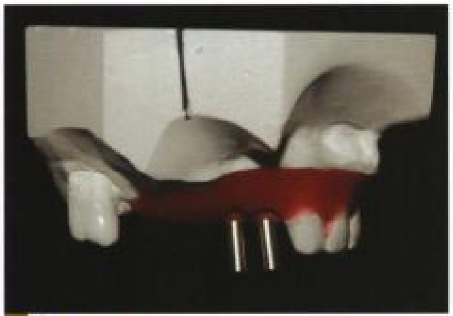
An impression of the wax-up and the access holes of the metallic tubes is made to fabricate an acrylic replica of these teeth. Also, this procedure will facilitate transferring of these replicas to the model where the surgical stent will be prepared. Thus, the impression must include teeth that did not suffer tooth alignment, to serve as orientation marks (Fig.7.19). For cases in which the orthodontic planning involves movement of all teeth in the set-up, references on the

Fig. 7.18.1 to 7.18.3 – Surgical guides in their correct locations.

Fig. 7.18.4 and 7.18.5 – A new diagnostic set-up is made to visualize the access holes in the implant-supported prosthesis.



7.18.1



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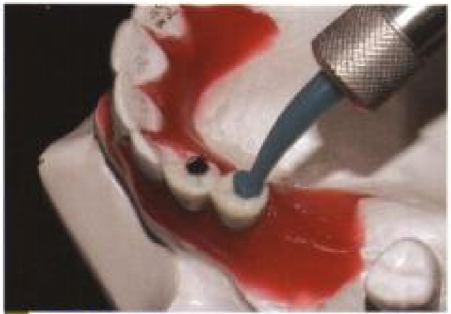
palatal and lingual regions must be made before dental cast duplication, according to Smalley.[61]

With the acrylic teeth positioned on the model that will be used to fabricate the surgical stent, the cervical contours are delimitated and these teeth are secured with pink wax (Fig. 7.20). Now, it is important to verify whether the access holes for bur positioning coincide with the reference marks on the study model. The surgical stent will maintain the inclinations determined by the metallic tubes in the set-up, which in turn will facilitate implant placement during surgery (Fig.7.21).

After the osseointegration period, orthodontic movements can be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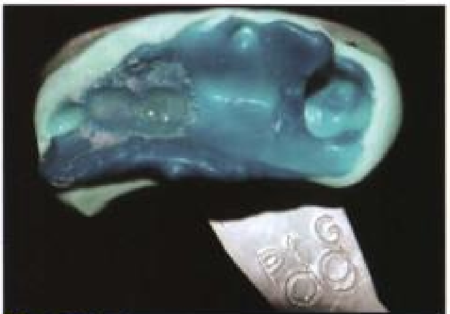
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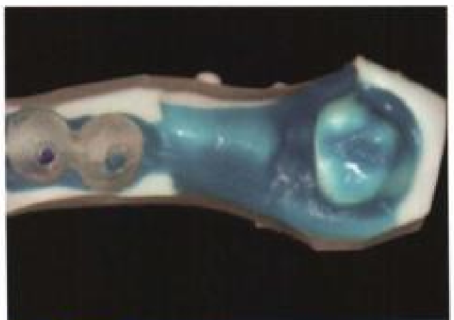
7.19.7


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Fig. 7.19.1 and 7.19.2 – An impression of the waxed teeth is made. A light viscosity material is syringed inside the access holes of the metallic tubes.

Fig. 7.19.3 – Impression of the same area with a partial perforated tray using tooth 18 as reference point.

Fig. 7.19.4 – Final aspect of the impression.

Fig. 7.19.5 – The internal part of the metallic tubes can be seen in the impression.

Fig. 7.19.6 – The impression is filled with acrylic resin.

Fig. 7.19.7 and 7.19.8 – The acrylic teeth ready to be positioned in the model of the surgical stent.

Fig. 7.20.1 and 7.20.2 – The acrylic teeth in the same position of the waxed teeth.

Fig. 7.20.3 – The cervical contours are delimitated and the acrylic teeth are secured with pink wax.

Fig. 7.20.4 – Observe coincidence of points determined by the digital gauge and the access holes in the acrylic teeth.

Fig. 7.20.5 – The same procedure is made in the lower arch.

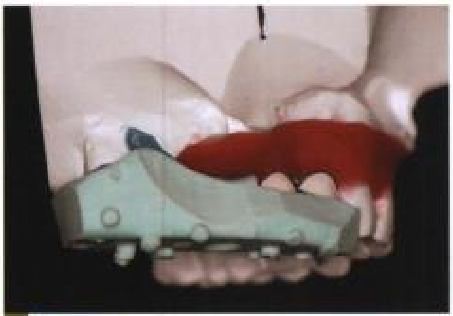
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Fig. 7.21.1 and 7.21.2 – Now, the surgical stents are made.


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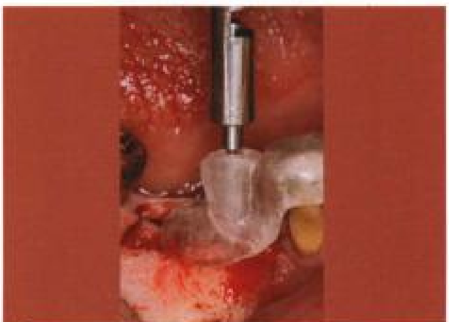

7.21.12

Fig. 7.21.3 and 7.21.4 – Positioning the surgical stent in the mouth moments before incisions.

Fig. 7.21.5 – Incision for implant placement in the maxillary arch. Observe extensive bone loss in the region of 16.

Fig. 7.21.6. and 7.21.7 – Surgical stent and the beginning of site preparation.

Fig. 7.21.8 and 7.21.9 – Implants and cover screw installation. A bone graft was made at the region of 16.

Fig. 7.21.10 – The suture is placed.

Fig. 7.21.11 to 7.21.14 – The same procedures described above, but not a bone graft, were performed in the lower arch. In addition, an implant was inserted at the 46 region due to a favorable osseous condition and to avoid the second surgical stage. The implant at the 36 region was inserted in another surgical time.

Fig. 7.21.15 – Panoramic radiograph showing the implants after surgery. Observe adequate parallelism between implants.

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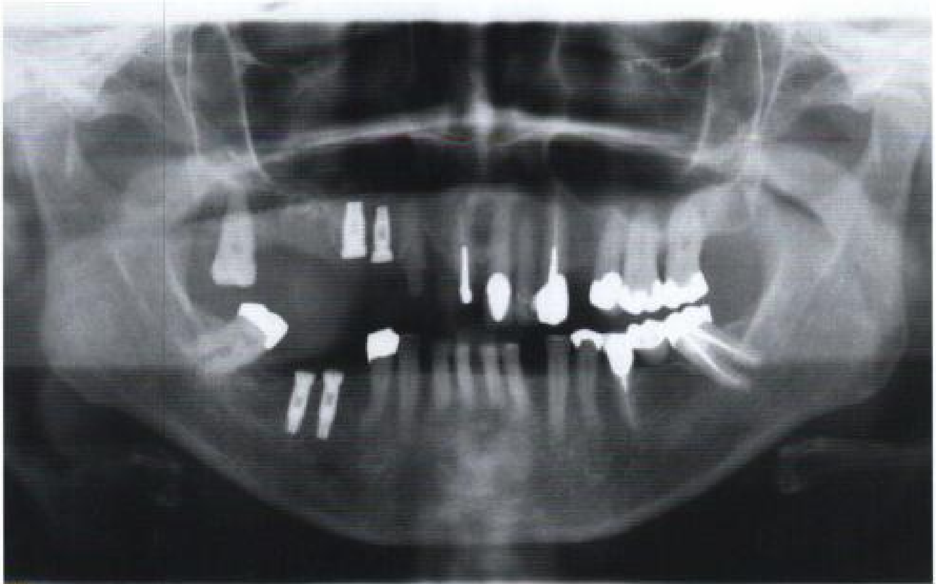

7.21.15

performed using the implants as absolute anchorage elements.

IMPLANTS AND THE GROWING PATIENT

Generally, implants are indicated for single, partially or completely edentulous adult patients. The use of implants in patients with ongoing craniofacial growth requires caution and the indications must be analyzed according to each situation. Common indications are congenital absence or traumatisms.[65] It is fundamental to determine the local for implant placement and its proximity to the adjacent teeth.[66,67]

The osseointegration process that determines the success in adult patients can have disastrous consequences in the growing patient. The natural teeth have a periodontal ligament, which permits necessary physiologic movements for occlusal adjustment during growth and development of cranial bones. Also, orthodontic movement is only possible due to the periodontal ligament. However, there is no periodontal ligament around the osseointegrated implants. In this way, the effects observed in children are similar to those found when ankylosed deciduous teeth are present. These teeth cannot follow normal eruption patterns and the occlusal adjustments during growth. Similarly, the implants cannot perform the same movements[61,65]. Basic knowledge of the pattern, timing, and type of facial growth are fundamental for the implantodontist[65].

There are two ways for growth monitoring[61,65]:

- wrist and hand radiographs, where the capping of all epiphyses and diaphyses means that the patient reached skeletal maturity and growth will no longer be observed;
- superimposing of cephalometric patterns from lateral radiographs at each six months following a period not inferior to 12 or 18 months. When the cephalometric patterns do not change, it means that facial growth no longer exists. However, this method needs long-term intervals which can delay implant placement.

Some recommendations must be made on the development and growth of the facial skeleton, as well as the dentition, when the implants have been considered. A major drawback is the extraordinary variation found in growth direction and quantity. Also, growth in children with lack of dental elements is unknown. In these patients, insufficient alveolar bone development and the small size of the jaws have considerable differences when compared to individuals with normal dentition[4,65].

It is known that maxillary transverse growth ends before the anterior- posterior and vertical growth. Girls have their pubertal growth earlier than boys but for a shorter period. On the other hand, boys have their pubertal growth later but for a longer period. Sexual characteristics found in boys and girls can be used to evaluate growth and developmental stages[3,4,65,68,69]. Thus, considering individual variations and bearing in mind that vertical growth is the last to cease, a safe margin would be 16 or 17 years-old for girls and 19 to 20 years-old for boys. Once, it is important to highlight that chronological age are not the best parameters and the individual variations on skeletal maturity cannot coincide with aging.

The most conservative approach consists of implant placement only after facial and dental growth and development has ceased. However, in some cases, strong psychological, emotional and social factors lead the clinician to consider an early treatment[70]. Possible benefits include alveolar bone preservation, esthetics enhancement, better function, and patient comfort. However, the literature[68,69] recommends extreme caution when implant placement occurs in individuals around 13 to 16 years-old

FINAL CONSIDERATIONS

The restorative treatment aims to provide a functional and esthetic occlusion. In this context, there are several treatment options, from tooth extractions to advanced surgical and reconstructive procedures. Developments in dental materials and new techniques have facilitated these treatment forms. A great revolution in the oral rehabilitation started with the advent of osseointegrated implants, since some treatments would never be performed in the traditional way. Thus, a multidisciplinary team is fundamental because each discipline provides the best efforts for final outcomes.

In this sense, orthodontic movement can bring several benefits to implantology, and several relationships can be established between them. A thorough knowledge of the periodontal tissue biology and dental occlusion allow implantodontists to know the right moment for orthodontic treatment. This knowledge cannot be ignored or underestimated, since patients can have better outcomes with this interaction.

The use of osseointegrated implants as anchorage elements is extremely efficient and benefits several patients. Treatment planning for implant placement as anchorage elements with further prosthetic rehabilitation is a complex process that demands compliment and interaction between the professionals involved.

The clinician can provide several treatment options. Whatever the options, the treatment success is directly related to the multidisciplinary approach that one wishes to develop.

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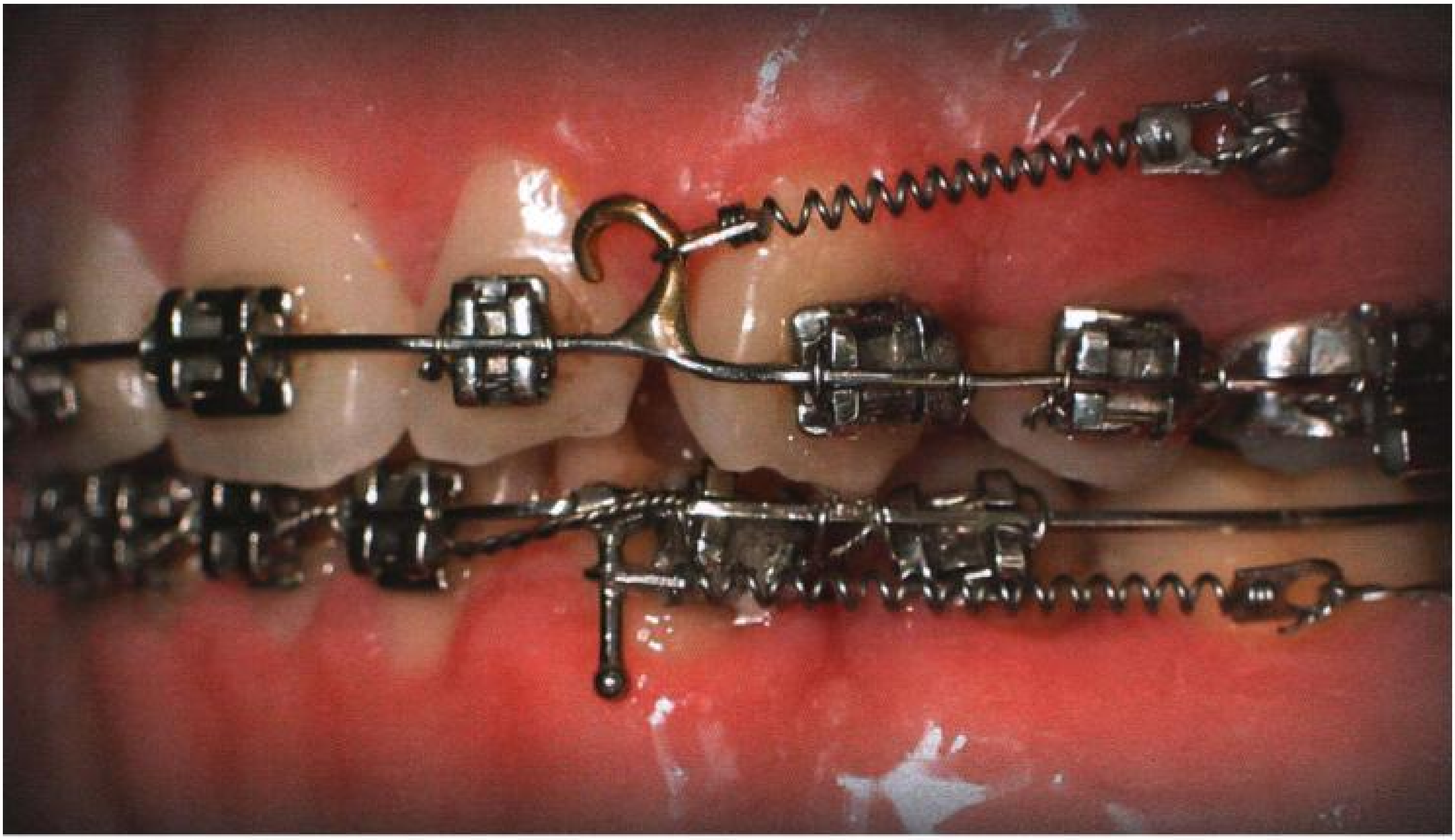
APTER

8

MPORARY NCHORAGE EVICES

N ISSAMU NOJIMA / MATILDE DA CUNHA GONÇA
AQUINO MELGAÇO / LUIZ FELIPE DE MIRANDA
ERNARDES DAS NEVES



Temporary Anchorage Devices

Several concepts were introduced in the Orthodontic field since the pioneer work of Kingsley, in 1861, to correct dental protrusion[1], and Angle's system (1928) for three-dimensional reorientation of the dental arches[2]. Thus, a great variety of systems and philosophies have been developed according to scientific principles in order to achieve the objectives of the orthodontic treatment. These objectives were described by Tweed in 1945, as follows: harmony and balance of facial lines, tooth stabilization after treatment, healthy oral tissues and an efficient masticatory apparatus[3]. Therefore, control of the anchorage mechanism is fundamental during the orthodontic therapy.

According to the Chapter 7, anchorage means resistance against undesirable tooth movement[4]. To avoid anchorage loss, several intra and extra-oral appliances have been proposed[1,4-6]. However, some require patient compliance, or orthodontic treatment will be compromised.

In 1969, Brånemark showed direct bone matrix apposition to the titanium material[7], and osseointegration phenomenon became one of the most important discoveries of the last Century[8]. This finding was considered a revolution in Oral Rehabilitation and affected significantly the dental practice.The use of implants for orthodontic anchorage has a positive influence on treatment planning, as many patients have multiple teeth loss. Implants benefit patient rehabilitation and at the same time provide a more effective orthodontic mechanics[9]. Nowadays, implant fixtures not only serve as prosthetic abutments but also as orthodontic and orthopedics anchorage[10-12].

The evolution of implantology as a specialty provided several developments, directly impacting other disciplines. Advances on implant design, shape, size, material and surface characteristics were proposed and studied. Orthodontists realized that the anchorage mechanics could be benefited. New systems were developed exclusively for temporary orthodontic anchorage. These new devices should be placed and removed with minimal discomfort and tissue trauma. This concept originated the Temporary Anchorage Devices (TADs), denomination suggested during the Meeting of the American Association of Orthodontists in Orlando, in 2004.[13]

TEMPORARY ANCHORAGE DEVICES (TADS)

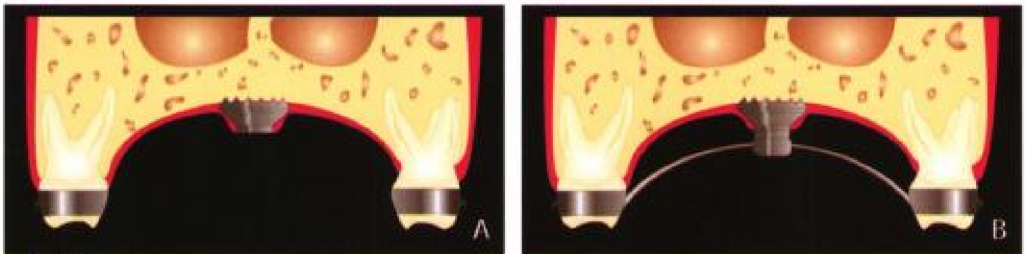
The specific nomenclature refering to the Temporary Anchorage Devices involves variations of implants, screws, pins and onplants (subperiosteal implants) aiming to provide orthodontic anchorage, being removed soon after the biomechanical treatment.[13]

Palatal implants

Two categories of palatal implants can be found: the onplants (subperiosteal)[14] and the intra-osseous.[15,16] Both need an osseointegration period and will serve as indirect anchorage, as seen later in this Chapter.

In the decade of 1990, Block[14] suggested the use of an implant over the bone surface to enhance orthodontic anchorage, named onplant. The term onplant refers to its position over the bone surface and not inside it, as a conventional fixture. The onplant is a relatively thin disk, with 8mm in diameter and 3mm in height. The surface in contact with bone is rough and covered with a hydroxyapatite layer. Thus, the biocompatible surface faces the bone (Fig. 8.1). Onplant has also internal threads and hexagonal configuration to receive several types of abutments according to each case. The period for osseointegration lasts 16 weeks, when a 300 grs force can be applied. However, due to the lack of this product in the market, onplants were replaced by the conventional intra-osseous palatal implants, which have been used in large scale.

Today, there are several types of palatal implants. For example, the



8.1

Fig. 8.1. A – The onplant in position. **B** – Transpalatal bar attached to the onplant.

Straumann Orthosystem has 3.3-4mm in diameter and 4-6mm in height. Its surface is mechanically and chemically roughened to improve osseointegration. Generally, implants matching these dimensions can be used as temporary palatal devices. This is important because the abutment needs to be soldered to a stainless steel wire with no less than 0.9mm in diameter (Fig. 8.2). A trephine bur is used to remove the implant at the end of the orthodontic treatment.

Mini-plates for bone anchorage

In the last two decades, buccomaxillofacial surgeries used internal rigid fixation titanium mini-plates for stabilization of osteotomized areas[18]. This modality can also be applied for orthodontic movements. Sugawara et al.[18], in 1990, described the use of titanium mini-plates for absolute anchorage.

According to this system, orthodontic movements can be performed in all three spatial directions, once the mini-plates are positioned far away from dental roots (Fig. 8.3).

Nowadays, new mini-plate systems have been exclusively developed for orthodontics use. The mini-plates used in buccomaxillofacial surgery do not have specific features for orthodontic anchorage, e.g., mini-plates have texturization on the surface facing the bone, difficulting oral hygienization of soft tissues[19].

Ideal locations for mini-plate placement must have 2-3mm cortical thickness to support a screw with 5-7mm in length and 2mm in


8.2A

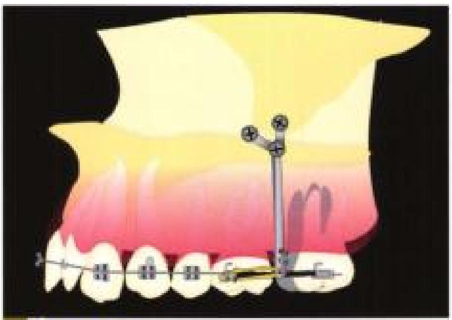

8.2B


8.2C

Fig. 8.2A – Palatal implant – SIN.

Fig. 8.2B – Healing abutment connected to the onplant.

Fig. 8.2C – Transpalatal bar (indirect anchorage) (Courtesy of Dr. Mônica Tirre).



8.3AB

8.3B

Fig. 8.3 – Mini-plates as rigid anchorage for antero-posterior tooth movements. **A** – Y-shape plate in the zygomatic crest. **B** – L-shape plate in the anterior border of the mandibular ramus.

diameter, thus providing good stability. Several shapes can be found (T,L,Y, an I) (Fig. 8.4.), and 2 to 3 screws are necessary for plate fixation. Preferred areas include: zygomaticomaxillary crest for anterior-posterior movement of the anterior dentition (Fig. 8.3A and 8.5); mandibular body for intrusion of the lower molars, as well as the anterior border of the mandibular ramus to distalization of the lower anterior teeth (Fig. 8.3B)[18].

Mini-implants

Cortical and bicortical screws have been used in buccomaxillofacial surgeries to fixate autogenous bone graft segments in areas with deficiencies and tissue loss. The screws can be also applied during internal rigid fixation of osteotomized segments, to decrease or eliminate intermaxillary blocking[17,20]. This concept was incorporated to the orthodontic discipline, which begins to apply the screw technology in the orthodontic treatment.

Creekmore and Eklund[21], in 1983, reported successful correction of deep bite by intrusion of the upper incisors with a vitalium surgical screw fixed beneath the anterior nasal spine. In 1996, one of the first papers considering titanium

8.4

Fig. 8.4 – Specific forms for SAS mini-plates – Dentsply Sankin.


8.5A


8.5B


8.5C

Fig. 8.5. A – Angle's Class I, division I malocclusion. **B** – Mini-plates at the zygomatic crest. **C** – Retraction of the anterior teeth with sliding mechanics and nickel titanium closed coil spring.

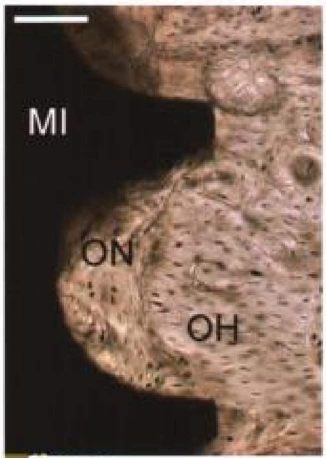
mini-implants (named at that time as titanium pins) was developed at the Master Degree course in Orthodontics, in the Federal University of Rio de Janeiro, Brazil. In this study[22], the authors installed titanium mini-implants between the roots of the lower molars of three monkeys to further characterize the bone adjacent to the titanium surface, after the osseointegration period.

Kanomi[23], in 1997, described the first clinical case using titanium mini-implants with 1,2mm in diameter and 6mm in length. The treatment planning consisted of intrusion of the upper incisors plancing an implant between their roots. After the osseointegration period, the abutment was connected and orthodontic movements applied. The author related a 6mm intrusion within 4 months of activation[23]. After this, several authors related similar clinical tools to improve orthodontic anchorage[24-26].

MINI-IMPLANT CHARACTERIZATION

Today, commercially available mini-implants are manufactured with Grade 4 commercially pure titanium (cp), and titanium alloys made of Ti-6Al-4V, providing great resistance to tension and deformation[38]. Titanium is a biocompatible material that, after contact with bone, triggers cellular adhesion phenomena and bone matrix production, fundamental for the osseointegration process (Fig. 8.6)[28-30].

The mini-implants are classified as TADs, and due to its temporary fixation for orthodontic anchorage, they present inherent topographic characteristics (Fig. 8.7). Implants for prosthetic anchorage include mechanical, electrochemical, or chemical surface modifications to generate roughened and porous



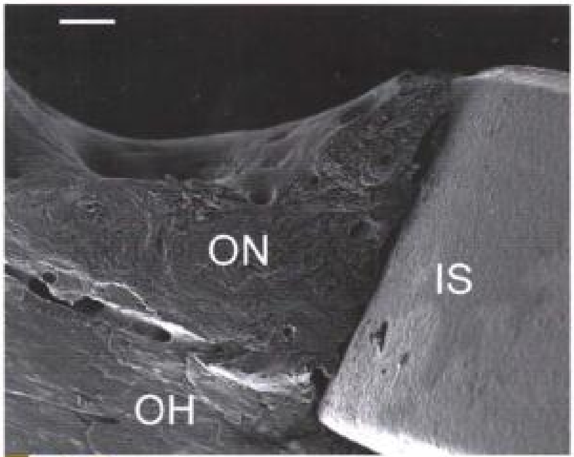


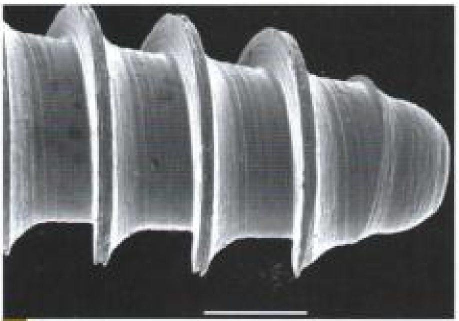
Fig. 8.6A – Section of the mini-implant at the rabbit tibia bone with 12 weeks of osseointegration; MI – mini-implant, ON – neoformed bone, OH, host bone; bar=100µm.

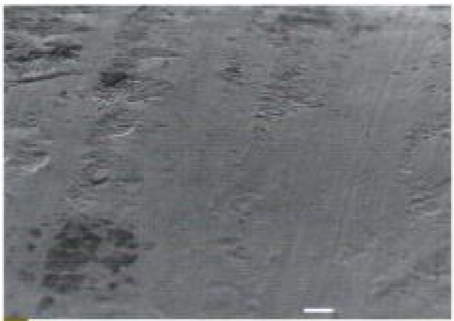
Fig. 8.6B – SEM of the subperiosteal implant in the rabbit tibia with 12 weeks of osseointegration; IS – subperiosteal implant, ON – neoformed bone, OH, host bone; bar=100µm.

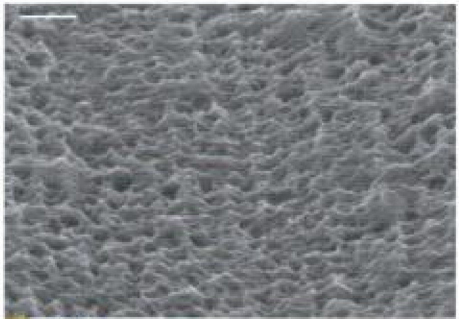
surfaces[31] (Fig. 8.8). This created topography provides better cellular adhesion mechanisms, fundamental to bone matrix formation and calcification during the early stages of osseointegration.[26,30-32] This process must not occur in orhtodontic mini-implants, witch must present only a smooth and machined surface, without texturization process during its fabrication (Fig. 8.7B). However, microgrooves and fissures can easily be detected by SEM analysis of smoothed surfaces.[31]

The efficacy of texturization process can be obtained through reverse torque tests. The implants with smooth surfaces serve as controls, and have demonstrated less torque values when compared to that with rough surfaces.[33-35] Understanding these differences is fundamental to indicate orthodontic mini-implant anchorage. After the treatment period, the mini-implants must be removed with slight forces, once torques above 18Ncm can generate bone fracture.[36]

The mini-implants have three distinct areas: thread, neck and top (Fig. 8.9). The threads will remain in direct contact with bone. The thread pitch and depths vary according to each manufacturer. Two basic thread forms can be found: parallel profile, which requires a screw thread, and a tapered profile, with self-tapping mechanisms. The diameter of the mini-implant screw varies from 1.2-2.0mm, with lengths of 6-12mm. The thinner the cortical plate, the wider the mini-implant diameter and length used. Thus, wider and longer mini-implants are indicated for the maxilla, and narrower and shorter mini-implants for mandible. The implant neck is another important issue. Once soft tissue forms around it, a well-smoothed collar must be present to provided better hygiene.[13] The leng-


8.7A


8.7B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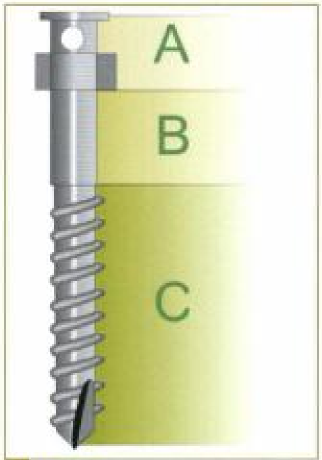


8.9

Fig. 8.7A – SEM of mini-implants with smooth surface. Bar=500µm.

Fig. 8.7B – Microgrooves and microfissures can also be observed in the smooth surface. Bar=10µm.

Fig. 8.8 – Mini-implant texturized surface. Bar = 5µm.

Fig. 8.9 – Mini-implant design. A – top (head), B – neck, C – threaded body.

th of the collar can be adjusted to the soft tissue thickness and height (Fig. 8.9). The mini-implant head serves as an attachment site for orthodontic forces; its rounded top prevents injuries to the gingival soft tissue, lips, and the alveolar mucosa. There is a constriction beneath the round part to anchor elastic chains (Fig. 8.10A) or nickel-titanium, stainless steel coil springs. In addition, a small orifice can receive metallic wires with/without close coil springs (Fig. 8.9 and 8.12).

INDICATIONS

Titanium mini-implants have several advantages: cost, the surgical procedure is easy to perform, can be inserted in many locations of the oral cavity, and provide excellent anchorage for orthodontic movements.

These implants can be inserted at the tuberosity region for distalization of the upper molars, and at the retromolar region, for uprighting of lower second molars (Figs. 8.10A to C) commonly inclinated towards the mesial due to the early loss of the first molars[38]. This is a precise implant indication because the conventional mechanics allows molar extrusion and premature contact with the antagonistic tooth (Fig. 8.11)[4]. The mini-implants are placed in an infraocclusion position and intrusive force component can be originated and upright the molar. Elastic chain is attached to the implant and achieves a hook or a lingual button bonded at the mesial surface of the molar. This force system provides and intrusive and uprighting force (Fig. 8.10D). At the edentulous areas, the TDAs serve as anchoring points for tooth uprighting, as well as anterior- posterior orthodontic movements[38].

Mini-implant insertion is commonly between the dental roots, which require extreme caution to not damage them. A noteworthy application of this technique can be found in molar intrusion, considered as the "Achilles Heel" in Orthodontics[37-39]. Considering upper molars, two vestibular implants (right and left sides) and a transpalatal arch are needed for intrusion of the posterior teeth. Another possibility is the insertion of a third implant at the midpalatal suture to counteract the buccal inclination forces (Fig. 8.13C), thus creating a pure intrusive movement. For the upper or lower incisors, the implants can be positioned between the central incisors or between the lateral and central incisors[13] (Fig. 8.14A and B).

Reduction of dental biprotrusion without headgear forces or patient collaboration can now be achieved by TDAs inserted between the roots of two posterior teeth (Fig. 8.15). In this case, the implant can be positioned between the second premolar and the first molar roots[24,38]. The vertical distance from the bone crest to the implant head must be determined and calculated to allow the resultant force to pass through the center of resistance of the anterior teeth. Generally, en-masse retraction is performed (canine-to-canine movement). Also, sliding mechanics can be applied. In these cases, wire tips are kept away from bracket slots, avoiding movement interruption (Fig. 8.15A). A second possibility is the use of segmented arch, witch forces are applied near to the center of resistance of the anterior teeth (Fig. 8.15B). Extreme caution is necessary to avoid and control excessive buccal or palatal teeth inclination.

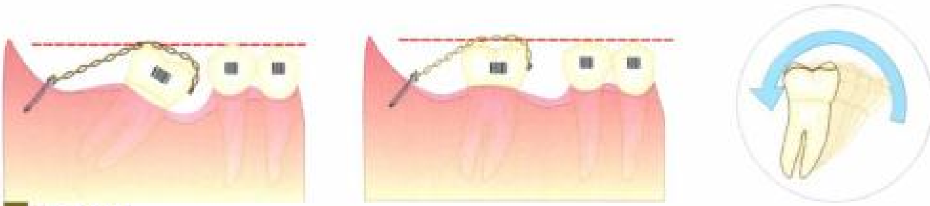
MINI-IMPLANT COMPLICATIONS

Complications in mini-implant usage are related to infections, postoperative pain, surrounding soft tissue inflammation, premature loss of the mini-implants and/or damage to the root surfaces during the surgical procedures. Infections rarely occur when surgical protocols are strictly followed by the dentist. Thus, the use of antibiotics is not necessary unless recommended by the patients' physician. These recommendations can be found at the Meeting of the American Association of Orthodontists and at the Journal of Clinical Orthodontics (May, 2005)[13]. Postoperative pain reported by patients refers more to "volume aug-


8.10A


8.10B


8.10C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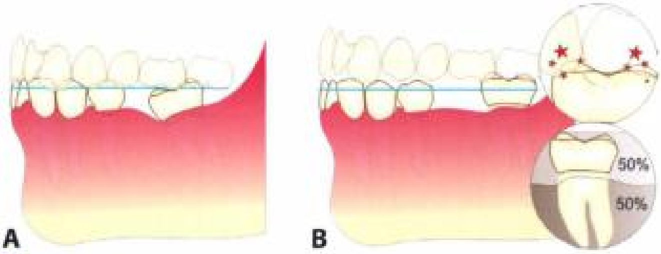

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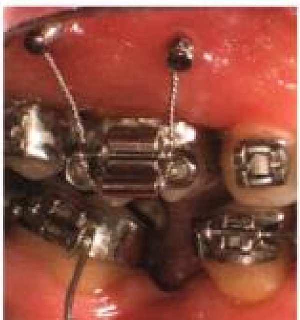

8.13B


8.13C

Fig. 8.10 – Inferior second molar verticalization. The tooth presents mesial inclination, soon after the loss of the element 36. **A** – Mini-implant at the retromolar area and beneath the occlusal plane. **B** – Elastic chain attached to mesial of 37, crossing over its occlusal surface. **C** – After verticalization, **D** – A button was bonded at the mesial of the molar. An elastic chain is attached to the mini-implant and crosses over the occlusal surface of the molar, which generates a distal intrusive force.

Fig. 8.11A – The left lower second molar had a mesial inclination due to the loss of the first molar. **B**. Molar verticalization resulting in anterior open bite and premature contacts.

Fig. 8.12 – Distalization of the lower premolar.

Fig. 8.13 – Intrusion movement in the upper first molar. **A** – Force was applied immediately after implant insertion. **B** – After tooth movement. **C** – Force applied in the palatal region.

8.14A

8.14B

8.15A

8.15B

Fig. 8.14 – Intrusion movement of the anterior teeth. A – Initial clinical views. B – After tooth intrusion.

Fig. 8.15 – Retraction of the anterior teeth. A – Sliding mechanics. B – Segmented mechanics.

mentation" at the mini-implant site and not to the surgical act itself.

After 1-2 week interval, periimplant gingivitis can be found when inadequate hygiene is performed and dental plaque proliferation is present (Fig. 8.16). This can result in implant loosening and consequent failure. Toothbrushes with soft bristles must be used at the area and a 0.12% chlorhexidine gel or solution can be applied with a cotton tip for 30 days to revert the problem. Clinical data showed that 15% of premature implant failures are related to periimplant infection. Also, the use of drills with the same diameter of the mini-implants is another cause. The association of narrow diameter mini-implants, thin cortical plates or both do not provide adequate primary stability and can lead to early implant failure[13,38].

Motoyoshi et al.[40], in 2005, stated that mini-implant success occurs when it remains stable for a period not inferior than 6 months in oral cavity. After placement of 124 mini-implants in 41 patients, the success rate was 85.5%. The maxilla and mandible presented a success rate of 88.8% and 79.5%, respectively. However, these differences were not statistically significant ($P<.05$)[40].

A space of 3-4mm between dental roots is necessary for mini-implant placement. These areas are found between central incisors, lateral and canines, second premolars and first molars, as well as between the first and the second molars. In addition, tooth alignment also increases the interradi-


8.16

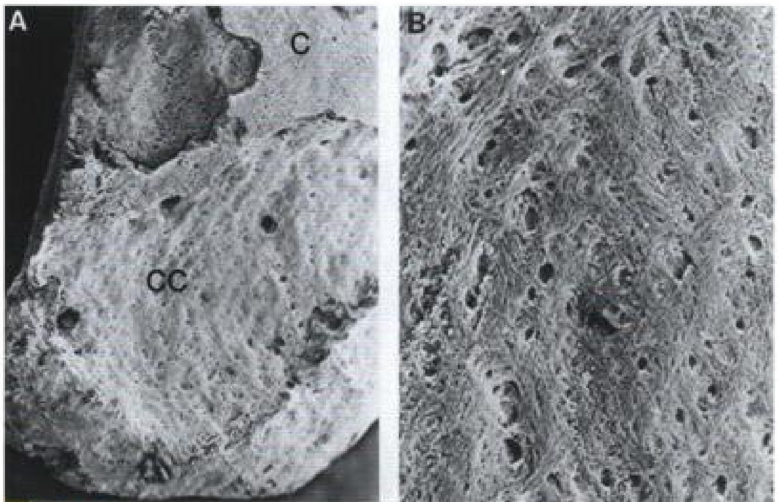
Fig. 8.16 – Periimplant gingivitis.

cular spaces;[41] thus, when the space is less than 3mm, previous orthodontic treatment must be performad to improve conditions for further implant insertion. It is important to avoid root damage during surgical procedures. When a space of 3mm is present and a mini-implant of 1.5mm in diameter is inserted, a space of 0.75mm between dental root and implant is sufficient to avoid accidents. Once the drill has touched the root surface, an additional healing period is necessary. The root surface facing the periodontal ligament has a highly cellular and vascularized cement layer. Thus, cicatrization occurs through deposition of cellular cement[42] (Fig. 8.17). Some procedures during implant insertion must be followed to avoid serious complications.

SURGICAL PROCEDURES

Before surgical procedures it is fundamental to evaluate the receptor site. When the TDAs are placed between roots, it is important to assure that sufficient bone thickness is available. The attached gingival is preferred to the alveolar mucosa, because it is a keratinized tissue, which facilitates oral hygiene procedures and avoids possible inflammatory processes that would lead to implant failure.

The exact location of the mini-implant insertion must be determined by an acrylic surgical guide previously prepared (Fig. 8.18A), or by a brass wire guide adapted to the contact point and extended towards the alveolar mucosa[38], indicating the insertion point (Fig. 8.18B). Also, a stent can be constructed with a rec-



8.17

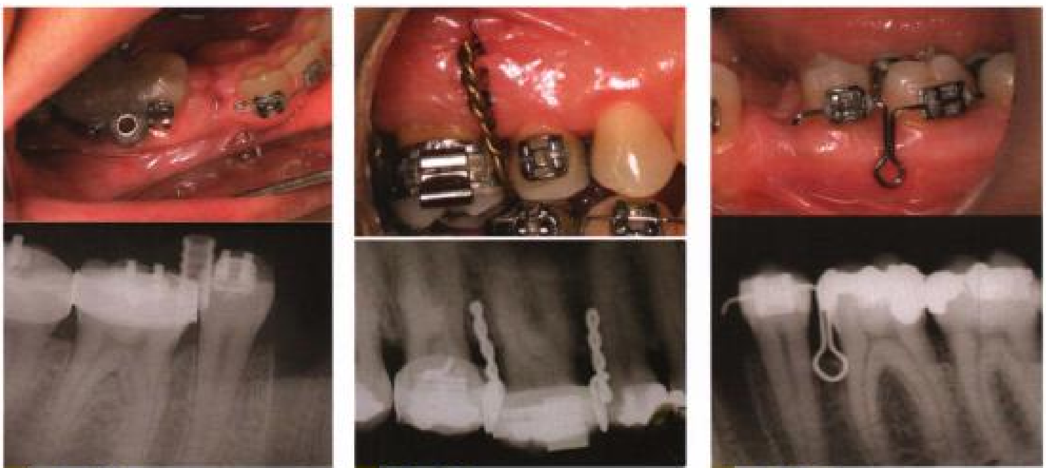
Fig. 8.17 – Root resorption generated by a palatal expansion appliance. **A** – Apical third of a upper first premolar; C – healthy cement layer, CC- resorption areas with cellular cement renewing. B – Detailed view evidencing the cellular cement.

tangular wire (0.019 x 0.025 inches), similar to a retraction loop and adapted to the receptor area (Fig. 8.18C). A periapical radiograph is obtained with the surgical guide. A radiograph film cone indicator device is ideal to avoid distortions. Before mini-implant insertion, the surgical area is disinfected with 0.12% chlorhexidine digluconate mouthrinse solution. Local anesthesia is administered (1/3 of the cartridge volume)[38].

No incisions are need for TDAs insertion. However, areas of thickness alveolar mucosa, as retromolar area, an incision is necessary. The mini-implant is inserted perpendicular to the alveolar bone, between the dental roots.. When insufficient space is present, the local elected for mini-implant insertion is at the apical region of the root. Low-speed rotations (800-1200rpm) and a well-refrigerated saline solution are fundamental during surgery[13]. During the surgical procedure, some complications such as root perforation can be detected, once bone and radicular root present tactile different densities.

Forces ranging from 50 to 200grams can be applied soon after mini-implant insertion and primary stability is comproved[13,25,38,43,44].

The TDAs practice is a new area in orthodontics and some clinicians are reluctant to its use. However, with clinical and experimental positive results TDAs become a useful option during orthodontic treatment, especially for adult patients.



8.18A 8.18B 8.18C

Fig. 8.18 – Surgical stent positioned in the oral cavity. **A** – acrylic guide. **B** – brass wire guide. **C** – rectangular wire guide.

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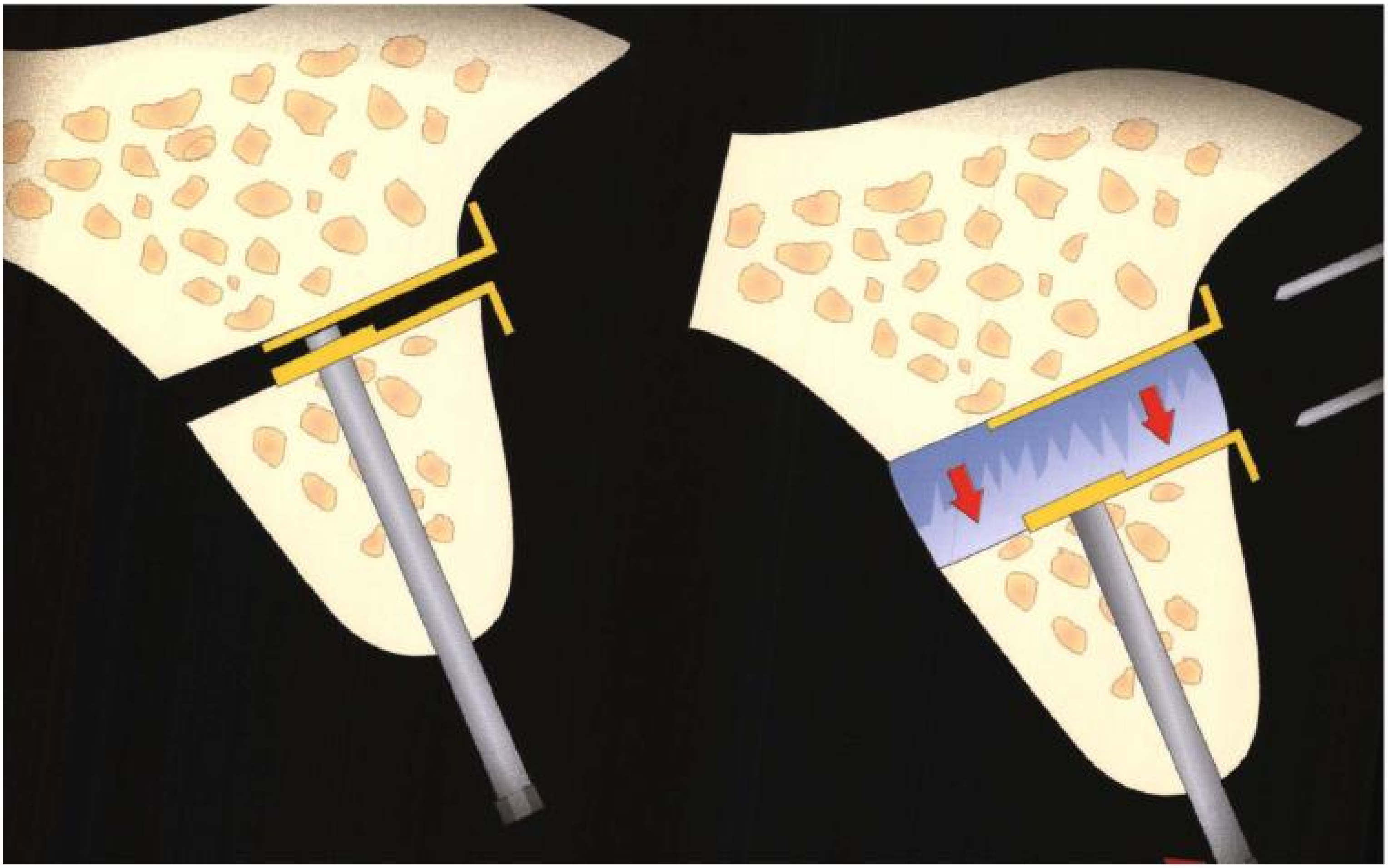
TER 9

VEOLAR DISTRACT TEOGENESIS

I. MARINHO / MARCELO M. SOARES / FÁBIO L.B. G



Alveolar Distraction Osteogenesis

INTRODUCTION

Presence of bone is a fundamental prerogative for patients that will receive osseointegrated implants. The continuous, irreversible and progressive alveolar ridge resorption compromises implant placement leading to a compromised prosthetic treatment.

Alveolar bone deficiencies in height, with concomitant increase in the interocclusal space generate a biomechanically unfavorable crown-to implant ratio, long teeth, and poor esthetics due to the lack of gingival tissue.

Therefore, the reestablishment of hard and soft tissues is imperative for function, esthetics, phonetics, patient comfort and self-steam.

Among the several techniques for alveolar bone reconstruction, alveolar distraction osteogenesis, or Ilizarov's technique, is widely accepted by the scientific community.

Autogenous bone grafts represent the "Working horse" for the reconstruction of atrophic or resorbed areas and can be obtained from various anatomic intra or extra-oral regions.

For tissue augmentation in width and thickness, few problems can be expected as the graft procedures are predictable, but certain limitations are found for vertical reconstruction of the alveolar bone. Factors such poor vascularization, insufficient gingival tissue to cover the wound area, and the peculiar anatomy, increases the likelihood of bone graft necrosis with subsequent resorption.

When compared to the autogenous grafts, the distraction osteogenesis process has some advantages: there is no need for a donor site, decreased morbidity, generalized tissue augmentation (periosteum, vessels, nerves, muscles) following bone growth, decreased bone resorption and infection, reproducibility, and high success rates.. The main disadvantage is that close and careful control is necessary throughout the process together with total patient's compliance.[1,2]

The distraction osteogenesis must be understood as a distraction histogenesis process, because the effects are simultaneous in several tissues (muscles, nerves, vessels, ligaments, etc.) and not only in the bone organ.

Techniques for body lengthening remote the ancient times and can be found in several cultures, being a common practice in certain populations (Fig. 9.1).

The distraction osteogenesis, or bone lengthening, is a biological process of bone neo-formation between two bony surfaces surgically separated, being gradually brought apart by an incremental device. Particularly, this process is triggered when the distraction forces act on the tissue callus that connected the separated segments, and continues with the applied forces. The generated tension stimulates bone neo-formation parallel to the vector of distraction.

After the success obtained in Orthopedics for the treatment of long bone defects, the distraction osteogenesis of the cranio maxillofacial complex became an established and useful tool and the technics are well accepted and applied to correct a wide range of deformities in the cranio maxillofacial surgery practice.[3-7]

HISTORICAL BACKGROUND

Hippocrates was credited for the mechanical manipulation of a fractured bone segment 2.000 years ago (Fig. 9.2).

Guy De Chauliac, in the XIV century, was the first to cite the continuous traction for fracture reduction. The osteomoty concept was well-established in the XIX century when Malgaigne, described the concept of external fixation to treat composite patella fractures.


9.1.1


9.1.2


9.2

Figs. 9.1.1 and 9.1.2 – Examples of tissue lengthening in several cultures.

Fig. 9.2 – Representation of hippocrates wore for bone traction.

The first case reports on distraction osteogenesis were made by Codvilla[9] and Abbot[10], but the clinical use and the methodology for bone callus distraction were introduced and standardized by Ilizarov[11,12] and Smelyshev[13]. They developed a process without bone graft to augment long bones in a single phase.

Ilizarov created a special device, and thus studied the frequency, rate and rhythms of bone distraction. He established the so called Ilizarov method: gradual traction in the tissues generates stress, which in turn stimulates growth and regeneration of new tissues (stress-strain law), being the bone mass and shape directly influenced the applied force and the available vascular bed.

Ilizarov made experimental studies on 120 dog tibias. He observed that a low activation rate (0.25-0.5mm/day) provided early bone consolidation. However, a satisfactory results and the formation of a fibrous tissue instead of bone were observed for values of 1.0mm/day and 2.0mm/day, respectively. Also, the best results were observed when the distraction device was activated many times a day (60 times/day) than sporadically (1-4 times/day).

In addition, Ilizarov[11,12] described two types of distraction mechanisms: physiological and bone callus formation. Also, epyphiseal (fast traction, 1-1.5mm/day) and chondro-diaphiseal traction (slow traction, 0.5mm/day) were described.

The Ilizarov technique became a well-recognized method in Orthopedics and Traumatology for the correction of congenital deformities, wound healing disturbs, traumas, and the reconstruction of affected bone after distal end tumor resections.[14] However, applicability of the Ilizarov principles for maxillofacial deformities was not considered for several decades.

The application of tension/compression forces in the craniofacial skeleton have been related since 1728, when Fauchard described an expansion arch to treat tooth crowding.[15,16] The first reports on maxillofacial distraction osteogenesis were made by Wescott[17] in 1859, with the application of a force in the maxillary bone to correct a cross-bite in a 15-year old girl. One year later, Angell[18] described a similar procedure but with a tooth-supported expansion screw and Goddart[19] in 1893, standardized the protocols for maxillary bone expansion with the screw being activated two times a day for 3 weeks. This aim was to allow for "bone material deposition".

The practice of tension/compression forces applied to the jaws became well-established in the 1960s, for a rapid maxillary expansion in growing patients. Nevertheless, this procedure involved distraction through a natural bony suture.

In 1973, Snyder et al.[20] were the first to describe the Ilizarov technique for mandibular bone lengthening in the dog mandible. In the following two decades, the interest on distraction osteogenesis had a slow progress with few publications on experimental works.[21,22]

At the beginning of the 1990s, research was intensified after the work developed and by Constantino, Friedman et al., reporting success on the distraction of segmental defects in the canine mandible bone (Fig. 9.3)[23-25].

Although several animal studies demonstrated the effect of distraction devices on the maxilla, mandible, facial middle third, and cranial vault, McCarthy was the first to introduce its clinical use, increasing the armamentarium for the treatment of congenital mandibular deformities. McCarthy et al.[4] published a case series of patients with mandibular congenital deformities, and hemifacial microssomia, treated by means of distraction osteogenesis (Figs.9.4 and 9.5).[4,26]

First applications of the distraction technique in the craniofacial skeleton were towards the mandibular bone[27-29]. However, its use was expanded to the maxillary deformities, as well as to the facial upper and middle thirds, with previous confirmation of its biological basis on experimental works for further clinical applications. The mobilization of the maxillary bone involves separation of several sutures, as well as osteotomies in selected bone buttresses. Unlike the long bones and the mandible, new bone formation in the maxilla must occur along the thin cortical plates.

Evaluation of biological basis for distraction of the facial middle third were conducted by Rachmiel et al.[30-32] Osteotomies were placed in a sheep model, and biopsies retrieved after 5 days of latency[5,10,15] 21 days after the distraction period, as well as 6 weeks and one year after the consolidation phase. The biopsy of a non-treated area served as control. Results from the above studies showed that the gradual distraction osteogenesis can be used in the upper and middle facial thirds since new bone is formed at the same time that the osteotomized segments were distracted, and the distraction gap is filled by a bone regenerate , thus eliminating the need for bone grafts.[33,34]

Guerreiro[35-37], in 1990, described the use of intra-oral devices for surgically assisted transverse expansion of the mandible, starting the miniaturization process for intra-oral distraction devices (Fig. 9.6).

In 1996, Block et al.[38,39] published an experimental work with the first report on alveolar distraction osteogenesis. The authors successfully obtained vertical ridge augmentation in a dog model. This work was based on the Ilizarov technique, suggesting that not only the new bone is formed parallel to the vector of force applied, but also perpendicular to the longitudinal axis in cases of lateral distraction for tibia widening.[11,12]

The clinical use of alveolar distraction osteogenesis began with Chin and Toth[40] with the publication of the first human models to correct alveolar bone defects after traumatic tooth loss. Since then, the interest on the technique has resurged and other clinical and experimental reports with several distraction devices were conducted.[41-45]

At that time, Chin and Toth[40] created an intra-oral alveolar distraction device (LEAD) (Fig. 9.7). It remains secured to the extra-alveolar region by microplates attached to the screw activation. The authors reported success with this technique achiving a vertical lengthening of 9mm. Good stability and sliding of the osteotomized segments were seen in all cases. Bone consolidation was verified through radiographic and histological evaluations. The implants were placed 12 weeks after the distraction

Fig. 9.3A and B – (Segmented mandibular regeneration by distraction osteogenesis (schematic drawing from Arch Otorinol Head and Neck Surg 1990;119:535.

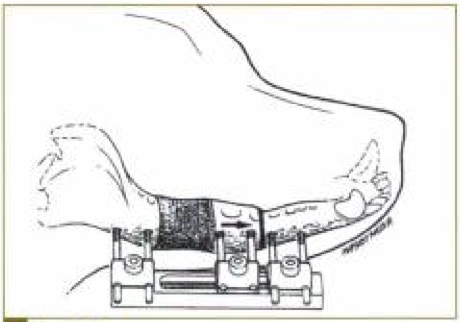
Fig. 9.4 – Extra-oral distraction device used by McCarthy to correct a mandibular deformity.

Fig. 9.5A – Right hemifacial microssomia.

Fig. 9.5B – Panoramic radiograph showing right condyle and ramus deficiencies. The ramus is shortened.

Fig. 9.5C – Clinical aspect of the right hemiface after distraction procedures. The facial (asymmetry was corrected) with simultaneous growth of hand and soft tissues.

Fig. 9.5D – Panoramic radiograph after the distraction osteogenesis process.



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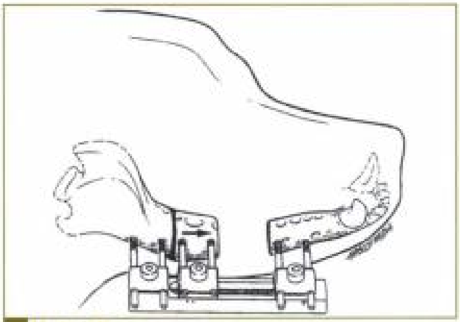

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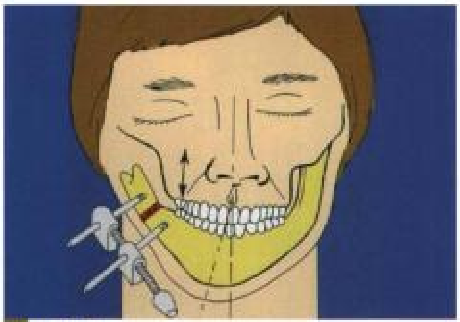

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9.5A

9.5B

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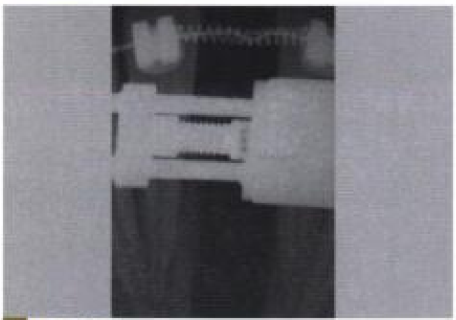
9.6A


9.6B


9.6C


9.6D

Fig. 9.6A – Transverse mandibular deficiency. The intra-oral distraction device in position for surgical assisted expansion.

Fig. 9.6B – The chisel used to complete the osteotomy.

Fig. 9.6C – Periapical radiograph at the distracted zone.

Fig. 9.6D – Final radiograph aspect showing bone maturation and mineralization at the distracted zone.

process. In addition, advantages of this technique include:

- no additional bone grafts were necessary;
- less resorption of the regenerated bone;
- less morbidity when compared to conventional techniques;
- less infection occurrences;
- dental implants can be placed 12 weeks after the distraction process;
- soft tissue gain.

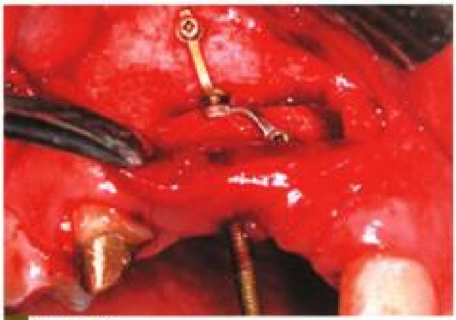
Hidding et al.[46,47] emphasized the concomitant soft tissue augmentation, demonstrating the advantage of preservation of the gingival architecture at the distracted region. This must be highlighted due to need for correction of both soft and hard tissue in complex and composite defects (loss of volume, mass and architecture of both soft and hard alveolar tissues).

After the report on of extra-alveolar distraction devices, other appliances were described to rehabilitate compromised areas. Gaggl et al.[48,49] reported the use of an implant-like distraction device, which has a dual purpose: to serve as an intra-alveolar distraction device and later, as an implant to support the dental prosthesis. With this in mind, the authors created the DI-SIS Distraction Implant, which consists of a conical, self-tapping laser machined surface implant with 4.1mm in diameter and 7, 9, or 11mm in length.

Since the works of Chin and Toth[40], several devices and techniques have been published[50-53] showing satisfactory results. It is important to note that there are several indications for alveolar distraction osteogene-

Fig. 9.7A and B – Dry skull model and clinical aspect of the distraction osteogenesis in the maxillary anterior region using the LEAD (Martin-Chin).[41] Alveolar distraction device.

9.7A



9.7B

sis, which must be analyzed for each case in particular. As the field of distraction osteogenesis is still evolving, indications are constantly changing and can be applied for the resolution of several deformities.

Histological aspects of distraction osteogenesis

The distraction osteogenesis process triggers a series of biological events, similar to that found in bone regeneration or healing. Several adaptative changes occur at the tissues in response to an applied tension force, with further bone regenerate formation. In this way, the tissue is repaired by primary intention without callous formation.

New bone formation at the distracted area follows the healing events of blood clot formation, inflammatory infiltrate, and deposition of collagen fibers with concomitant capillary migration. There is an increase in the number of mesenchymal cells similar to newly formed fibroblasts, and later, mature fibroblasts organize to deposit the extracellular matrix. The collagen fibers are lined parallel to the tension forces, providing a path for capillary migration with further mineralization. The main fiber found at the distraction of tubular bones is the α-1 chain at the collagen type I.[54]

When the regenerated tissue and the capillaries develop at the same time, the osteoprogenitor cells will differentiate in a vascular media to form bone.[55]

Karp et al.[56] made histologic sections in the dog mandible with sequential evaluation at 10 and 20 days during the distraction phase, and 56 days after the consolidation phase.[14,28] The authors observed four steps and distinct areas at the distraction gap, being a central fibrous area with collagen fibers parallel to the tension vectors, a bone forming area at the fibrous tissue with bone spikes and osteoblasts, a bone remodeling area with resorption and apposition margins, and mature areas with cortical bone formation.

In the alveolar distraction osteogenesis, three phases, after the initial osteotomy, with specific biological events must be observed. Undisturbed bone healing is only achieved if strict adherence to the Ilizarov protocol is followed: atraumatic osteotomies, activation rate of 1mm/day, and stability of the distraction device for maintenance of the vector of distraction and lack of mobility during the period of consolidation.

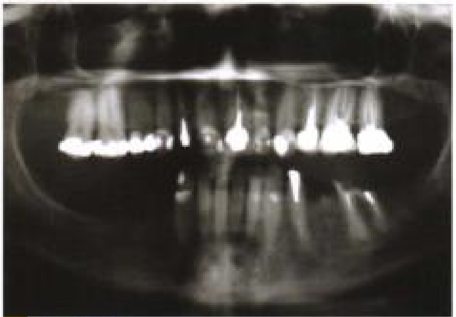
First phase – latency phase

This period comprehends the time between the osteotomies to the start of activation of the distraction device. A fibrous callus is formed here (soft callus). This period usually lasts for 5 to 7 days and coincides with the biologic events of conventional bone repair. The periosteum is reformed also with capillary reorganization. Mesenchymal cells from the medullar tissue invade the area, with subsequent periosteal formation and deposition of an immature bone callus.[57] After all, inflammatory phase is resolved, give rising to the proliferation phase.

Second phase – distraction phase

At this period, the osteotomized segment is being dislocated under tension forces to form the new bone tissue. This phase lasts for 1-2 weeks and there is a new repair process. Dynamic micromovements are ge-

9.8.1



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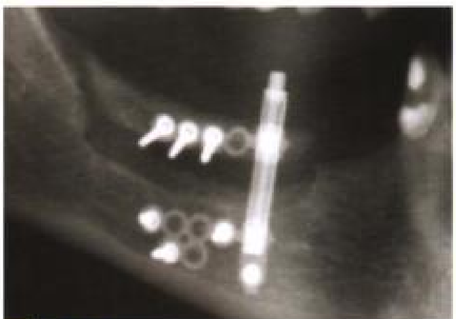


9.8.6

Fig. 9.8.1 – Right lateral pre-operatory view. Mandibular atrophy at the posterior region.

Fig. 9.8.2 – Pre-operative panoramic view.

Fig. 9.8.3 – Osteotomy at the posterior alveolar ridge to delimitate the transport disk.

Fig. 9.8.4 – Track device with an activation screw of 9mm. stability of the distraction device after screw fixation.

Fig. 9.8.5 – Radiographic aspect soon after device installation.

Fig. 9.8.6 – Radiographic aspect after treatment. Note vertical displacement of the transportat disk.

Fig. 9.8.7 – Radiographic aspect after consolidation phase of the distracted area.

Fig. 9.8.8 – The distracted area is exposed. Observe new bone formation between the transport disk and basis of the osteotomy.

Fig. 9.8.9 – Distraction device removed. The vertical bone gain can be measured between the metallic plates.

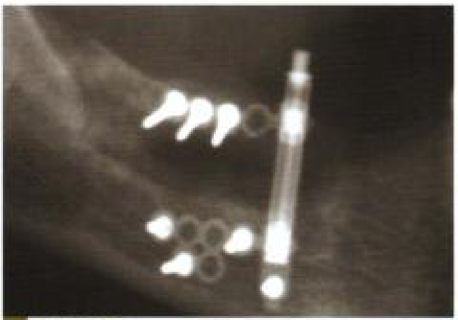
Fig. 9.8.10 – Mandibular region submitted to distraction. The transport disk and the distracted area are distinct.

Fig. 9.8.11 – Surgical aspect after implant placement. Biopsy sites of the regenerated bone.

Fig. 9.8.12 – Radiographic aspect after implant placement.

Fig. 9.8.13 A, B – Native bone biopsy (transport disk) showing normal alveolar bone characteristics.

Fig. 9.8.14 A, B – Biopsy at the distracted area showing neoformed bone with lamellae, vessels and bone lacunae filled with osteocyte cells.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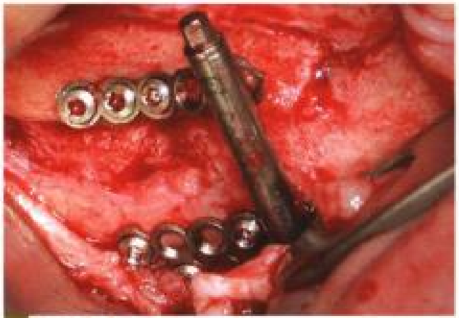
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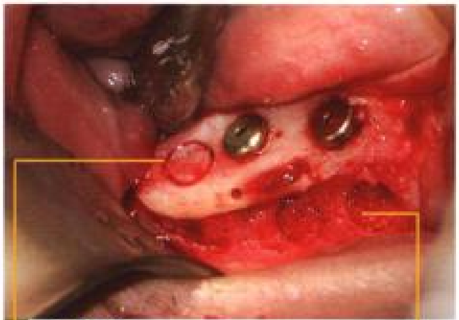
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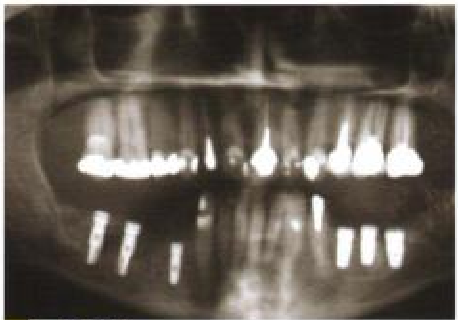
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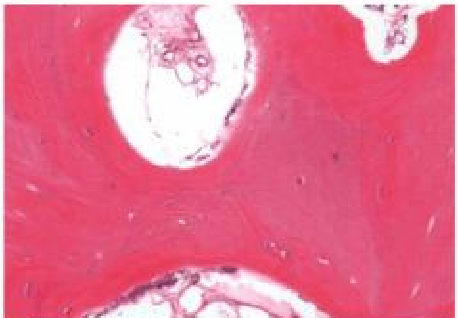
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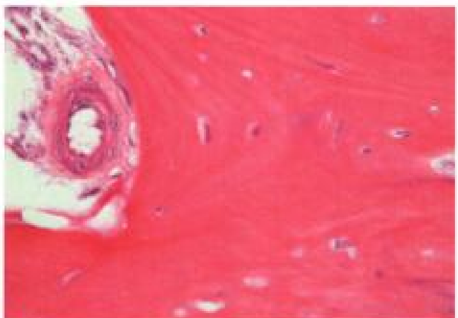
9.8.14A


9.8.14B

nerated with tissue formation parallel to the tension vectors. New vessels are formed along with fusiform fobroblastic cells (distraction fibroblasts). These cells can be found at the periphery of blood vessels, producing additional collagen that is lined parallel to the tension site.[57] The collagen type I is the main precursor of bone formation, which occurs under stress/strain forces applied to the immature callus. First, the cicatrization process occurs via intramembranous mechanisms. This justifies the theory that tension forces favor intramembranous and not endocondral healing. It has been observed that these cells secrete osteocalcina, osteoporin, and alkaline phosphatase, evidencing osteoblastic differentiation. Thus, the distraction vectors favor condroblasts and fibroblasts to differentiate into osteoblastic cells.[58,59]

It is not known whether bone callus maturation is due to fast maturation of the collagen fiber network along with osteoid matrix deposition or to an osteoblastic proliferation due to physical stimulus. To summarize, we do not know what factor (osteoblastic increase, synthetic activity of each cell, or both) is responsible.[58]

The vascular growth observed is 10 times greater than in the conventional healing process. Thus, the distracted fibrous area has more blood nutrients and undifferentiated mesenchymal cells, which will be further differentiated into condroblasts and osteoblasts. Vessels and cells are deposited along the longitudinal axis of the parallel collagen fibers. Histochemical studies made by Ilizarov[2,11,12] demonstrated an increase in piruvic and lactic acid concentrations (metabolic enzymatic products), meaning that controlled tensions on the granulation tissue trigger mesenchymal cell differentiation into osteoblastic cells and favors the production of osteogenic proteins.[57]

Karp et al.[56] observed a tough, large bone trabeculae at the center of the distracted site 14 days after the end of activation period, as well as a bone bridge at the margins of the osteotomized sites 1 month later. Two months after distraction, the distraction gap was filled with mineralized bone and showed remodeled areas with dense cortical tissue.

Third phase: consolidation phase

The regenerated bone matures at this period before removal of the distraction device.

There is a reparative callus, as well as regeneration of the soft tissues, periosteum, blood vessels, and proliferation of osteogenic cells.[56] For cranial bones, a period of 3 to 5 weeks is recommended for children and 6 to 12 weeks for adults. For facial bones, there is an intramembranous ossification, although endocondral sites have been related in some studies.[60]

Raghoebar et al.[61] made light microscope analysis of distraction specimens and confirmed the radiographic appearance of new bone at the distracted site. In most cases, intramembranous ossification was seen in both mineralization zones. The bone trabeculae were parallel to the distraction vectors.

Several studies showed that there is vital lamellar bone, some trabecular bone, and a cell-rich, fibrous zone, at the center of the distracted tissue. The bone tissue had osteocytes within lacunae, which characterizes its vitality. The adjacent sites followed the newly formed osseous structures, implying in complete anatomic and physiologic interactions.[24,30]

The effect of loading on distraction sites were studied in rats submitted to femoral distraction. In group 1, areas submitted to distraction withstood the rat body weight, whereas in group 2 no loads were applied. Four days after the consolidation phase, rats in group 1 had more regenerated bone, BMP-2 and -4, osteocalcin, and collagen type I than in group 2. Also, collagen type II was formed in the later. Thus, loading favors bone regeneration during the distraction process, although optimal levels are still not elucidated.[62]

To summarize, histologic observations and the physiologic principles have been well-documented in long bones and more recently in the maxillofacial complex. During the distraction phase, bone formation occurs due tension/stress vectors exerted in the immature bone callus. The midportion of this tissue consists of a central zone where the osteoid matrix is deposited along collagen fibers parallel to the distraction vectors.

Ossification occurs when a primary ossification front comes from both sites of the central fibrous zone, forming an immature bone bridge through the distracted area. Bone remodeling begins during consolidation phase and continues up to a 1-2 year period, and creates mature bone similar to the adjacent area. Although the new bone volume is similar to the adjacent tissue, animal model studies demonstrate that the mineral content, radiopacity, and strength are 30% less of the results found in the adjacent mature area.[30,32] In addition, soft tissue changes can be seen at the distraction area. Muscular mass and soft tissue volume increase due to a process called distraction histiogenesis.[63] Clinically, it offers some clear advantages because some patients present with muscle and soft tissue deficiencies. The neurovascular content inside the transported segments are stimulated to regeneration. Experimental studies in dogs showed regeneration of the mandibular canal with its neurovascular elements. However, functional activity of regenerated structures was less than normal.[39]

BIOLOGICAL FACTORS OF DISTRACTION OSTEOGENESIS

Several factors can influence the distraction process, which can be divided into two basic groups: osseous factors and distraction factors.

Osseous factors

Vital osteocytes are essential as an adequate source of osteoblastic activity at the distraction site. In this way, the surgical protocols must minimize the thermal or mechanical injuries to the bone tissue. Similarly, an adequate vascular supply is critical to the osteogenesis. Arterial insufficiency can cause ischemic fibrinogenesis within the distracted segment, resulting in a loose and irregular rather than a dense and organized collagen network. Occlusion of vein drainage is associated to cystic degeneration.[64] The surgeon must verify and determine if the adjacent soft tissues are well vascularized. Early studies in long bones concluded that the periosteal and endosteal layers were fundamental to osteogenesis and some authors described the use of cortical cuts through minimal periosteum incisions. More recent studies have shown that the periosteum can provide enough osteogenic capacity to an adequate distracted area, and this is very true for well-vascularized bones of the maxillofacial skeleton.[65-67]

Besides, special attention must be given at the transport disk (distraction segment) and the osteotomy method.

Transport Disk (Distraction segment)

The transport disk must be of appropriate size, in order to maintain adequate nutrition, accommodate the distraction device, and provide sufficient area to the regenerating bone in the activation phase. The distraction chamber, a space between the transport disk and the base of the osteotomy, must be wide enough so that the volume of the distracted area could have satisfactory density and stability. In addition, the segment must have sufficient height and width to the fixation screws as well as stability during function. [68]

Osteotomy

The osteotomies must take place under abundant irrigation preferably with the use of microsaws, in order to obtain a more precise cut with less heat and trauma for the soft tissue and the vascular network. In this way, the periosteum of the adjacent alveolar crest and at the lingual side can be preserved, because these will provide nutrition for the transport disk. Vertical osteotomies must be slightly divergent coronally to provide adequate displacement of the transport disk without bony interferences that can limit the movement or alter the distraction vector. (Fig. 9.9).

Distraction factors

The frequency, rate and rythmum are factors that influence on the quality of the regenerated soft tissue.[69]

Latency period. This is a very most critical point. Most reports on maxillofacial surgeries show the empiric application of observations of studies in long bones and recommend a 4-10 days interval between the osteotomies and the beginning of the activation phase. The latency phase of 4-7 days is well indicated for alveolar distraction, thus avoiding premature bone exposition at the oral cavity.[70-72] A latency period greater than 10-14 days increase the likelihood of early bone union.

The clinician must associate his/her common sense and the surgical background in cases with several situations, such as: regions submitted to multiple surgeries, scarring of the adjacent soft tissues, recurrent, chronic or early infections at the distraction area, bone grafts associated to the distraction segments, and other surgical procedures in the same area.

Distraction timing (rate and frequency of activation). The rate (mm/day) and frequency (number of times that the distractor is activated within 24 hours) also influence on the neoformed bone. A higher activation rate (>2mm/day) leads to

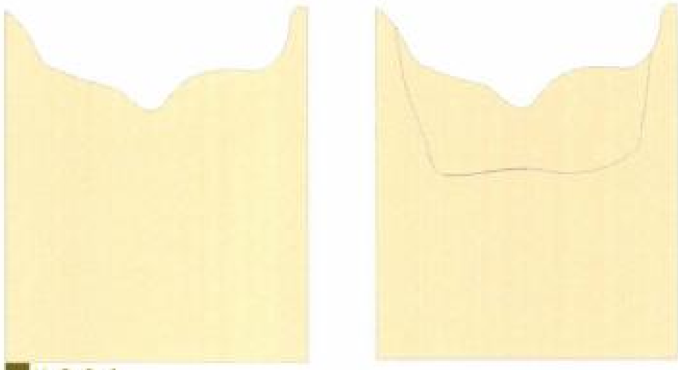
Fig. 9.9.1 – Osteotomy lines are placed.

Fig. 9.9.2 – Positioning, adaptation and provisional fixation of the distraction device prior to osteotomy.

Fig. 9.9.3 – Osteotomies are finalized.

Fig. 9.9.4 – The distraction device is secured in position after the obsteotomies are completed.

Fig. 9.9.5 – Possible interferences and sharp angles are checked during displacement of the transport disk. Observe divergence between the vertical osteotomies to provide free movements in the transport disk



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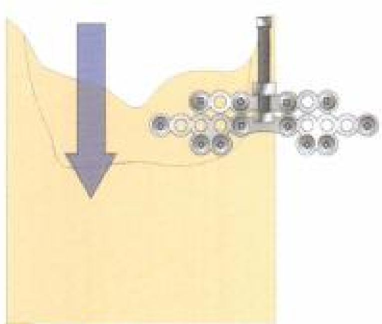

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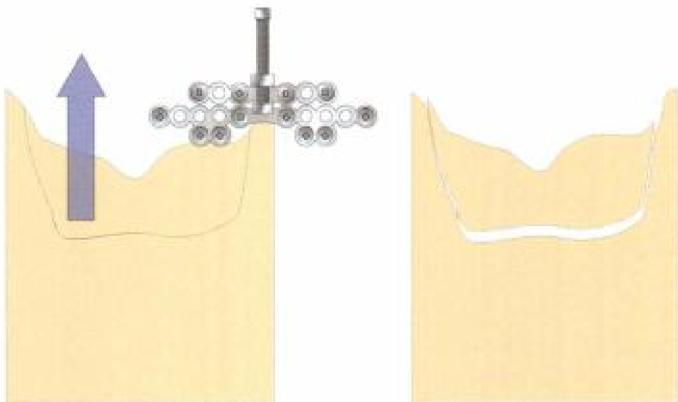

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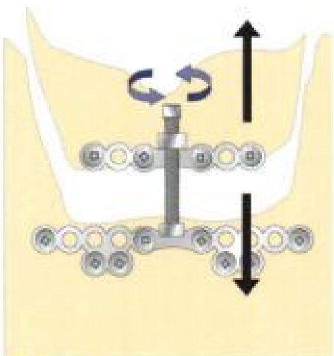

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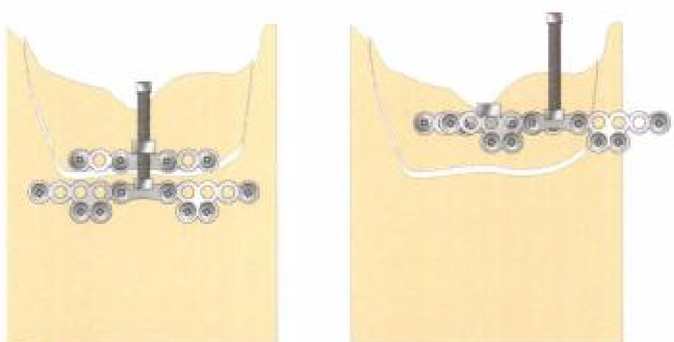


9.9.5

fibrous union, whereas a lower activation rate (<0.5mm/day) leads to premature bone union interfering with the desired displacement. Ueda[75] demonstrated in the rat tibia that low activation rates (0.5mm/day per 5 days) generated a fibrocartilaginous tissue, whereas high activation rates (1mm/day per 5 days) generated intramembranous ossification, with rapid new bone formation. Gaggl et al.[74] considered that ideal rates would be of 0.5mm/day.

Ilizarov[64] had already documented that a continuous frequency would be interesting. The distraction rate directly influences on the cellular differentiation and production of the extracellular matrix. However, this frequency is difficult to achieve from the clinical perspective and some experimental works had adopted devices that can keep constant activation rates, eliminating the undesirable effects that prevent adequate bone formation.[75-78]

Consolidation period

The patient must be compliant with follow-ups and hygiene protocols during the consolidation period, which varies from 8-16 weeks, depending of patient's age and local tissue conditions.[79]

According to the studies with long bones, several authors have established consolidation periods based on the length obtained after distraction. Thus, for long bone extremities, 2 days of consolidation were sufficient for each millimeter achieved.[80-82]

Remodeling and consolidation have been widely studied, evaluated and measured with bone densitometry, computerized tomography, histomorphometric and imunnohistochemical techniques, as well as by conventional radiographs. Mazzonetto and Maurette[83] carried out a radiographic study to evaluate a technique for vertical alveolar distraction of atrophic ridges. Mean distraction values observed in 60 cases were 6.27mm (0-10.83mm) according to the treated region, being 51.6% in the posterior mandible (4.60mm), 36.66% in the anterior maxillary region (7.46mm), 8.33% in the anterior lower region (6.73mm), and 33.3% in the posterior maxillary region (6.32mm).

Age and systemic factors. Usually the younger the patient, the faster the bone remodeling. In young patients, a long latency period or a slow distraction rate can lead to early bone consolidation. Thus, during mandibular lengthening, Chin and Toth[40] established a 5-day maximum latency period for patients between the ages of 2.5-17 years. Aronson et al.[84] related a statistically significant difference between radiodensities of rat tibia at 4 months and 24 months, with mineralization values at the distraction areas of 95% and 36%, respectively.

The application of distraction osteogenesis is not well established in irradiated patients due to hypoxia, hipovascularization, and cell viability. However, one study in the dog mandible showed similar behavior for irradiated and non-irradiated bones.[85]

Tobacco smoking seems to affect the distracted sites. One study with rabbit tibia submitted to tobacco inhalation during distraction osteogenesis showed densitometry and biochemical values lower than the controls. The authors considered that alterations on vessel network could be the cause, but the precise molecular mechanism is still unknown[86].

CRITERIA AND INDICATIONS FOR ALVEOLAR DISTRACTION OSTEOGENESIS

Indications

With the increasing in the life expectancy, an increasing number of patients have suffered from secondary alveolar atrophy due to development anomalies, cysts, tumors, traumatism, tooth loss, and periodontal disease. Although several options (autogenous or alloplastic bone grafts) have been available for the treatment of these pathologies, each one presents certain limitations in cases of complexes defects.

Most of the implant-supported reconstructions need soft and hard tissue grafting to obtain adequate long-term biomechanical and esthetic results.

Considering that the distraction osteogenesis process favors tissue formation, one can realize that potential applications of this technique are for growth and development deficiencies, as well as in tissue loss. The alveolar bone can retrieve its form, mass, and resistance due to the distraction process that provides new bone in a safe and predictable way, before implant placement and prosthetic rehabilitation.

The use of distraction osteogenesis for vertical alveolar ridge augmentation has increased[70,87,89] since the experimental work of Block et al.[38,39] and the clinical studies conducted by Chin and Toth[40].

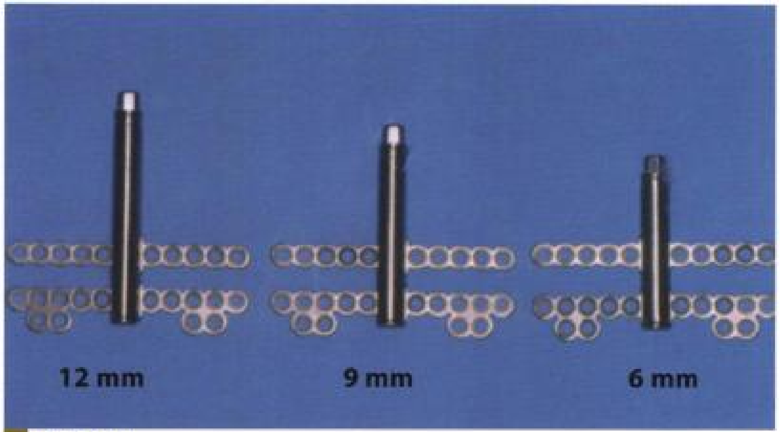
Several types of intra-oral alveolar distractors were developed to augment vertical ridge dimensions, and include extra-oral, intra-oral, and implant distraction devices[91,92].

We have observed that, although several types of distractors are available, most cases can be treated with the TRACK device, due to its design, versatility, better adaptation and fixation to the alveolar segment (Fig. 9.10).

It is important to highlight that most indications for distraction osteogenesis concentrate on the vertical alveolar augmentation of the residual ridges, and more recently horizontal distractors have been introduced in the market (Fig. 9.11).

The following are some of the possibilities with the alveolar distraction osteogenesis in the current clinical practice:

- severe alveolar ridge atrophy with accentuated vertical deficiency (Fig. 9.12);
- alveolar shape and volume defects (Fig. 9.13);
- esthetic vertical deficiency in the anterior alveolar ridge;



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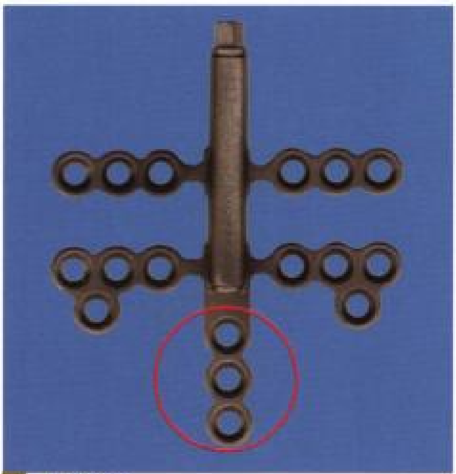


9.10.2

Fig. 9.10.1 – The TRACK distraction devices can be found in three different lengths.

Fig. 9.10.2 – TRACK-PLUS with a vertical plate segment for better controlling of the distraction vectors.

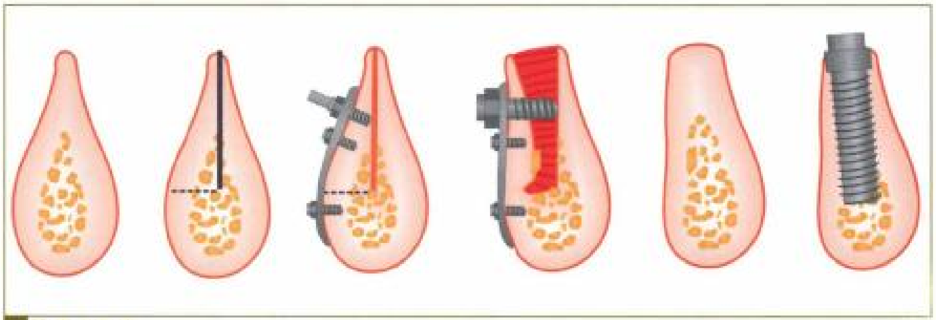
- bone grafting not indicated;
- congenital alveolar defects;
- complex and composite ridge defects (hard and soft tissue deficiencies, with loss in height and thickness);
- failure of bone graft or guided bone regeneration;
- vertical transposition of incorrectly placed implants (Fig. 9.14).

The distraction osteogenesis is a technique for gradual bone growth, offering the possibility to form new bone in a safe and predictable way by natural regenerative mechanisms, as well as receptor site preparation for osseointegrated implants. Bone crest gain occurs at both vertical (height) and horizontal (width) dimensions. This can be done at the implant placement surgery, with vertical overcorrection and secondary remodeling of the knife-edge type, or by surgical leveling at the top of the crest to resolve esthetic problems, as will be demonstrated here in the next cases.

The use of distraction technique for height and width bone gain does not preclude bone grafting procedures.

Fig. 9.11.1 – Schematic drawing of alveolar horizontal distraction process.

Fig. 9.11.2 – The alveo-wider™ device for horizontal distraction osteogenesis.



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9.11.2D

Alveolar distraction devices (Fig. 9.15)

The distraction devices can be classified according to their intra or extra-oral localizations. Also, they can be classified according to the proposed use: distractor, implant-distractor, or abutment-distractor. Besides, a distinction can be made among them according to vertical or horizontal augmentation procedures.[90]

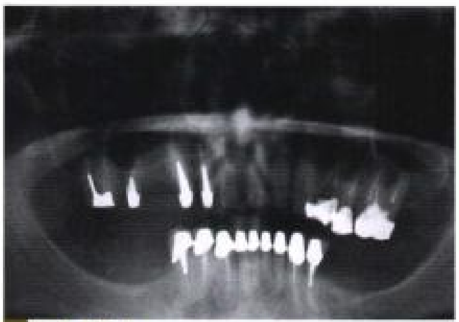
The above cited devices, along with the Ilizarov distractor, apply the same four principles for a successful procedure:

- corticotomies or complete osteotomies;
- latency period;
- conservative rhythms of distraction;
- consolidation period.

COMPLICATIONS ON ALVEOLAR DISTRACTION TREATMENT

Infection and inflammation

Infection is the most common complication seen after surgical pro-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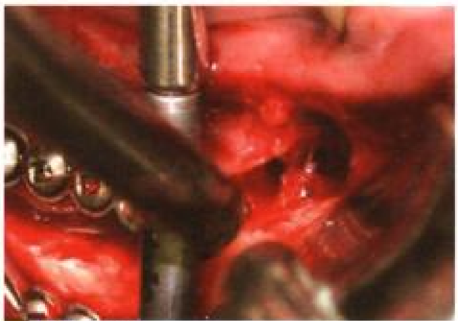
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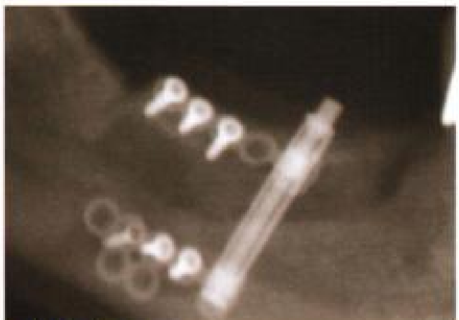
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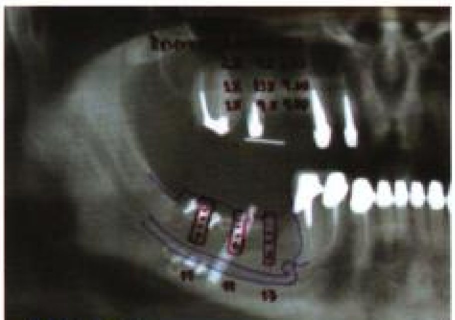
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Fig. 9.12.1 – Pre-operative panoramic radiograph showing mandibular atrophy at the posterior regions.

Fig. 9.12.2 – Clinical aspect showing bilateral ridge deficiency with subsequent increasing in the interocclusal space and tongue interposition.

Fig. 9.12.3 – Surgical planning to select the shape and size of the distraction device.

Fig. 9.12.4 – Osteotomies are placed and the transport disk is created.

Fig. 9.12.5 – The distractor is secured into the bone. Interferences are checked.

Fig. 9.12.6 – Try-in of distractor aperture and transport disk movements.

Fig. 9.12.7 – Intra-oral aspect after sutures. Observe a slight volume and the top of the activation screw in the oral cavity.

Fig. 9.12.8 – Radiographic control after distraction process.

Fig. 9.12.9 – Radiographic control after consolidation phase show mineralization of the distraction gap.

Fig. 9.12.10 – Implant surgery planning after removal of the distraction device.

Fig. 9.12.11 – Alveolar ridge before distractor removal. Observe new bone formation at the distraction gap.

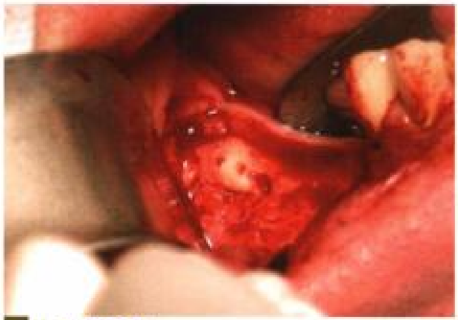
Fig. 9.12.12 – The device is removed.

Figs. 9.12.13 and 9.12.14 – Implant placement 12 weeks after the consolidation period.

Fig. 9.12.15 – Panoramic radiograph after definitive prosthesis.

Fig. 9.12.16 – Final clinical view showing the prosthesis and the depth of the buccal vestibule.

Fig. 9.12.17 – Clinical frontal view after case finalization.



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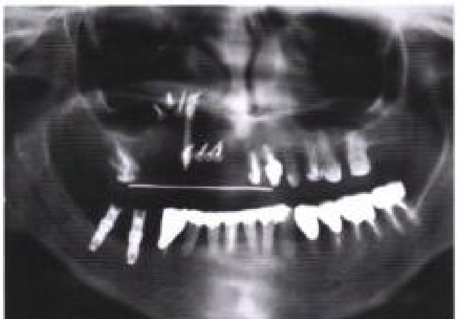
9.13.10

Fig. 9.13.1 – Atrophic maxillary area showing horizontal and vertical deficiencies.

Fig. 9.13.2 – Alveolar ridge augmentation after mandibular ramus bone graft to icrease alveolar width prior to vertical distraction.

Fig. 9.13.3 – Osteotomy incorporating the bone graft into the distracted segment.

Fig. 9.13.4 – The distractor is secured in the grafted area.

Fig. 9.13.5 – The interferences are checked and the transport disk is activated.

Fig. 9.13.6 – Clinical aspect before device activation.

Fig. 9.13.7 – Clinical aspect show vertical alveolar loss in the maxilla.

Fig. 9.13.8. and 9.13.9 – Clinical aspect after the distraction period and correction of vertical deficiency. The provisional prosthesis was adjusted to provide space for bone growth.

Fig. 9.13.10 – Panoramic radiograph after distraction showing vertical bone gain at the atrophic site.

Fig. 9.13.11 – Clinical aspect at distractor removal showing the neoformed bone.

Fig. 9.13.12 – Implant placement. Observe complete mineralization of the regenerated bone.

Fig. 9.13.13 – Intra-oral view after prosthesis delivery.

Fig. 9.13.14 – Panoramic radiograph with prosthesis in position.

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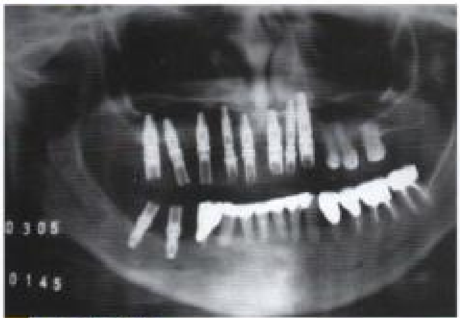

9.13.14

Fig. 9.14.1 – Lateral and occlusal views of an incorrect implant placement at the canine region. The implant is too far apical.

Fig. 9.14.2 – Radiograph aspect showing implant position.

Fig. 9.14.3 – Osteotomies are placed and the implant is included in the transported segment.

Fig. 9.14.4 – The implant position into the transported segment prevents insertion of screwed distraction devices. The TRACK device cannot be installed.

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Fig. 9.14.5 – The distractor is incorporated into the provisional prosthesis. Interferences are checked and the transport disk is tried-in.

Fig. 9.14.6 – Clinical aspect after suturing. Observe incorrect implant apical positioning.

Fig. 9.14.7 – Clinical aspect during activation of the distraction device.

Fig. 9.14.8 – Final clinical aspect after the distraction period.

Fig. 9.14.9 – Occlusal view after the consolidation phase showing vertical gain in the alveolar ridge.

Fig. 9.14.10 – Final implant position.

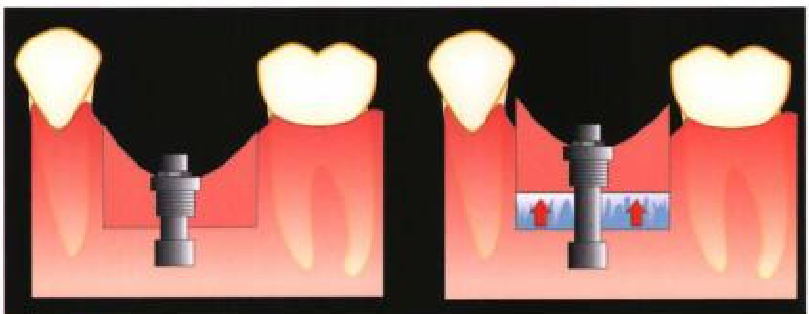

9.15.1

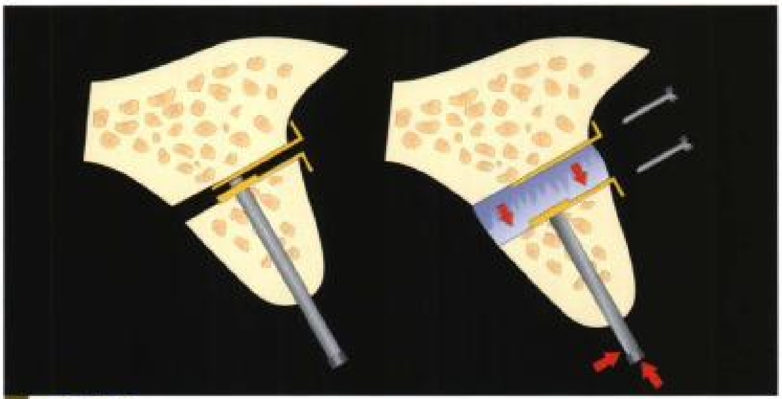
Fig. 9.15.1 – OGD Distractor (OsteoGenic Distractor; ACE Surgical Supply, Brockton, MA).

Fig. 9.15.2 – LEAD distraction device (Leinbinger Endosseous Alveolar Distractor; Stryker- Leibinger, Freiburg, Germany.)

Fig. 9.15.3 – TRACK Distractor (Tissue Regeneration Alveolar Callus Distraction, Martin, Tuttlingen, Germany).

Fig. 9.15.4 – DISSIS Implant Distractor (Distraction Implant System; SIS, Klagenfurt, Austria).

Fig. 9.15.5 – ROD5 Distractor (Oral Osteodistraction, Buffalo Grove, IL.).



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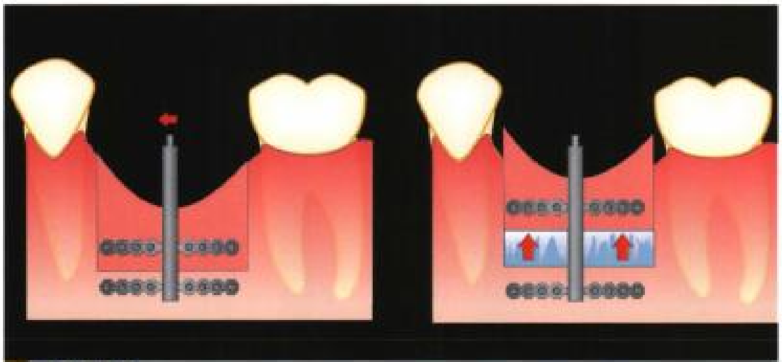

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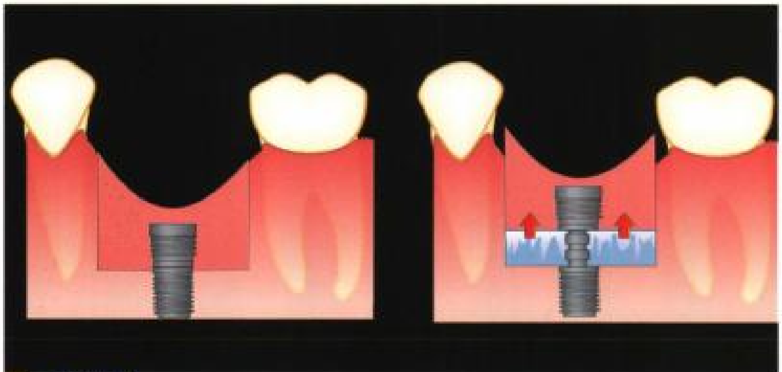

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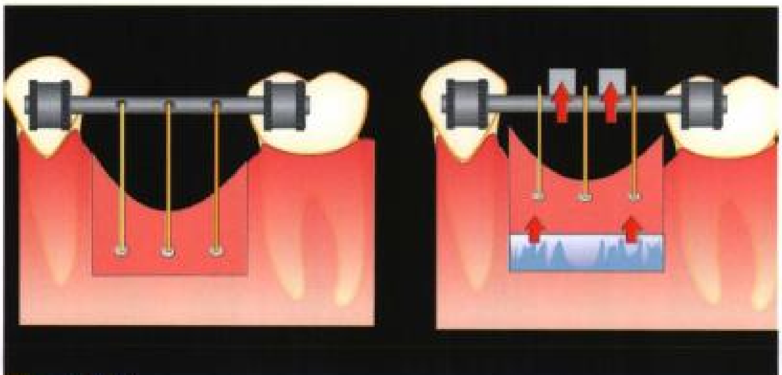

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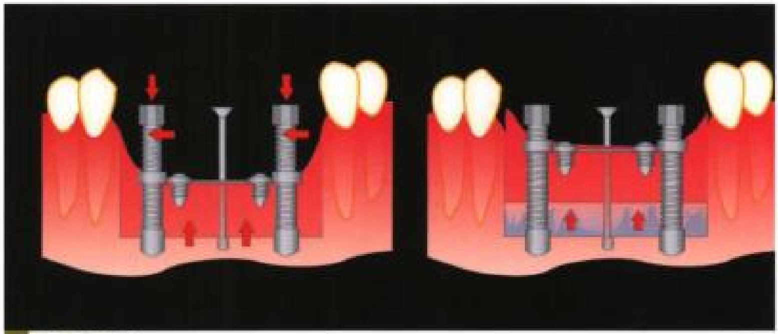

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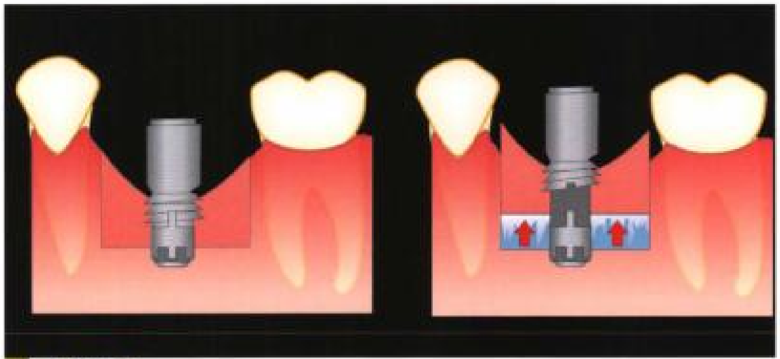

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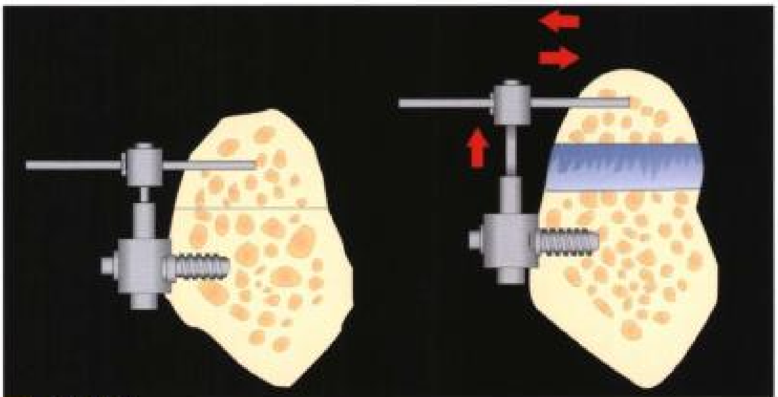

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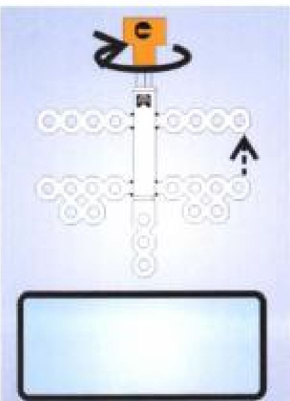

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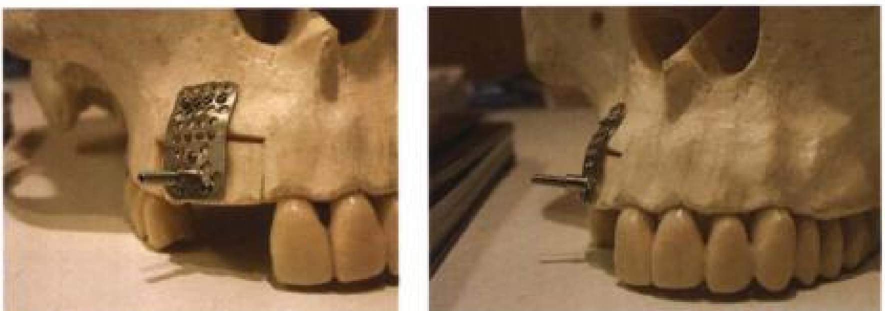

9.15.10

Fig. 9.15.6 – GDD Distractor (Groningen Distraction Device, Martin, Tuttlingen, Germany).

Fig. 9.15.7 – CAD Distractor (Compact Alveolar Distractor, Plan 1 Health, Udine, Italy).

Fig. 9.15.8 – Bidirecional Distrator (Bidirectional Crest Distractor, Surgitec, NV, Bruges, Belgium).

Fig. 9.15.9 – Distrator Alveolar Conexão tipo TRACK (Conexao, Sao Paulo, Brazil).

Fig. 9.15.10 – Wider Alveolar Distrator (Horizontal Alveolar Ridge Distraction Device – Okada Medical Supply Co., Tokyo, Japan).

cedures. It is fundamental to patients understand that the post-operative instructions are as important as the surgical protocol per se, because many patients may not return to the dental office for follow ups and monitoring, may have a compromised oral hygiene, or not activate the distraction device according to the needed timelines, increasing the likelihood of abscesses and celulitis. Infections can be prevented with the use of antibiotics and the oral hygiene measures must be reinforced during the treatment phase.

Intra-operative complications

Fracture of the distraction segment

First, this occurs due to an inadequate size of the distraction segment, and second, during the displacement of osseous segment with chisels or inappropriate instruments.

As a consequence, part of the cortical bone is lost, and the bone formation in the affected area will be compromised.[92]

These complications can be avoided by an adequate design of the distraction segment, and complete osteotomy at the lingual or palatal cortical plate. The segment must be free without tilting movements. Care must be taken to not lacerate the periosteum at the lingual side, which in turn compromises the blood supply of the transportation segment.

Once the distraction segment has fractured, consolidation of the fragment is allowed and a new procedure with mini-plates and screws must be performed according to Guerrero et al.[93]

Lingual osteotomy

Difficulties in completion of lingual osteotomy were verified by Garcia et al.[92] in 100% cases, also cited by Uckan et al.[94] The use of thin chisels like cement spatulas, inserted on the buccal side and passing through the lingual side (always verified with the tip of the fingers and without damage to the periosteum, lingual mucosa and floor of the mouth) is a good alternative for displacement of the lingual side of the bone block.

Damage to the inferior alveolar nerve

A thorough knowledge of the anatomy of the mandibular bone is fundamental because sometimes the horizontal osteotomy is placed near the roof of the mandibular canal (Fig. 9.16).

In addition to the localization of the mental foramen, the use of complementary exams such as radiographs and tomography is essential for precise nerve localization, avoiding serious complications to the nerve structures.

COMPLICATIONS DURING ALVEOLAR DISTRACTION TREATMENT

Incorrect distraction vector

This is due to interferences in the osteotomies or to the musculature

9.16

Fig. 9.16 – Intraoperative clinical view showing that the osteotomy is very close to the mental nerve foramen. Care must be taken to mobilize and protect the nerve without trauma.

that deviate the planned distraction vectors (Fig. 9.17 and 9.18). A deviation to the lingual side is common, and more bone is formed at this area. Thus, the distraction device must be corrected.[94] Recently, Hoffmeister and co-authors[95] described the concept of floating bone, when studying the management possibilities of the immature bone callus to set up the distraction vector.

Soares et al.[96] pointed out the need to manage multiple vectors to obtain an adequate distraction vector.

The vertical osteotomies must be divergent, so that when the distractor is activated, no interferences are seen on the lateral bone walls.[97] Today, some devices permit correction of bucco-lingual inclination (MODUS and others).

The improvement and development of new alveolar distractors emphasizes the three-dimensional control of bone formation.

Device fracture

The plate that contains the fixation orifices is soldered to the activation screw. The distractor must have its plate perfectly adapted to the bone segments. The adaptation is provided with an appropriate instrument (Fig. 9.19). Part of the plate that was not in use must be removed with a precision cut pliers and sharp edges rounded. When an intense movement is performed, the soldered area can be fractured.

In regions with more than 30mm in width, two distraction devices must be installed to avoid overloading at the activation screw and its fracture, as well as for better control of the distraction vector (Fig. 9.20).

During the course of the distraction process, if the distraction segment becomes locked, or there is incomplete or incorrect osteotomy, any attempt of activation will fracture the screw.

Mucosal perforation caused by distracted segment

This occurs when some sharp edges or bone spikes are seen in the distracted segment. Surgical burs and bone files can be used to treat the defects.[92]

In small soft tissue exposures, a conservative treatment is sufficient to mucosal recovering. The bone is flattened under abundant irrigation with a rotary instrument.


9.17A

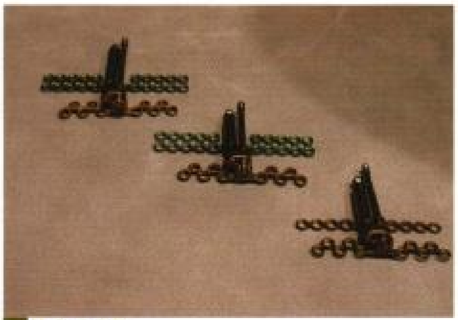
9.17B

Fig. 9.17A-B – The MODUS Bi-directional Distractor (MEDARTS-AG, Swiss) can correct vector's angulation.


9.18

Fig. 9.18 – Incorrect inclination of the transport disk.

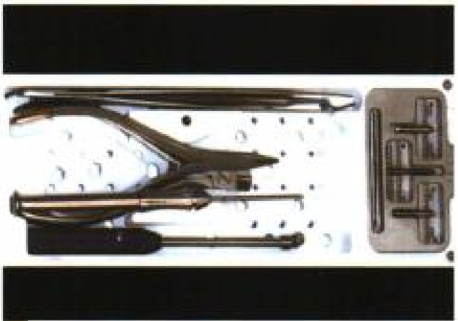
9.19

Fig. 9.19 – Metallic tray for the adaptation and installation of the distraction devices. The box must contain: one precision cut plier, 2 pliers to curve the distractor plates, and the activation key.

Ankylosis of the osteotomized segment

This complication occurs when the patient does not control the activation periods, resulting in early consolidation of the transportation segment.

Suture dehiscence

After suture removal, the osteotomized segment or the distractor can be exposed if the surgical principles were not followed correctly. Often, the distraction process is not interrupted and tissue healing by secondary intention will completely cover the exposed region (Fig. 9.21).

COMPLICATIONS DURING CONSOLIDATION PERIOD

Presence of secondary osseous defects

In some circumstances, some fenestration areas or even bone sequestration is seen, and the correction of

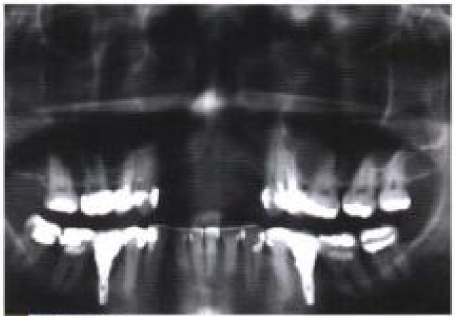
9.20.1


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Fig. 9.20.1 – Panoramic radiograph showing a curved bone defect in the anterior maxillary region.

Fig. 9.20.2 – Clinical view showing the edentulous anterior rigde. Observe alveolar deficiencies in height and width.

Fig. 9.20.3 – A bone graft from the mandibular ramus is fixed to the atrophic ridge prior to the osteotomies and installation of the distraction device. For vertical augumentation.

Fig. 9.20.4 – Frontal view. The graft was incorporated to the transport disk. Two devices were installed for better controlling of the distraction vectors.

Fig. 9.20.5 – Frontal view of the distractors during the consolidation period. The defect was completely resolved.

Fig. 9.20.6 – Radiograph aspect after the consolidation period showing mineralization of the distracted segment.

Fig. 9.20.7 – Occlusal view showing bone thickness augmentation after bone graft and simultaneous distraction.

Fig. 9.20.8 – Surgical aspect after the distractors been removed. Observe the vertical gain and that the graft was incorporated to the distracted segment.

Fig. 9.20.9 – Four implants installed in the anterior regenerated region.

Fig. 9.20.10 – Frontal view after osseointegration and before the second stage surgery.

Fig. 9.20.11 – Occlusal view after healing abutment connection and sutures.

Fig. 9.20.12 – Occlusal view after prosthesis delivery. The maxillary anterior arch perimeter was restored. Also, there is adequate proportion among the incisor teeth.

Fig. 9.20.13 – Patient smile showing adequate proportion of prosthetic crowns, which is in harmony with the rest of maxillary arch.

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9.20.13

Fig. 9.21.1 - 9.21.2 – Suture dehiscence with exposure of the distractor plate and healing by second intention.

9.21.1

9.21.2

these small defects is made by regenerative procedures.

Also, these residual defects are seen in non compliant patients, during incorrect activation, or for prolonged retention of the distraction device.

As already mentioned, a high activation rate or rapid distraction will lead to unsatisfactory results with fibrous union formation.

Also, implant installation soon after distractor removal is complicated. (no original, este parágrafo está sem ligação com o parágrafo anterior; consultar o autor)

Bone distractors

According to Soares et al.[98] and Guerra[99], there is a clear advantage when the distraction osteogenesis is performed for the vertical growth of the atrophic alveolar ridge, compared to the maxillary autogenous bone grafts. One of the possible disadvantages is in the flap design for device removal and immediate implant placement.

Generally, a considerable soft tissue flap is needed to remove the distractor, and sometimes a vertical incision must be placed in the activation screw, at the midportion of the flap. One way to minimize this problem is the use of resorbable screws to secure the plates, as described by Soares et al.[100] and Marinho et al.[101]. According to these authors, the resorbable screws not only prevents the use of releasing incisions to access the distractor, but also reduces the time for its removal.

Maxillary alveolar transportation for reconstruction of alveolar clefts

In the treatment of patients with alveolar fissure, the transportation segment is moved into the defect and through the soft tissues creating new alveolar bone and mucosal tissue away from the fissure, while the defect is reduced with local bone and attached gingiva.

The alveolar transportation is a treatment alternative for tissue scarring, wide alveolar fissures and unsuccessful surgical attempts (Fig. 9.22). Surgery can be performed under local anesthesia and intravenous sedation; the oronasal fistula is eliminated, as well as the need for large bone graft from extra-oral donor areas. Also, the surgery provides a stable segment for orthodontics and prosthetic finalization.

VANTAGES AND DISADVANTAGES OF ALVEOLAR DISTRACTION

Vantages

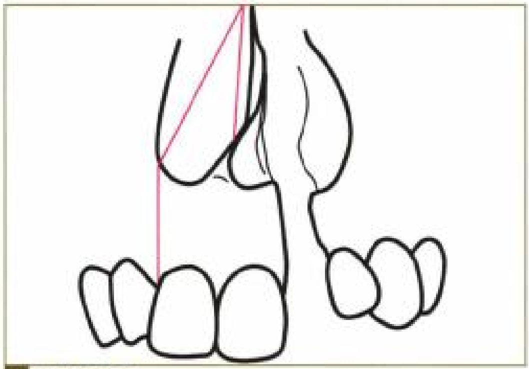
- technical simplicity;
- in situ bone formation x bone graft;
- recurrence is minimized;
- secondary bone loss is diminished;
- less surgical time;
- less blood loss and morbidity associated to the grafting procedures;
- favorable short-term surgical results.

Disadvantages

- device discomfort (size and volume);
- extra-care with activation screw and pins;
- patient's compliance to treatment;
- total treatment time is increased;
- the distractors are technique-sensitivity;
- surgical procedure to remove the distractors;
- control of distraction vector is limited.

Fig. 9.22.1 – Schematic drawing of the unilateral alveolar fissure.

Fig. 9.22.2 – The transport disk is displaced toward the alveolar fissure. The central and lateral incisors are incorporated to the into the transport disk.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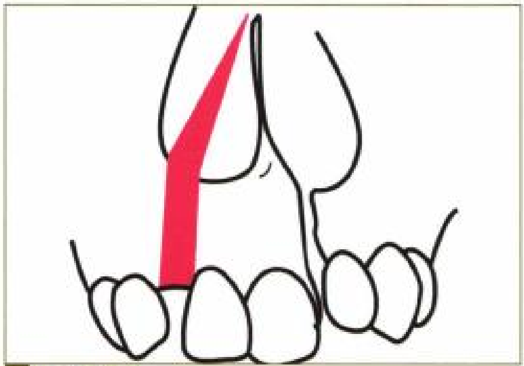
9.22.2

Abstract

The alveolar distraction osteogenesis is the lengthening of bone fragments through osteotomy, in a slow and controlled procedure. Adherence to specific surgical protocols warrants ossification;

the distraction process is divided into: osteotomy and distractor installation, latency, transportation, consolidation and remodeling.

The soft tissues follow bone growth and remodeling.

Vitality and lamellar bone orientation in the distraction osteogenesis is superior to that of bone grafts.

Future trends: constant distraction, stimulus for consolidation, tissue engineering.

Conclusion

The alveolar distraction osteogenesis is clinical alternative for the reconstruction of the atrophic alveolar ridge. The technique is characterized by the lack of morbidity at the donor area and unlimited volume increase, along with simultaneous lengthening of the adjacent soft tissues.

Long-term results of this technique are not known. Clearly, the distraction process can generate bone with enough plasticity and remodeling properties to withstand applied loads.

The potential of distraction osteogenesis for substituting traditional treatment protocols resides on the development of technological innovations that will allow for implantable and multidirectional devices, installed with minimal incisions, with self-activation and control properties.

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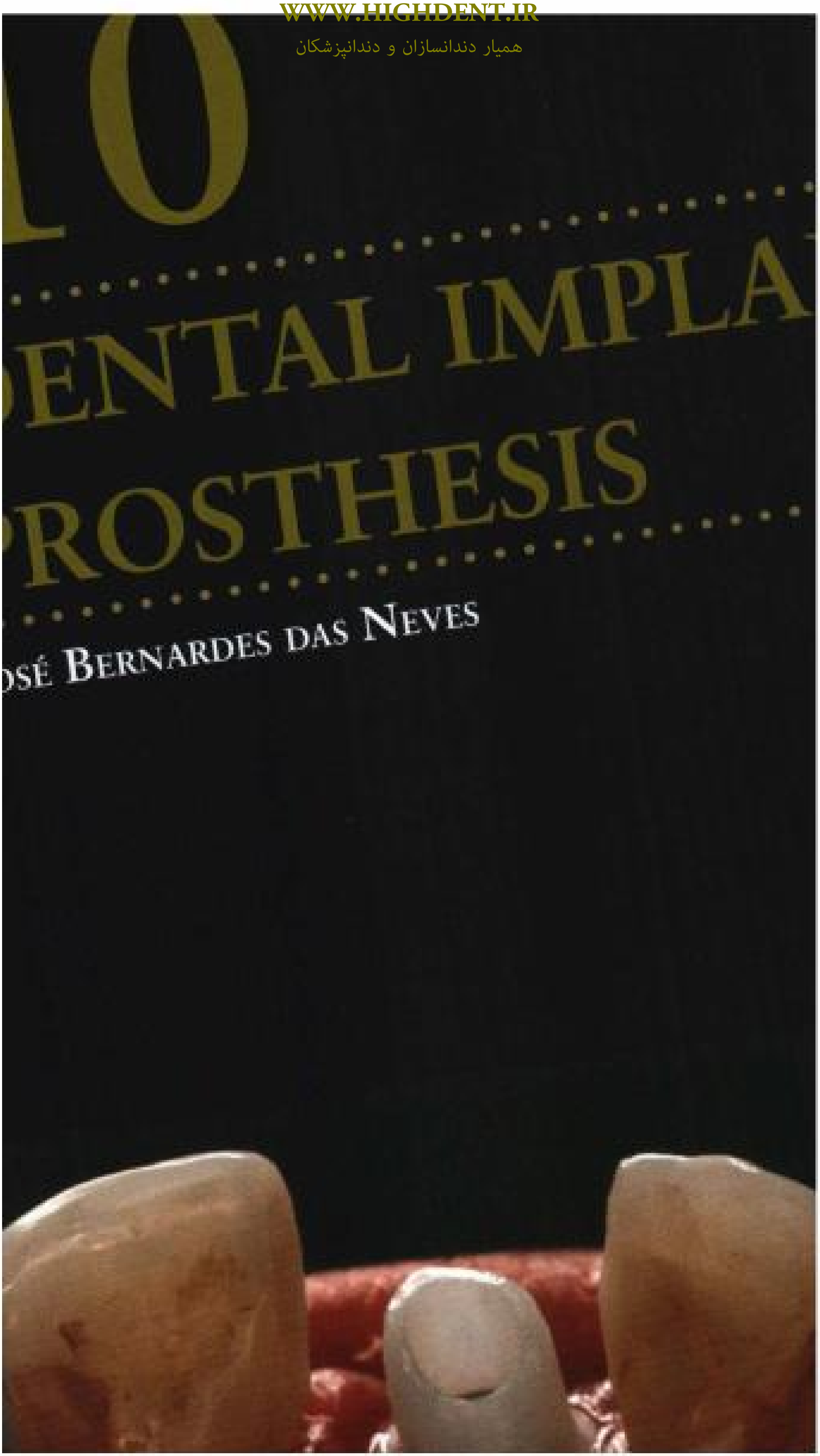
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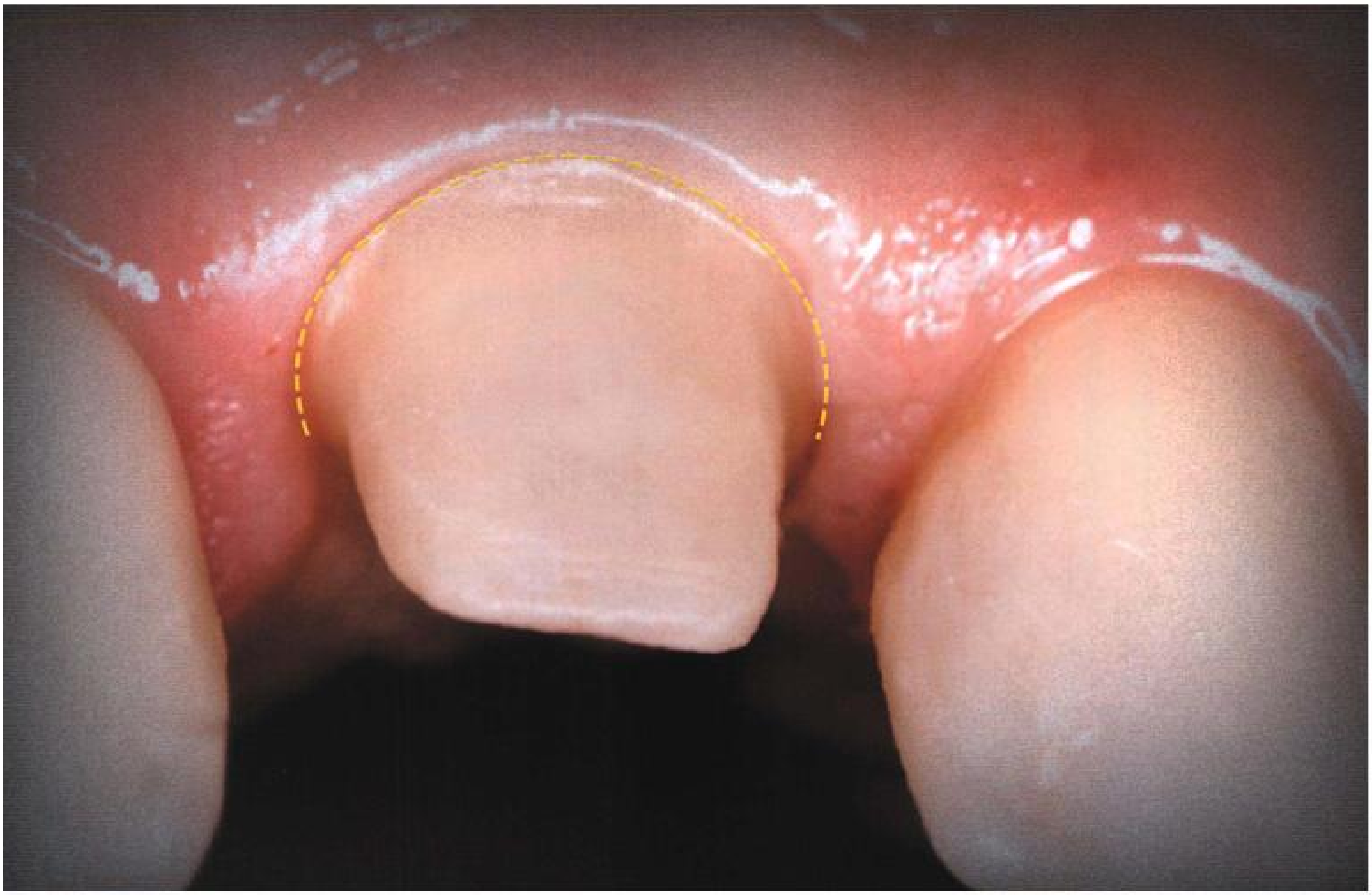
DENTAL IMPLA
PROSTHESIS
OSÉ BERNARDES DAS NEVES



Dental Implant Prosthesis

PATIENT EXPECTATIONS

Long-term esthetics and function with high predictability.

- preservation of dental structure;
- maximum comfort;
- less risk during surgery and healing periods;
- avoidance of removable prosthesis;
- facilitated oral hygiene;
- preservation of bone structure;
- less chair time;
- better cost/benefit ratios;

In the last decade, the esthetic aspect has had a tremendous impact in dentistry. Several advances in dental materials and treatment planning provide less invasive procedures, as well as higher long-term predictability. Today, conventional fixed prosthesis techniques and materials allow for crowns in esthetic areas to be almost imperceptible, with the same results observed in the implant-supported prostheses. In addition, available technology can create metal-free crowns, such as porcelain veneering on a CerAdapt abutment. In the words of Prof. Peter Scharer, "the newer ceramic systems provide a more natural looking appearance".

Prosthesis

In the prosthodontic field, tooth loss can be treated in several ways: single crowns, fixed partial dentures, resin-bonded retainers, removable partial dentures, complete dentures, overdenture, and implant prosthesis. Also, tooth loss can be resolved by orthodontic treatment (space closing).

All above aspects have specific indications, advantages, and disadvantages. In certain occasions, it is difficult to choose the appropriate modality. For this, other parameters must be considered, such as patient's expectations, systemic conditions and socio-economic conditions.

The implant must be the first option for the replacement of tooth loss, and the patient must present the following characteristics: normal healing capacity, non-restored adjacent teeth, unfavorable pontic design, large edentulous spaces, loss of strategic pontic, preserved bone structure between teeth with diastema.

The success o implantology is characterized by long-term esthetics and performance. Implant surgeries on key positions are made with reconstructive procedures for the hard and soft tissues. However, desired results are not always achievable. For this, prosthetic restorations with pink porcelain to masquerade the gingival tissue can be a good, non-surgical option, providing lip support, symmetry of gingival architecture and restoration of lost papillae. Also, the esthetic outcomes can superpose the patient's expectations.

Small pink porcelain increments (interproximal papilla) do not need modifications on the infra-structure. However, innovative designs must be provided for patients with extensive soft and hard tissues deficiencies, with the use of a metallic structure at least 1.5mm-thick to support pink porcelain.

Complete dental and gingival contours are necessary in large restorations. The metallic framework is tried-in for lip supporting, interarch relationship, phonetics, easy of maintenance, and the gingival hue provided by the technician. A silicon mold is made after teeth or the diagnostic set-up to register the dental positions. These data are transferred to the definitive prosthesis.

Generally, implant-fixed prostheses are not indicated when edentulous patients in the maxillary arch present the following characteristics:

- lip support can be reestablished without appropriate buccal support;
- limited access for oral hygiene procedures;
- phonetic impairment due air passage through the prosthesis;
- esthetic compromise when the implants are not placed in the natural tooth positions;

In these situations, overdentures are well-indicated.[1,2]

When two or more adjacent teeth are lost in the anterior maxillary region, soft tissue conditioning can be obtained through a provisional prosthesis supported by several implants, but only with the alveolar crest and the emergence implant profile found at the same level. To create local conditions that match the fixed prosthesis design, lateral and vertical bone and soft tissue augmentation is fundamental.

In cases of extreme alveolar resorption, with concomitant vertical and horizontal loss, it is almost impossible to restore the natural dentition with a conventional implant-fixed prosthesis. Pre-operative evaluation of the patient smile will determine the boundaries between soft tissue and the cervical aspect of implant crowns. For this, when the implants are placed in the anterior maxillary region, the use of a surgical guide is mandatory. In this way, adequate implant-supported restorations will provide harmonious integration between adjacent teeth and the patient smile.

Pre-prosthetic evaluation of edentulous spaces

- mesio-distal dimension of the edentulous space, including comparisons with the analog tooth;

- three-dimensional analysis of the edentulous space related to soft tissue configuration and the osseous crest architecture;
- adjacent teeth: volume and three-dimensional position, the amount of surrounding soft tissue, periodontal and endodontic conditions, crown-to-root ratio, root length and inclination in the frontal plane, diastema;
- Maxillomandibular relationships; vertical dimension of occlusion, anterior guidance and the interocclusal height;
- esthetic parameters: the height of lip line, occlusal plane orientation, dental versus facial symmetry, lip support, intact papillae, adequate thickness and quality of the keratinized mucosa, as well as harmony and symmetry in the gingival tissue (Box 10.1).[3]

Fundamental criteria for esthetics in implantology

- smile symmetry;
- tooth size, shape and texture;

Box 10.1

Dentolabial analysis Prosthetic considerations for an esthetic rehabilitation		
Tooth display at rest		Reestablish 1 to 5mm of tooth displaying according to patient age and gender
Incisal border	Incisal curvature Incisal profile	Reestablish convex incisal curvature, parallel to the lower lip. Incisal profile at the level of the vermilion border
Smile line	High Low	When possible, idealize a gingival curvature (surgery, orthodontics). Avoidance of multidisciplinary complex treatment at the gingival levels. When possible, create supragingival margins
Smile length		Evaluate tooth display. Select the most appropriate materials and techniques to optimize esthetics in the vestibular region.
Buccal corridor		Create adequate buccal contours. Reestablish correct inclination of posterior teeth. Idealize progressive smiles.
Interincisal line x median line		Reestablish the verticality of incisal line. Do not consider any discrepancy with the median line
Occlusal plane x commissural line		Reestablish the parallelism between the occlusal plane and the comissure, interpupilar, and horizontal lines.

Adapted from Fradeani[6], p.111.

- arch form;
- tooth color;
- the length of the central incisors;
- golden proportion;
- inclination and position of the median line;
- axial alignment of the remaining teeth;
- relationship between incisal margins and lip line;
- graduation of the buccal corridor;
- height of the contact points;
- gingival height and contour;
- gingival zenith;
- incisal edge configuration;
- basic characteristics of tooth form;
- occlusal and incisal plane (Box 10.2).

Essential requirements for esthetic optimization in implantology

Esthetic restorations must have adequate bone support, as well as appropriate soft tissue quantity and quality.

- adequate horizontal and vertical bone volume;

Box 10.2

Dental analysis Upper teeth		
Type	Identify tooth type according to:	Adjacent teeth Old photos and/or study casts Gingival architecture
Color	Choose tooth color according to: Adjacent teeth, age, and patient desire. Chromatic changes must be allowed from central incisor to canine teeth. Perception of illusion: variations on hue, chroma, valor, translucence/opacity and surface characterizations, to create the illusion of modified surfaces	
Texture	Macro and microtextures	Adjacent teeth Age Gender
Shape and contour	Restore shape and contour according to morphologic individual tooth characterization. Perception of illusion: transition line angles, contour, ridges, horizontal and vertical lines	
Dimension	Similar to that found in natural teeth	Width : 8.3 to 9.3mm Length: 10.4 to 11.2mm
Proportion	Restore natural dimensions especially for the central incisor teeth	Width-length ratio: 75 to 80%
Incisal border	Reestablish correct bucco-lingual inclination of incisal border	Internal border of the restoration in a more apically position
Incisal profile	Recreate correct incisal profile	The incisal profile must be found behind the vermilion border of the lower lip.

Adapted from Fradeani[25], p.180.

- well positioned implants (mesio-distal, apico-coronal and bucco-lingual dimensions);
- healthy and stable periimplant soft tissues;
- Soft tissue contour.

Fundamental criteria in dental implant prosthesis

- normal healing capacity;
- intact adjacent tooth;
- unfavorable dental abutments;
- large edentulous segments;
- absence of strategic dental abutments;
- presence of diastema.[9]

Causes of tooth loss

- tooth extraction due to carious lesion;
- root fractures;
- dental avulsion due to accidents;
- root resorption over time due to tooth reimplantation;
- partial anodontia (uni, bilateral, or total);
- periodontal disease.

PROSTHETIC OPTIONS FOR EDENTULOUS PATIENTS

Single-tooth edentulous patients

Tooth loss can generate esthetic complications (mainly in the anterior region), functional impairment, risk of eruption/migration of adjacent or opposing teeth, and finally, caries and periodontal disease.[5]

Removable partial dentures

Advantages: low cost, patient is familiarized with treatment;

Disadvantages: removable appliance, risk of caries and periodontal disease, some patients cannot cope with, need for tooth preparation (rest seats and guide planes), prosthesis extension, masticatory and phonetic impairments.

Contra-indications: patients that do not tolerate removable prosthesis.

Fixed partial denture

Advantages: predictability, patient is familiarized, fixed appliance.

Disadvantages: risk of caries, periodontal and/or endodontic problems, cement dissolution in the oral cavity, fractures, esthetic problems, preparation of adjacent/opposing teeth, post-operative sensitivity.

Contra-indications: long edentulous span, inadequate abutments.

Resin-bonded fixed prosthesis

Advantages: less preparation in the adjacent teeth, fixed appliance, less chair time, and low cost rates.

Disadvantages: risk of prosthesis dislodgment, postoperative sensitivity in the abutment teeth, fractures, longevity, compromised esthetics (metal framework), likelihood of soft tissue overgrowth in the pontic area.

Contra-indications: high occlusal demand and considerable vertical trespass (overbite).

Single-tooth implant fixed prosthesis

Advantages: no tooth preparation, good access for proximal contacts, no risk of caries, good bone healing and stability.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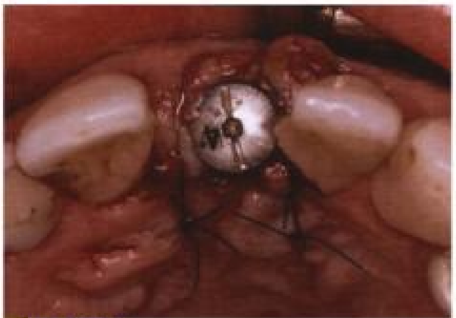
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Patient MMLF, 55 years-old, female. Root fracture at tooth 21. The patient was scheduled for implant surgery.

Fig. 10.1.1 – Clinical aspect of root fracture with periapical abcess.

Fig. 10.1.2 – the tooth 21 was extracted. Observe the root fracture.

Fig. 10.1.3 – Two months after extraction. Hard and soft tissue loss is seen.

Fig. 10.1.4 – wide-diameter, treated surface implant with PRP gel and particulate autogenous bone.

Fig. 10.1.5 – Second surgical stage. The flap was rotated from palatal to buccal for soft tissue augmentation.

Fig. 10.1.6 – Fifteen days after healing abutment connection.

Fig. 10.1.7 – One month after soft tissue conditioning with the provisional prosthesis in place. The soft tissue has matured; the mesial aspect still needs more tissue.

Fig. 10.1.8 – Five months after soft tissue conditioning. Observe excellent periimplant tissue contour obtained with consecutive provisional crown relining.

Fig. 10.1.9 – Transfer impression procedure. Observe customization of the transfer component.

Fig. 10.1.10 – Pick-up impression.

Fig. 10.1.11 – Working cast with the alumina oxide abutment (ZiReal).

Fig. 10.1.12 – Diamond burs to prepare the abutment.

Fig. 10.1.13 – The ZiReal abutment has an intern metallic structure to reinforce de alumina oxide.

Fig. 10.1.14 – The abument shoulder is 4mm in height.

Fig. 10.1.15 – Abutment customization.

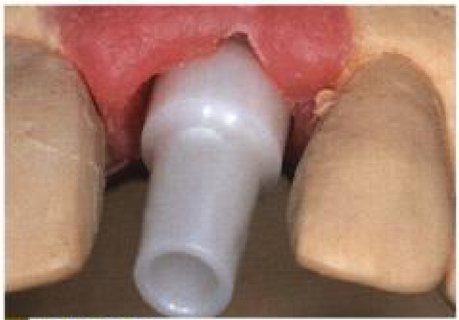
Fig. 10.1.16 – The abutment esthetic margin is delimited in the working cast.

Fig. 10.1.17 – The abutment is prepared under high-speed rotation and abundant irrigation.

Fig. 10.1.18 – The prepared abutment.

Fig. 10.1.19 – Abutment try-in.

Fig. 1.10.20 – clinical palatal view.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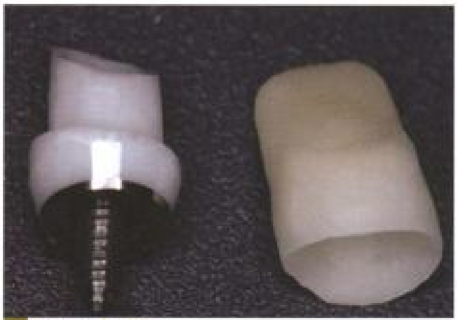
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Fig. 1.10.21 – The ZiReal abutment and the CAD/CAM Procera coping.

Fig. 10.1.22 – Final periimplant soft tissue contour.

Fig. 10.1.23 – the Procera coping is tried in the mouth.

Fig. 1.10.24 – Three months after crown cementation. Periimplant papillae are still under development.

Fig. 10.1.25 – Incisal view. Implant crown anatomy is very similar to the adjacent teeth.

Fig. 10.1.26 – Frontal view 3 months after cementation. Buccal and lingual papillary contours under maturation.

Fig. 10.1.27 – Clinical final aspect. Patient's smile line.

Fig. 10.1.28 – Clinical view three years later. Observe soft tissue maturation.

Fig. 10.1.29. Periapical radiograph three years later.

Fig. 10.1.30. Clinical view 5 years later. Observe soft tissue stability and esthetic requirements.

Disadvantages: limited clinical results, risk of implant failure, fracture and loss of retention, papillae cannot be completely regenerated, metal showing through the soft tissue cervical region, more treatment time, two surgical phases, risk of screw loosening and fracture.

Contra-indications: compromised systemic health before surgical procedures (Fig. 10.1).

Orthodontic Procedures: space closing with orthodontic movements

Partially edentulous patients

Removable partial dentures

Advantages: low cost, patient is familiarized with, tooth/edentulous area are restored, prevents eruption of opposing/occluding teeth.

Disadvantages: prosthesis extension, risk of caries and periodontal problems, impaired phonetics, taste alteration; unpleasant sensations brought by the major connectors, difficult to address esthetic problems, soft tissue irritation, accommodation period.

Contra-indications: patients that do not tolerate removable prosthesis.

Fixed partial dentures

Advantages: fixed appliance, patient is familiarized with treatment, longevity, psychological issues (similar to natural dentition), less dentobacterial plaque accumulation (Fig. 10.2).[7]

Disadvantages: risk of caries, periodontal and endodontic problems, fracture of restoration, cement dissolution, preparation of the adjacent teeth.

Contra-indications: inadequate abutments, long edentulous spans to be restored (Figs.10.3 to 10.5).

Patient NMA, 52 years-old, female. This patient has functional and esthetic problems, being scheduled for implant placement at the right posterior upper region.

Fig. 10.2.1 – Periapical radiograph. Observe great bone loss at teeth 15 and 17, as well as pneumatization of the maxillary sinus.

Fig. 10.2.2 – Three months after extraction of teeth 15 and 17.

Fig. 10.2.3 – Periapical radiograph three months after extraction. Observe maxillary sinus condition.

Fig. 10.2.4 – Incison placed for maxillary sinus augmentation. Observe the lack of buccal vestibule and keratinized mucosa.


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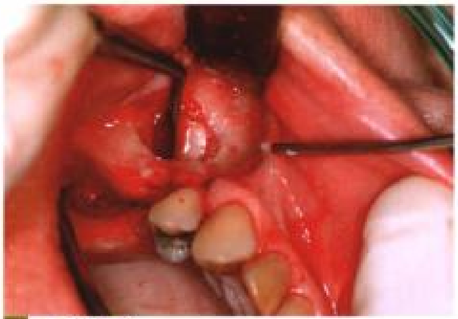
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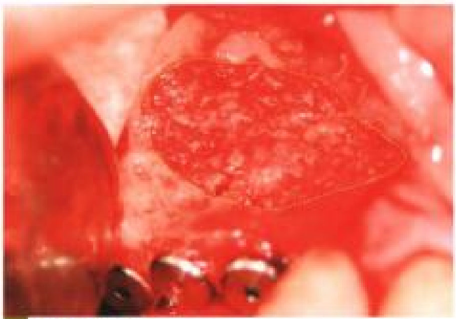
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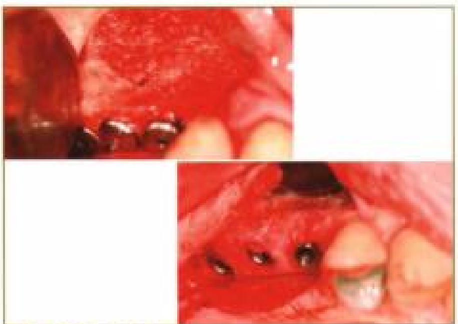
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10.2.14

Fig. 10.2.5 – The flap is elevated for sinus augmentation.

Fig. 10.2.6 – The floor of the maxillary sinus is elevated.

Fig. 10.2.7 – Implants placed at regions of 15, 16 and 17 concomitantly to sinus augmentation.

Fig. 10.2.8 – Observe sinus bone filling with autogenous graft material.

Fig. 10.2.9 – Sutures.

Fig. 10.2.10 – Six months after the second surgical stage. There is a shallow buccal vestibule.

Fig. 10.2.11 – Radiograph six months later. Observe bone healing.

Fig. 10.2.12 – Implant uncovering 6 months later. Observe complete regeneration of the maxillary sinus wall.

Fig. 10.2.13 – Before and after maxillary sinus augmentation.

Fig. 10.2.14 – The flap was rotated from palatal to buccal aspect for keratinized tissue augmentation and buccal fornix enlargement.

Fig. 10.2.15 – suture.

Fig. 10.2.16 – Postoperative view one month later.

Fig. 10.2.17 – Three months after soft tissue maturation. Observe the buccal vestibule and papillae.

Fig. 10.2.18 – Impression transfer procedure.

Fig. 10.2.19 – Gold metallic infra-structure.

Fig. 10.2.20 – Metalloceramic fixed prosthesis.

Fig. 10.2.21 – The prosthesis will be screwed to the implants.

Fig. 10.2.22 – Metalloceramic prosthesis in the working model.

Fig. 10.2.23 – Palatal view of the prosthesis.

Fig. 10.2.24 – Prosthesis delivery.


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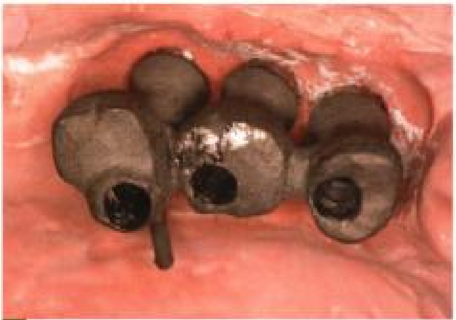
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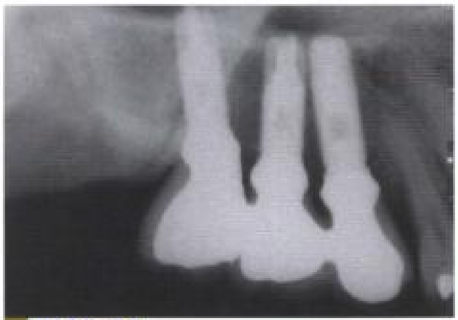
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Fig. 10.2.25 – Final radiograph. Excellent fit at implant-abutment interface.

Fig. 10.2.26 – Frontal view. Observe excellent esthetics and the buccal corridor.

Fig. 10.2.27 – Clinical view three years later. Observe excellent soft tissue and buccal vestibule quality.

Fig. 10.2.28 – Clinical control 4 years later.


10.3.1


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Patient ASR, 52 years-old, female. Clinical aspect.

Fig. 10.3.1 – Fistula at teeth 12 and 23; also, poor esthetics and prosthetic crowns.

Fig. 10.3.2 – Periapical radiographs. Observe iatrogenic process.

Fig. 10.3.3 – After guided soft tissue regeneration, four implants are placed. There is excellent soft tissue in the area.

Fig. 10.3.4 – Impression with implant replicas and artificial gingiva.

Fig. 10.3.5 – Working cast.

Fig. 10.3.6 – UCLA abutments cast in PT-Pd alloy. Observe implant positioning.

Fig. 10.3.7 – Diagnostic wax-up with artificial gingival tissue.

Fig. 10.3.8 – Palatal view of the tooth wax-up.

Fig. 10.3.9 – Wax-up try-in.

Fig. 10.3.10 – Occlusal adjustment.

Fig. 10.3.11 – Metalloceramic fixed prosthesis after glazing. The pink porcelain is added for a more natural looking.

Fig. 10.3.12 – Prosthesis palatal view.

Fig. 10.3.13 – The prosthesis was installed.

Fig. 10.3.14 – Palatal view. Observe access for hygiene procedures.

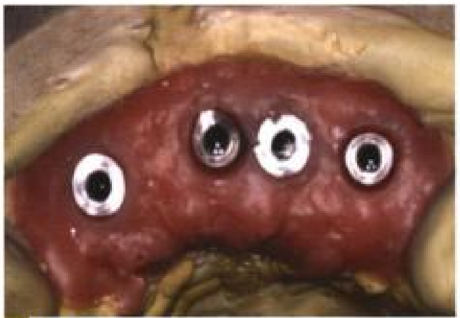

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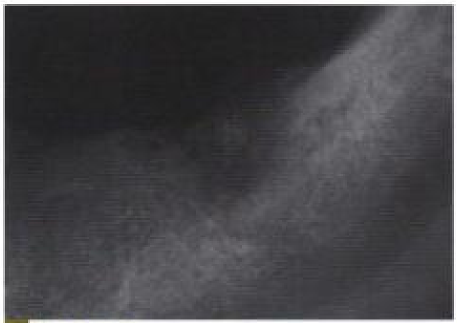
Fig. 10.3.15 – Final aspect. Patient has a low smile line. Transition between cervical contour and alveolar mucosa is not visible. The patient is very satisfied with her treatment.

10.4.1



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Patient EOS, 50 years-old, female. Tooth 37 is fractured and has a poor prognosis.

Fig. 10.4.1 – Periapical radiograph. Observe coronal fracture and periapical lesion at tooth 37.

Fig. 10.4.2 – Tissue healing three months after extraction.

Fig. 10.4.3 – Teeth 34 and 35 have giroversion and compromise the esthetic aspect. A gingival tissue graft was performed four months ago.

Fig. 10.4.4 – Implant placement at regions 36 and 37.

Fig. 10.4.5 – Five months after implant cicatrization. Observe transmucosal components.

Fig. 10.4.6 – Impression transfer at 36 and 37. Metalloceramic crown preparations at teeth 34 and 35.

Fig. 10.4.7 – Working cast.

Fig. 10.4.8 – Infra-structure carving at teeth 34 and 35. Observe the papillary tissue.

Fig. 10.4.9 – Gold infra-structure try-in.

Fig. 10.4.10 – Periapical radiograph showing excellent implant-abutment fit.

Fig. 10.4.11 – Before and after prosthetic treatment.

Fig. 10.4.12 – Clinical view three months later.

Fig. 10.4.13 – Final clinical aspect.

Fig. 10.4.14 – One year later.

Fig. 10.4.15 – Periapical radiograph after 3 years.

Fig. 10.4.16 – Five years later. Observe soft tissue stability around implants and teeth.

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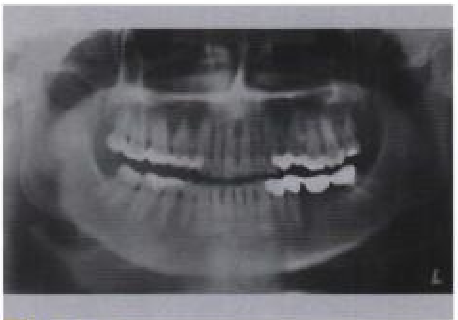
Fig. 10.4.17 – Control after 6 years.

Fig. 10.4.18 – Clinical aspect after 7 years. There is gingival recession in the tooth-supported crowns; the implant sites are stable.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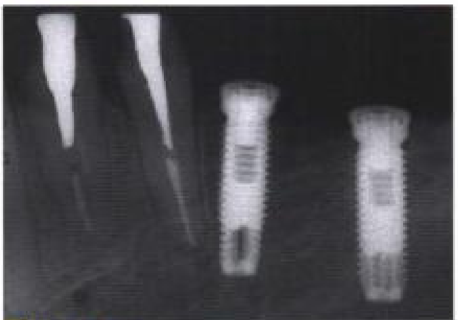
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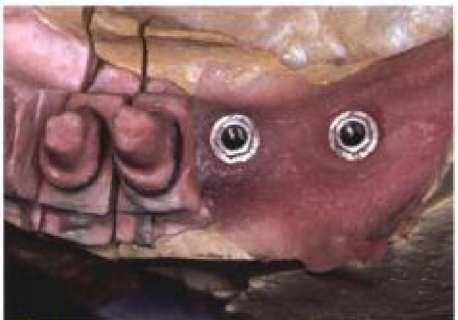
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Patient MSR, 52-years old, female. Her left lower prosthesis was fractured.

Fig. 10.5.1 – Panoramic radiograph.

Fig. 10.5.2 – Periapical radiograph three months after tooth removal.

Fig. 10.5.3 – Two implants placed in the regions of 36 and 37.

Fig. 10.5.4 – Transferring procedure.

Fig. 10.5.5 – Working cast with artificial gingiva at teeth 34 and 35. Two metalloceramic crowns will join the implants.

Fig. 10.5.6 – Prosthesis wax-up.

Fig. 10.5.7 – Infra-structure try-in.

Fig. 10.5.8 – Infra-structures in the mouth.

Fig. 10.5.9 – Periapical radiograph showing prosthesis fit.

Fig. 10.5.10 – Two metalloceramic crowns were placed at teeth 36 and 37.

Fig. 10.5.11 – Porcelain built-in.

Fig. 10.5.12 – Occlusal adjustment.

Fig. 10.5.13 – Occlusal adjustment. Contact points are seen.

Fig. 10.5.14 – Metalloceramic crows already glazed.

Fig. 10.5.15 – Definitive prosthesis.

Fig. 10.5.16. Clinical view 3 years later.


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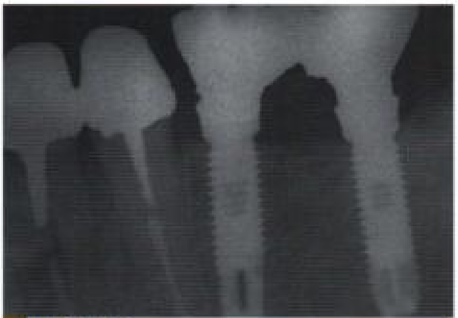
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Fig. 10.5.17 – Clinical view 5 years later.

Fig. 10.5.18 – Clinical view 7 years later.

Implant-supported fixed prosthesis

Advantages: functional improvement, fixed appliance, retrieveability, bone stability, no need for adjacent tooth preparation, no risk of caries.

Disadvantages: risk of screw loss or fracture, implant failure, two surgical stages, increased treatment time, risk of fracture restoration, esthetic changes.

Contra-indications: inadequate osseous structure for implant placement (no possibility for reconstructive techniques), compromised systemic health (Fig. 10.6 to 10.9)


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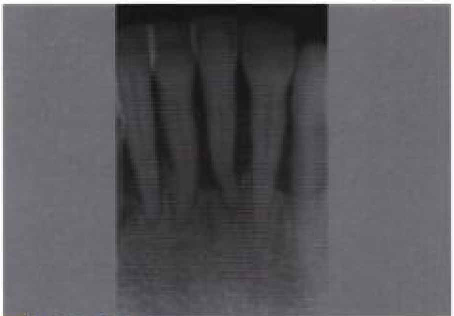
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Patient CS, 66 years-old, female. The patient has advanced periodontal disease in the anterior lower region, being scheduled for tooth extraction and implant placement.

Fig. 10.6.1 – Periapical radiograph. Observe bone loss.

Fig. 10.6.2 – Periapical radiograph of teeth 32 to 42. Observe extensive bone loss.

Fig. 10.6.3 – The four lower incisors were removed and two implants placed.

Fig. 10.6.4 – Working cast.

Fig. 10.6.5 – Healing abutment with plaque accumulation. The patient is not compliant with hygiene procedures.

Fig. 10.6.6 – Diagnostic wax-up.

Fig. 10.6.7 – The infra-structure waxed-up in the working cast.

Fig. 10.6.8 – Cast gold infra-structure.

Fig. 10.6.9 – Observe silicone index and the cast infra-struture.

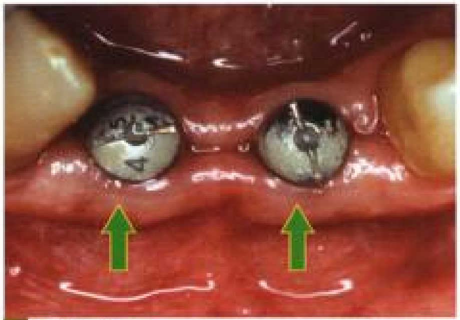
Fig. 10.6.10 – Infra-struture tried in the mouth.

Fig. 10.6.11 – Periapical radiograph showing excellent implant-abutment fit.

Fig. 6.10.12 – Metalloceramic prosthesis is glazed.

Fig. 6.10.13 – Definitive prosthesis in the mouth.

Fig. 6.10.14 – Clinical view 7 years later.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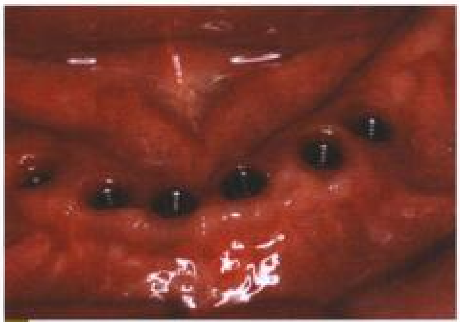

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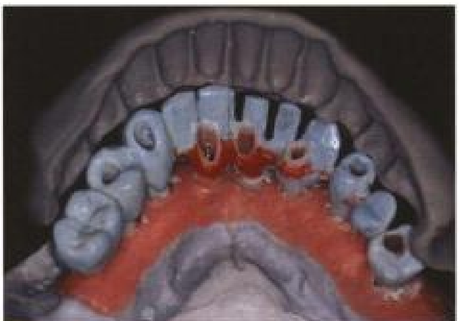

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Patient AS, 60 years-old, male, caucasian. This patient lost all teeth due to advanced periodontal disease; the existing complete dentures cannot provide sufficient chewing and comfort. Also, the patient is not satisfied. Implant placement is indicated.

Fig. 10.7.1 – Seven implants were placed in the mandibular arch.

Fig. 10.7.2 – Impression transfer procedure with implant replica and artificial gengiva.

Fig. 10.7.3 – Prosthetic treatment planning: upper complete removable denture and an implant-supported lower complete denture. Frontal view.

Fig. 10.7.4 – Right lateral view.

Fig. 10.7.5 – Left lateral view.

Fig. 10.7.6 – Wax-up try-in.

Fig. 10.7.7 – Occlusal view of implants 36 to 46.

Fig. 10.7.8 – Wax-up in the working cast. Observe seven implant replicas.

Fig. 10.7.9 – Wax-up. Lingual view. Observe implant inclination and the silicon index.

Fig. 10.7.10 – Observe intaglio view of the silicon index and infra-structure wax-up.

Fig. 10.7.11 – The infra-structure is joined together with pattern acrylic resin.

Fig. 10.7.12 – Pink porcelain added in the working cast.

Fig. 10.7.13 – Observe adequate room for ceramics and the screw access.

Fig. 10.7.14 – Observe prosthetic components and the implants. Here, the pink porcelain was insert.

Fig. 10.7.15 – Prosthesis installed in the mouth.

Fig. 10.7.16 – Lingual prosthetic view. Observe screw access at the occlusal and lingual areas.

Fig. 10.7.17 – Prostheses in the mouth.

Fig. 10.7.18 – Complete removable denture in the upper arch occluding with an implant-supported, metalloceramic fixed prosthesis in the lower arch. Observe characterization of artificial gingival tissue.

Fig. 10.7.19 – Clinical control 3 years later. Observe excellent periodontal health and porcelain quality.

Fig. 10.7.20 – Lingual view of the metalloceramic prosthesis at regions 36 to 46.


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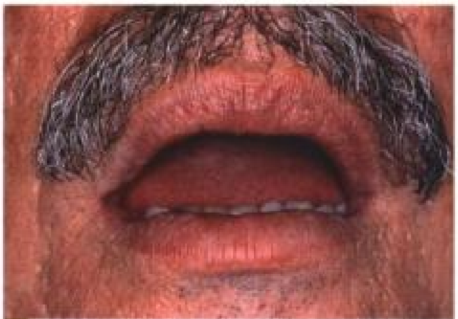
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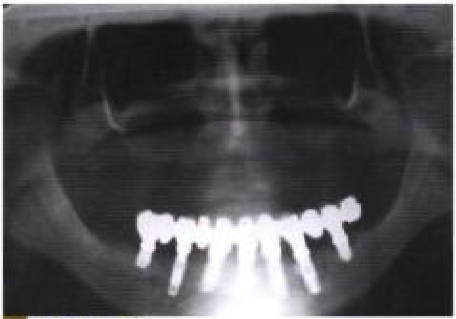
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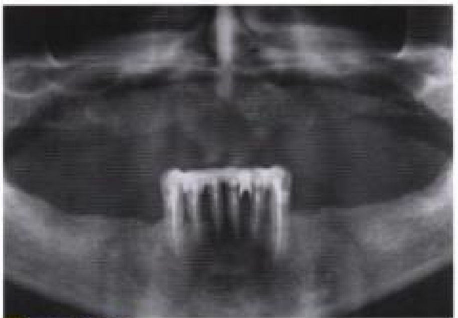
Fig. 10.7.21 – Clinical control 4 years later.

Fig. 10.7.22 – Panoramic radiograph – 4 years later.

Fig. 10.7.23 – Clinical view after 5 years. Observe space for oral hygiene procedures (arrow).


10.7.23


10.8.1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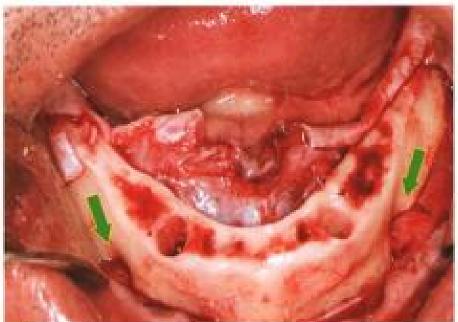
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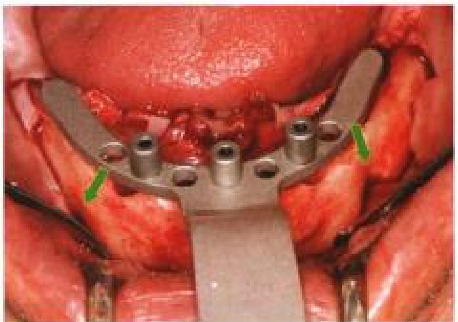
10.8.4

Patient APF, 36 years-old, Caucasian male, smoker.

Fig. 10.8.1 – Clinical aspect of teeth 33 to 43. Observe extensive bone loss and gingival retraction. The treatment planning included tooth extraction and immediate implant placement with 4 inclined implants.

Fig. 10.8.2 – Panoramic radiograph.

Fig. 10.8.3 – After tooth extraction and bone crest flattening. Observe mental nerve foramen.

Fig. 10.8.4 – The implants were not placed according to the pre-fabricated surgical stent.

Fig. 10.8.5 – The two most distal implants were inclined.

Fig. 10.8.6 – Implants and the multunit abutments in position.

Fig. 10.8.7 – Transfer copings in position.

Fig. 10.8.8 – The implants were joined together with pattern acrylic resin and further to the individual tray. The impression material was injected inside the tray.

Fig. 10.8.9 – Multifunctional guide in position serving as individual tray. At the same time, vertical dimension of occlusion is registered and transferred to the semi-adjustable articulator.

Fig. 10.8.10 – Final impression.

Fig. 10.8.11 – intaglio surface of final impression.

Fig. 10.8.12 – Adequate intermaxillary relationship transferred to the articulator.

Fig. 10.8.13 – Working cast.

Fig. 10.8.14 – The implant prosthesis was processed. The inclined implants emerge at the occlusal fossa of the premolar teeth.

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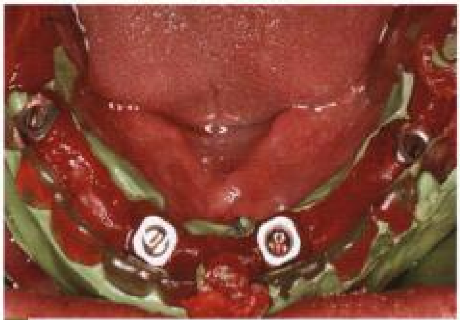

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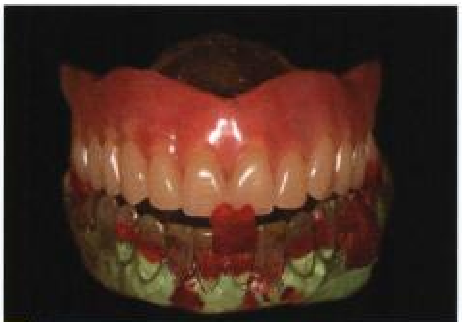

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Fig. 10.8.15 – Observe excellent finishing and polishing of the cast gold infra-structure.

Fig. 10.8.16 – Definitive prosthesis in the working cast.

Fig. 10.8.17 – Three days after prosthesis delivery.

Fig. 10.8.18 – Occlusal view.

Fig. 10.8.19 – Final panoramic radiograph. Observe excellent fit of the implant prosthesis.

Fig. 10.8.20 – Clinical aspect, frontal, right and left lateral views.

Fig. 10.8.21 – Final esthetic aspect. Complete upper denture and implant-supported lower denture.

Patient MAP, 53 years-old, male. This patient had mal-positioned implants in both maxillary arches. Also, the patient was scheduled for all implant extraction.

Fig. 10.9.1 – Lateral cephalometric radiograph. Observe interach relationship and implant positioning.

Fig. 10.9.2 – Panoramic radiograph. Five mal-positioned implants in the upper arch and three in the lower arch, with lesions at the apical implant thirds.

Fig. 10.9.3 – Clinical aspect. Extensive perioral soft tissue loss can be observed.

Fig. 10.9.4 – Intra-oral aspect. Frontal view. Note absence of adequate interarch space, with extrusion of the lower teeth.

Fig. 10.9.5 – Right lateral view. The lower posterior teeth are occluding with the upper alveolar ridge.

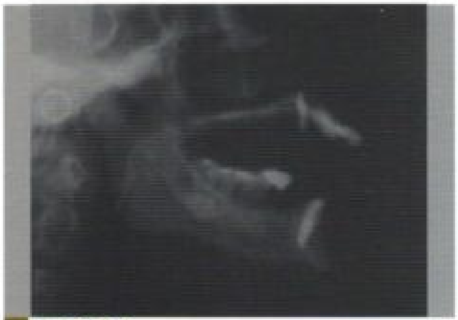
Fig. 10.9.6 – Left lateral view. Observe positioning of the upper anterior implant and the lower molar occluding with the alveolar ridge.

Fig. 10.9.7 – After implant removal. Cranial bone graft was placed at the maxillary arch and the an immediate loading procedure performed in the lower arch. Diagnostic set-up in both arches.

Fig. 10.9.8 – Eight implants were placed in the maxillary arch. The transfer copings are connected.

Fig. 10.9.9 – The implants are joined together with pattern acrylic resin.

Fig. 10.9.10 – Working cast with artificial gingiva.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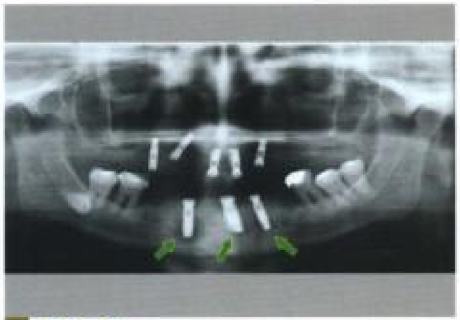
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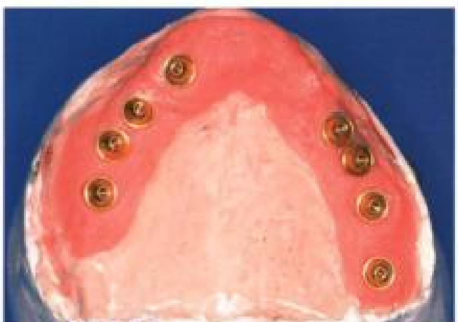
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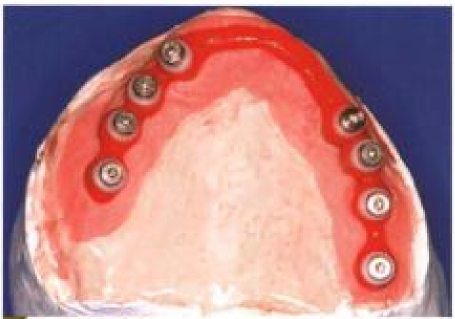
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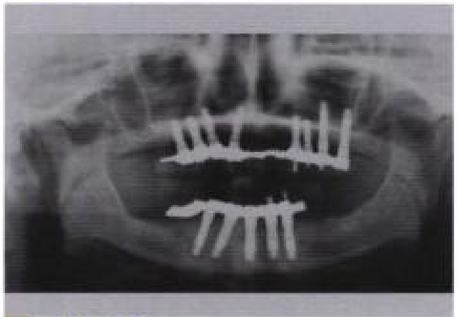
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Fig. 10.9.11 – occlusal view. Infra-structure wax-up.

Fig. 10.9.12 – Infra-structure wax-up. Lateral view.

Fig. 10.9.13 – Acrylic teeth and infra-structure try-in.

Fig. 10.9.14 – Frontal view. Definitive prosthesis.

Fig. 10.9.15 – Six months later. The lower prosthesis after 1 month (immediate loading).

Fig. 10.9.16 – Panoramic radiograph showing 8 implants in the maxilla and 5 implants in the mandible.

Fig. 10.9.17 – Clinical control. Observe excellent esthetics. Metalloplastic superior and inferior prostheses.

Fig. 10.9.18 – Lateral cephalometrics view: before and after implant placement.

Fig. 10.9.19 – Clinical aspect of the lower arch.

Fig. 10.9.20 – Surgical guide in position.

Fig. 10.9.21 – The alveolar ridge is flattened before implant placement.

Fig. 10.9.22 – Frontal view. Surgical guide in position.

Fig. 10.9.23 – Five implants placed in the mandibular arch.

Fig. 10.9.24 – Implants in position.

Fig. 10.9.25 – Mult-unit abutments.

Fig. 10.9.26 – Transfer copings.

Fig. 10.9.27 – The transfers are joined together with pattern acrylic resin.

Fig. 10.9.28 – Impression pick-up procedure.

Fig. 10.9.29 – Multifunctional guide to transfer intermaxillary relationships.

Fig. 10.9.30 – Working cast with multi-unit implant abutments and artificial gingiva.


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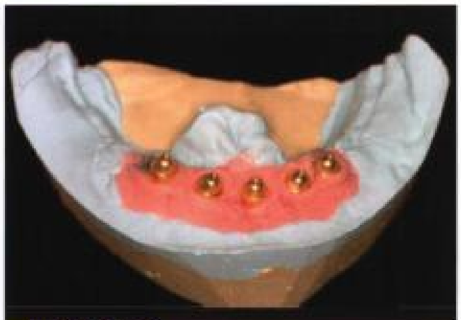
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Fig. 10.9.31 – Infra-structure wax-up.

Fig. 10.9.32 – Acrylic teeth try-in in the mouth.

Fig. 10.9.33 – Infra-structure and acrylic teeth attached to pink wax.

Fig. 10.9.34 – Intaglio surface of cast gold infra-structure.

Fig. 10.9.35 – The prosthesis was processed.

Fig. 10.9.36 – Prosthesis delivery 4 days later.

Fig. 10.9.37 – Observe excellent esthetic profile.

Fig. 10.9.38 – Frontal view of the complete prostheses.

Fig. 10.9.39 – Clinical aspect after 1 week. Observe previous and actual conditions.

Fig. 10.9.40 – Patient's perioral soft tissue view before and after implant and prosthesis installation.

Fully Edentulous Patients

Complete denture

Advantages: patient is familiarized with, cost, predictability, reestablishment of occlusal vertical dimension.

Disadvantages: bone resorption, removable appliance, loss of masticatory efficiency, phonetic problems, taste sensation alteration, short-term longevity, palatal covering, difficult to cope with, nausea, need for soft tissue revision and conditioning, several appointments are necessary for patient's adaptation, instability, risk of prosthesis fracture, no auxiliary retention mechanism is provided.

Contra-indications: patients that cannot tolerate a removable appliance.

Overdentures

Definition

Removable partial dentures or complete dentures with auxiliary retention mechanisms (attachments) connected to root or implant abutments, improving prosthesis retention and stability.

Indications

To prevent secondary bone resorption, since the behavior of tooth or implant-supported overdentures is similar. In the implant-supported overdentures, bone resorption seen is 0.1-0,2mm annually.

Alveolar bone deficiencies can be treated with overdentures in fully edentulous patients. Also, this prosthesis is indicated for esthetic and phonetic reasons.

Overdenture retention and stability is determined by the number of implants placed, its distribution, and by the attachment type in each case.

Retention can be provided by independent attachments (ball, Dalla Bonna, O'ring). Also, the implants can be joined with rigid cast bars. Of course, oral hygiene is facilitated in the first scenario, because dental plaque deposits can be seen around the bar, generating soft tissue overgrowth and inflammation.

Main advantages are:

- patients with congenital or post-surgical defects;
- soft and hard tissue esthetic defects can be improved with base extension;
- lip and facial support can be improved with prosthesis design;
- different attachment mechanisms can improve prosthesis retention;
- when compared to conventional complete denture individuals, patients wearing an implant overdenture showed greater reproducibility of chewing pattern, retention and stability;
- implant maintenance is less complicated due to the number of fixtures placed;
- fewer implants are a good cost/benefit relation for the patients;
- patients can convert the overdentures to an implant-fixed prosthesis through additional fixtures; also, the existing overdenture serves as provisional appliance while the definitive prosthesis is fabricated.

The main disadvantage is due to the fact that an overdenture is a removable appliance, and the volume of acrylic resin is considerable to reestablish soft and hard tissue loss.[30]

Attachments for *Overdentures*

The attachment type must be planned before implant surgery. For this, study casts mounted in a semi-adjustable articulator with correct/desired maxillomandibular relationship is fundamental to evaluate the intermaxillary space to determine attachment height and type. Next, most common overdenture attachments systems are listed below:

- Locator
- Bar-clip system
- O'Ring
- ERA
- Bar-clip/O'Ring association
- Bar-clip/ERA association

Some aspects must be considered during attachment selection:

- bone quality;
- the number of implants;
- implant length and diameter;
- implant location;
- prosthetic convenience;
- cost.

Bar-clip system

The implants are joined through a metallic bar that will receive the female retention mechanism (clip).

Components

- burnout plastic bar to be cast with precious or semi-precious alloys
- pre-fabricated metallic bar: ready to be joined to the abuments (e.g., Nobel Biocare system);
- plastic or metallic clips

Bar-clip in the edentulous mandible

Number of implants

Two equidistant implants (20mm) are sufficient for two or more clips

Bar-clip in the edentulous maxillae

Number of implants

Four strategically placed implants are recommended, with two in the canine region

The aforementioned characteristics will provide biomechanical advantages, preventing occlusal loading over the implants, not only in the basal area, but also because the retentive mechanism allows for anterior-posterior rotation and minimizes load in a vertical direction.

Overdentures: clinical and laboratorial aspects

The principles for complete denture fabrication must be applied for overdentures. Reproduction of the tissue-bearing area is fundamental for optimal retention and stability.

Resilient retention mechanism

A spacer must be provided between the female part and the bar, which in turn will allow vertical and horizontal movements. It compensates for the intrusive movement under occlusal exercise, due to the resilient capacity of mucosa when submitted to masticatory forces, avoiding bar overloading, and implant compromise. Although no resilience is provided by the plastic clips, the modulus of elasticity permits rotational freedom for overdentures. Thus, the systems with plastic clips can be considered resilients (Fig. 10.10).

Advantages: access for maintenance, better control of the facial profile, better stability and retention, better masticatory efficiency, proprioceptive capacity and psychologic demands.

Disadvantages: risk of fracture or implant failure, risk of prosthesis fracture, increased treatment time, two surgical stages and frequent maintenance.

Implant-supported fixed prosthesis

Advantages: fixed appliance, retrieveability, longevity, better masticatory efficiency and bone stability.

Disadvantages: phonetic problems, oral hygiene maintenance is difficult, implant failure, risk of prosthesis fracture, increased treatment time, two surgical stages are need.

Contra-indications: inadequate number of implants, less bone structure, compromised systemic health (Figs. 10.11 to 10.14).


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Patient MLB, 60 years-old, Caucasian female. This patient had a lower complete denture. The alveolar ridge is extremely resorbed.

Fig. 10.10.1 – Clinical aspect.

Fig. 10.10.2 – The surgical guide was fabricated according to the existing inferior prosthesis.

Fig. 10.10.3 – Three implants were placed. A conservative incision was made because the patient had plastic surgery in the mental area.

Fig. 10.10.4 – Three months later. Healing abutments connected.

Fig. 10.10.5 – The abutments were connected. Observe gingival growth around the region of 43 due to healing abutment loosening.

Fig. 10.10.6 – Gold cast bar with pre-fabricated components.

Fig. 10.10.7 – Periapical radiograph showing excellent fit of implant-abutment, as well as abutment-cast bar junctions.

Fig. 10.10.8 – The lower prosthesis was processed.

Fig. 10.10.9 – The intaglio surface of the lower prosthesis with space for bar-clip attachments.

Fig. 10.10.10 – Clips attached to the bar. The undersurface is blocked with pink wax to avoid acrylic excess which prevents prosthesis removal.

Fig. 10.10.11 – Female parts in the lower prosthesis.

Fig. 10.10.12 – Final occlusal adjustment.

Fig. 10.10.13 – Frontal view.

Fig. 10.10.14 – The lower overdenture provides superior esthetics and excellent occlusal relationships.

Fig. 10.10.15 – Frontal clinical aspect. Observe excellent esthetic appearance.

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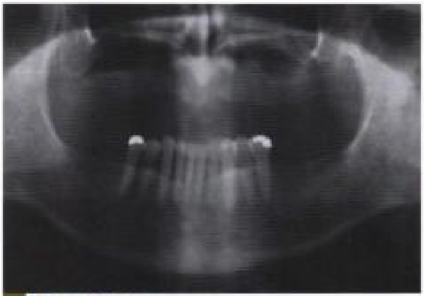
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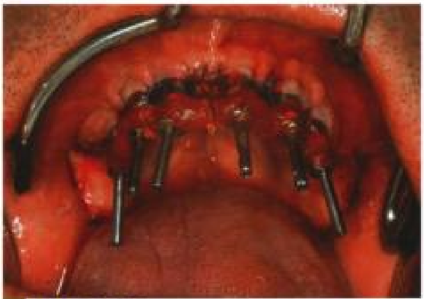
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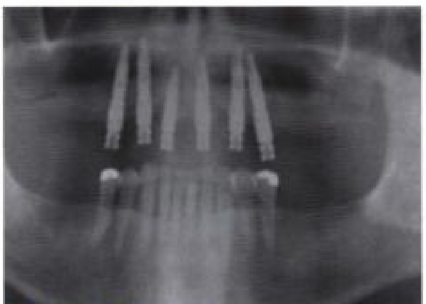
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Patient PR, 58 years-old, Caucasian male. This unsatisfied patient has worn an upper complete removable denture for three months. Implants will be installed in the maxillary arch.

Fig. 10.11.1 – Panoramic radiograph. There is good bone quantity in the anterior region.

Fig. 10.11.2 – Surgical guide.

Fig. 10.11.3 – Implants placed in the anterior region. Note implant inclinations at 13 and 23.

Fig. 10.11.4 – Frontal view of the inclined implants.

Fig. 10.11.5 – Transfer copings joined together with pattern acrylic resin.

Fig. 10.11.6 – Impression transfer procedure.

Fig. 10.11.7 – Occlusal view of the impression obtained.

Fig. 10.11.8 – Registering the intermaxillary relationships.

Fig. 10.11.9 – Panoramic radiograph of the six implants placed at the anterior upper region.

Fig. 10.11.10 – Working cast.

Fig. 10.11.11 – Cast gold infra-structure.

Fig. 10.11.12 – Observe position of the inclined implants.

Fig. 10.11.13 – Infra-structure try-in. The implant at 13 emerges between the second premolar and the first molar, whereas the implant at 23 emerges between the first and second premolar.

Fig. 10.11.14 – Two days after implant placement. Observe soft tissue quality.

Fig. 10.11.15 – Intermaxillary relationship registration.

Fig. 10.11.16 – Panoramic radiograph. Observe excellent cast gold infra-structure and prosthetic component fit.

Fig. 10.11.17 – The cast gold infra-structure is tried in the mouth with the acrylic teeth.

Fig. 10.11.18 – Palatal view. Observe screw access in the occlusal plane.

Fig. 10.11.19 – The upper complete prosthesis is processed.

Fig. 10.11.20 – Intaglio surface of the cast gold infra-structure.


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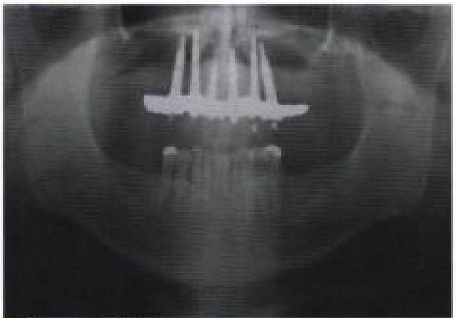
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Fig. 10.11.21 – Prosthesis delivery after 72 hours.

Fig. 10.11.22 – Frontal view. Observe excellent occlusion.

Fig. 10.11.23 – Observe the excellent esthetics. The patient is very satisfied.

Fig. 10.11.24 – The patient now has an younger aspect. The perioral soft tissues are supported by the prosthesis.


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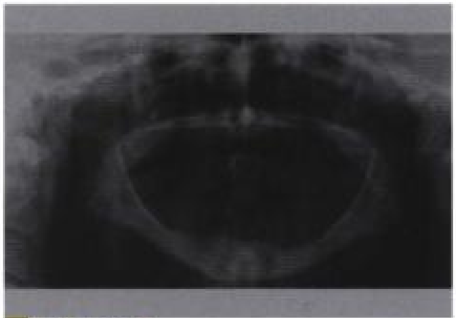
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Patient ERA, 42 years-old, Caucasian male. Skeletal Class III relationship with maxillary deficiency, edentulous condition, severe atrophic bone and mandibular prognatism.

Fig. 10.12.1 – Lateral cephalometric view. Observe severe maxillary resorption.

Fig. 10.12.2 – Panoramic radiograph. Observe maxillary bone resorption.

Fig. 10.12.3. Frontal and lateral profile views. There is circumoral soft tissue collapse and loss of vertical dimension (aspect of facial aging).

Fig. 10.12.4. This patient has worn complete upper and lower dentures for 20 years. Note Class III occlusal relationship.

Fig. 10.12.5 – Observe the occlusal aspect of the atrophic maxillary arch.

Fig. 10.12.6 – Cranial vault bone graft. Observe particulate bone.

Fig. 10.12.7 – Around 10 cm-thick graft was removed.

Fig. 10.12.8 – Bilateral sinus augmentation with the particulate cranial vault graft filling the space. (Surgery by Dr. Luis Henrique Marinho).

Fig. 10.12.9 – Onlay cranial vault bone graft at the lateral and anterior maxillary aspects.

Fig. 10.12.10 – Clinical aspect 6 months later. Note the lack of buccal vestibule due to mucoperiosteal flap advancement.

Fig. 10.12.11 – Lateral cephalometric view. Observe bone graft and bilateral sagital osteomoty for mandibular retraction (5mm) and the establishment of Class I relationship.

Fig. 10.12.12 – Panoramic radiograph six months after the bone graft procedure.

Fig. 10.12.13 – Surgical guide for implant placement.

Fig. 10.12.14 – Implants in the maxillary arch.


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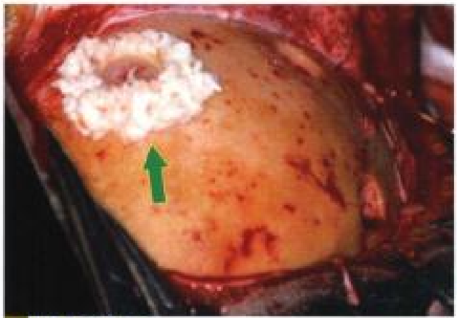
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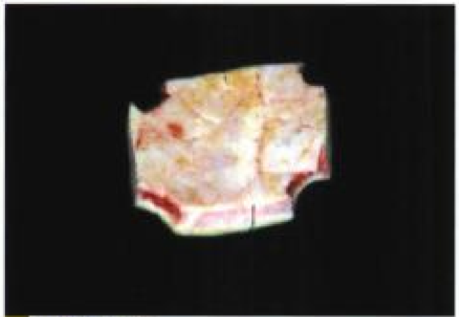
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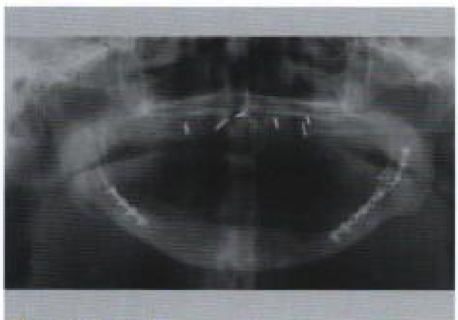
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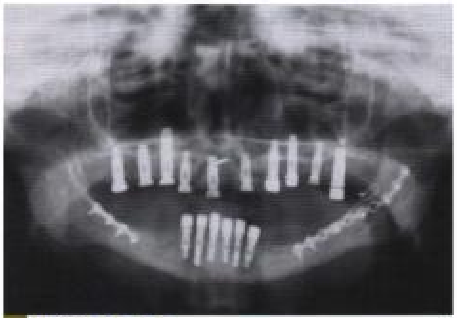

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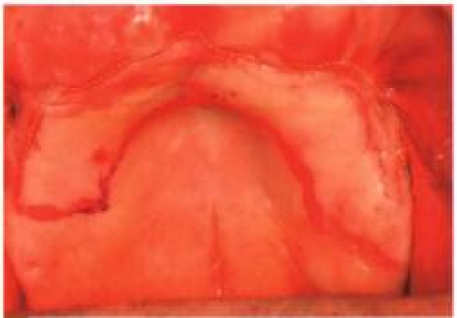

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Fig. 10.12.15 – Panoramic radiograph. Observe the osseointegrated implants.

Fig. 10.12.16 – Lateral cephalometric radiograph. Six months after implant placement.

Fig. 10.12.17 – The free gingival keratinized graft is delimited in the palatal region for gingivolabial vestibule reconstruction.

Fig. 10.12.18 – The gingival graft removed from the palate.

Fig. 10.12.19 – Vestibuloplasty procedure for sulcus deepening. Partial thickness flap and apical flap positioning through slow resorbable sutures (PDS II, Ethicon).

Fig. 10.12.20 – Placement and graft stabilization with suture.

Fig. 10.12.21 – Acrylic plate secured with to transpalatal screws; the objective here is to protect the wound area.

Fig. 10.12.22 – Clinical aspect 3 months after implant uncovering. Observe the alveolar ridge and mucosa with bone exposure at the region of 13.

Fig. 10.12.23 – Acrylic teeth set-up. Class I occlusal relationship for implant-supported prosthesis.

Fig. 10.12.24 – Impression procedures.

Fig. 10.12.25 – Implant replicas connected to the analogs.

Fig. 10.12.26 – Working cast with artificial gingiva.

Fig. 10.12.27 – Infra-structure wax-up.

Fig. 10.12.28 – Cast gold infra-structure.

Fig. 10.12.29 – Gold infra-structure in the working cast.

Fig. 10.12.30 – Metalloplastic prosthesis finished.

Fig. 10.12.31 – The prosthesis tried in the mouth.

Fig. 10.12.32 – Final clinical aspect.

Fig. 10.12.33 – Clinical aspect after one year.

Fig. 10.12.34 – Lower arch view after bilateral sagital osteotomy and the reestablishment of Class I occlusal relationship.


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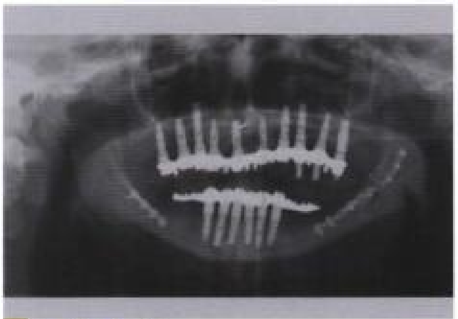

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Fig. 10.12.35 – Six implants immediate loaded in the lower arch.

Fig. 10.12.36 – Cast gold infrastructure.

Fig. 10.12.37 – Finished prosthesis in the working cast.

Fig. 10.12.38 – Clinical aspect one year later.

Fig. 10.12.39 – Frontal and lateral views. Observe facial esthetic improvement.

Fig. 10.12.40 – Panoramic radiograph one year later.

Fig. 10.12.41 – Clinical aspect 3 years later. Observe the wear facets in the lower acrylic teeth.

Fig. 10.12.42 – Clinical aspect 4 years later. Observe the wear facets.

Fig. 10.12.43 – Clinical aspect after 4 years (upper prosthesis) and 3 years (lower prosthesis), respectively. Observe excellent interarch relationship.

Patient IMT, 59 years-old, female. This patient has worn an upper complete removable denture and a lower removable partial denture. She was unsatisfied with esthetics and function. Implant placement was scheduled.

Fig. 10.13.1 – Lateral cephalometric radiograph. Observe advanced maxillary bone loss.

Fig. 10.13.2 – TC of the maxillary anterior region confirming extensive bone loss.

Fig. 10.13.3 – Observe partial absence of the alveolar processes at the premolar regions and extensive sinus pneumatization.

Fig. 10.13.4 – Working cast.

Fig. 10.13.5 – Wax rim for registering of esthetic reference lines.

Fig. 10.13.6 – Acrylic teeth tried in the mouth and relining of the upper prosthesis with a polyether material.

Fig. 10.13.7 – the nasolabial sulcus, buccal corridor, lip line, and smile line must be checked during try-in.

Fig. 10.13.8 – Clinical aspect of the upper alveolar ridge. Combination's syndrome sequelae is evident.

Fig. 10.13.9 – Observe extensive alveolar bone loss. Five implants will be placed at the anterior region, along with 2 zygomatic implants for immediate loading.

Fig. 10.13.10 – Left zygomatic implant.


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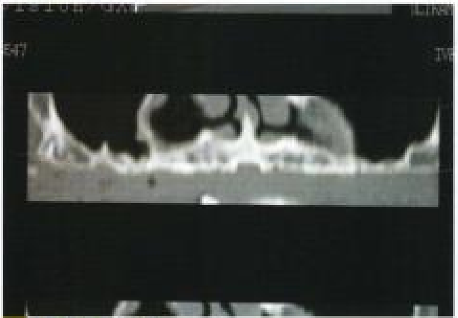
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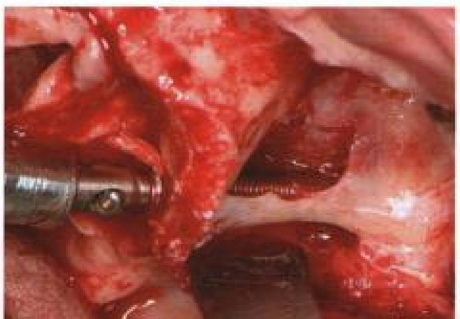
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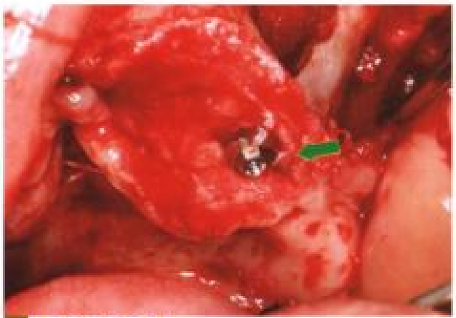
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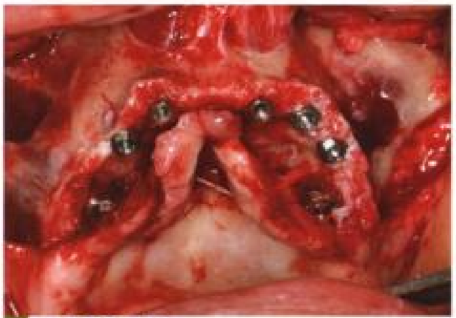
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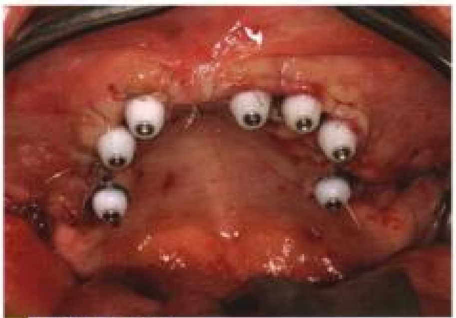
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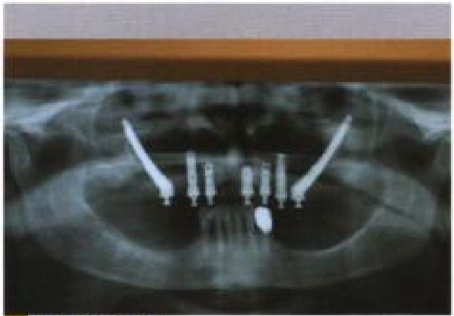
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Fig. 10.13.11 – Observe that the head of the zygomatic implants emerges in a palatal direction.

Fig. 10.13.12 – The implants installed.

Fig. 10.13.13 – Protection caps installed.

Fig. 10.13.14 – Panoramic radiograph. Observe the length of zygomatic implants.

Fig. 10.13.15 – Impression transfers joined together with pattern acrylic resin.

Fig. 10.13.16 – Observe palatal positioning of zygomatic implants.

Fig. 10.13.17 – Registering of intermaxillary relationships.

Fig. 10.13.18 – Working cast with artificial gingival soft tissue.

Fig. 10.13.19 – The infra-structure has been fabricated.

Fig. 10.13.20 – Internal view of the gold cylinders.

Fig. 10.13.21 – Infra-structure is tried in the mouth.

Fig. 10.13.22 – Acrylic teeth set-up, frontal view.

Fig. 10.13.23 – Intaglio surface of the cast gold infra-structure.

Fig. 10.13.24 – Acrylic set-up tried in the mouth.

Fig. 10.13.25 – Observe the palatal position of the zygomatic implants.

Fig. 10.13.26 – Metalloplastic prosthesis delivery after 72 hours.

Fig. 10.13.27 – Palatal view 72 hours later.

Fig. 10.13.28 – Panoramic radiograph. Observe infra-structure fit to the implants.

Fig. 10.13.29 – Clinical control 5 days later.

Fig. 10.13.30 – Frontal, right and left lateral views of the finished prosthesis.


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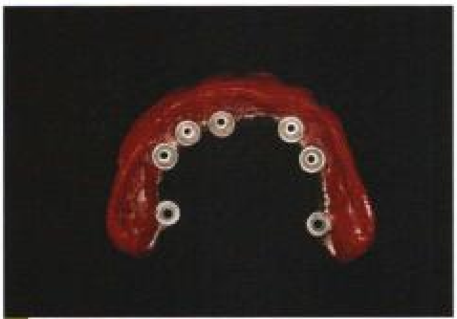
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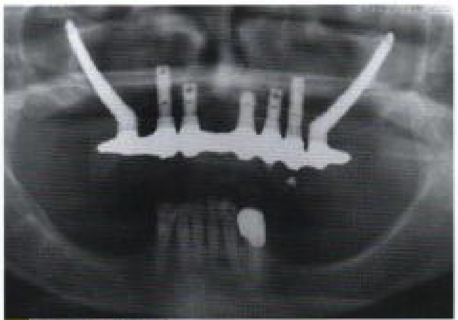
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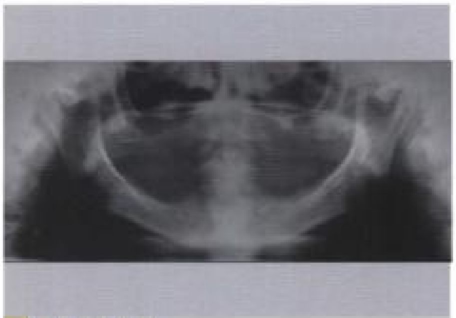
Fig. 10.13.31 – Frontal aspect. The patient is very satisfied.

Fig. 10.13.32 – Clinical aspect 1 one later.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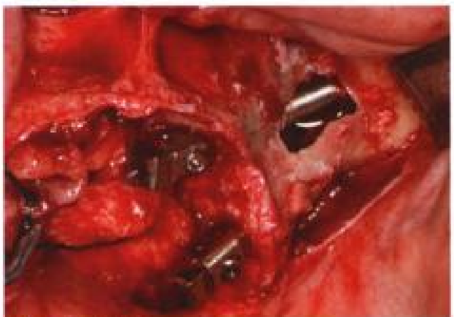
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Patient DMF, 40 years-old, Caucasian female. This patient has worn upper and lower complete dentures for a long time. Chewing, esthetics, and stability severely compromised.

Fig. 10.14.1 – Panoramic radiograph. Observe bone loss in the maxillary arch.

Fig. 10.14.2 – Lateral cephalometric radiograph. Observe bone loss in the maxillary arch.

Fig. 10.14.3 – Clinical aspect. Observe bone loss and the mucous tissue.

Fig. 10.14.4 – There is Class III occlusal aspect; in fact, the patient has anterior cross bite due to severe wearing of the acrylic teeth.

Fig. 10.14.5 – Full-thickness flap elevated to expose the maxillary atrophic bone.

Fig. 10.14.6 – Two zygomatic implants placed in the left side. Observe the bone window in the maxillary sinus.

Fig. 10.14.7 – the four zygomatic implants well positioned.

Fig. 10.14.8 – The zygoma implants are near the alveolar bone.

Fig. 10.14.9 – Ostell device at the top of the implant. Observe the ISQ values.

Fig. 10.14.10 – Observe suture and the protection caps over the multi-unit abutments.

Fig. 10.14.11 – Panoramic radiograph in the postoperative period.

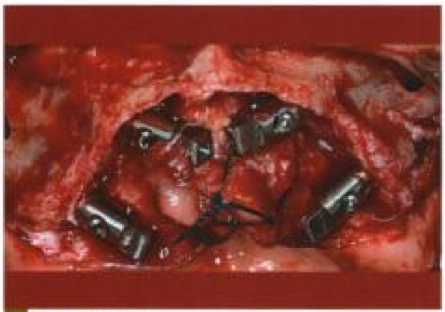
Fig. 10.14.12 – Lateral cephalometric radiograph after surgery.

Fig. 10.14.13 – PA radiograph showing implant positions.

Fig. 10.14.14 – The transfer copings are joined together with pattern acrylic resin.

Fig. 10.14.15 – Impression transfer procedure.

Fig. 10.14.16 – Multi-unit analog replica and artificial gingival in the impression.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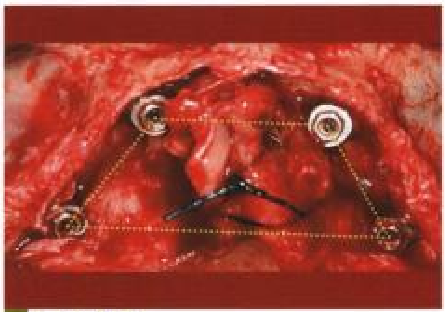
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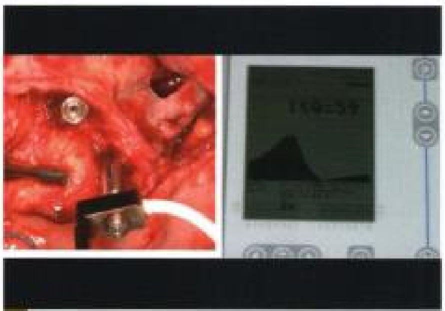
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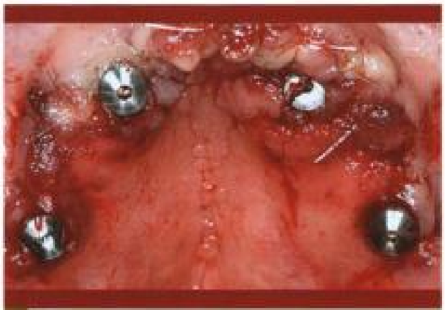
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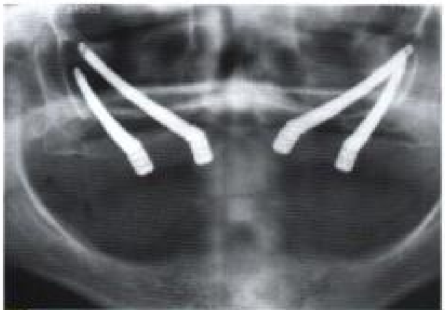
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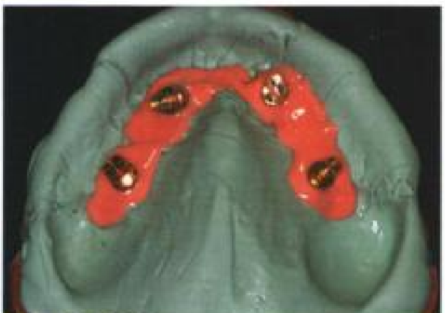
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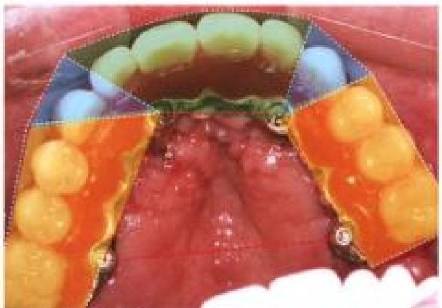
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Fig. 10.14.17 – The working cast.

Fig. 10.14.18 – Acrylic teeth set-up.

Fig. 10.14.19 – Frontal view of the teeth set-up.

Fig. 10.14.20 – Cast gold infra-structure.

Fig. 10.14.21 – Observe the screw access for the implants.

Fig. 10.14.22 – Prosthesis try-in within two days.

Fig. 10.14.23 – Observe the upper and lower complete dentures.

Fig. 10.14.24 – The well-positioned implants create bilateral cross-arch stabilization. Closing the Roy Polygon.

Fig. 10.14.25 – the metalloplastic prosthesis is processed.

Fig. 10.14.26 – Observe the implant positioning.

Fig. 10.14.27 – Prosthesis delivery. The soft and hard tissue deficiencies were resolved with acrylic.

Fig. 10.14.28 – Palatal view.

Fig. 10.14.29 – Clinical aspect three days later. Observe excellent soft tissue quality and final patient occlusion.

Fig. 10.14.30 – Postoperative radiograph of 4 zygomatic implants and prosthesis.

Fig. 10.14.31 – Esthetic appearance after 3 days .

Fig. 10.14.32 – One week after healing.

Fig. 10.14.33 – One year later. Right, left lateral and frontal views.

Fig. 10.14.34 – Clinical aspect before and after treatment.

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Provisional restorations

The success of any definitive tooth or implant-supported prosthesis is directly related to the quality of provisional restorations. Thus, provisional restorations can be divided into immediate, short-term or long-term modalities.

Functions

- to provide favorable esthetics;
- to keep the soft tissues in their original positions;
- to sculpt the soft tissues for adequate emergence crown profile and esthetics;
- serve as a guide for transfer customization;
- to reestablish proximal contact points;
- improve masticatory function;
- to keep or reestablish the vertical dimension of occlusion.[10]

Provisional restorations must have the following characteristics:

Biological factors:

protection to the dentin-pulp complex: it must protect the pulp organ from extrinsic factors, as well as provide good tissue healing after injuries from the tooth preparation.[11,12] Provisional crowns margins must be well-adapted to prevent microleakage;

periodontal health: adequate crown contours, periodic relining and good superficial texture will contribute for excellent periodontal health, which in turn influences on tooth impression and cementation of the definitive prosthesis.[13,14]

stability: to avoid tooth extrusion or migration. Any movement requires modification of the definitive prosthesis before its cementation.

self-cleaning mechanisms: adequate contours will provide good prosthesis hygiene. Probably, problems of margin recession will not occur after prosthesis cementation.

Mechanical factors:

Occlusion: it must provide adequate lateral and protrusive movements, improving comfort during mastication. Also, self-steam can be improved.

Atraumatic restorative margins: to avoid gingival irritation or bleeding with the provisional crowns, because rough margins can be found in mal-adapted acrylic or metallic crowns. Also, acrylic resin crowns must be well-trimmed. Tissue proliferation is frequently seen around excess resin in the cervical margins.

Resistance and retention forms: it must resist to applied occlusal forces without fracture or dislodgment. Fabrication of a new set of provisional crows takes time and does not improve patient/clinician relationship. Once removed, restorations must be intact.

Esthetic factors:

esthetics: Excellent esthetics must be provided in the anterior and premolar regions. The color, form, texture and contours must be as similar as possible to the existing natural dentition to guarantee patient's satisfaction while the definitive work has been planned.

Implant-supported prostheses

In addition to the requirements aforementioned for tooth supported prosthesis, the implant-supported prosthesis exerts a fundamental role. Their contribution is provided in the following aspects:

Previous preparation

Adequate of oral cavity before implant surgery is fundamental for good outcomes. In this way, several dental disciplines must collaborate to provide a harmonious ambient for implant placement. Suppression of infected areas, orthodontic corrections, restorative procedures, surgeries, elimination of periodontal pockets, and the fabrication of the provisional prosthesis allow clinicians to provide ideal conditions for implant treatment.[16]

Gingival sculpting and contouring

The provisional restorations are strategic in areas where the esthetic aspect is fundamental.[17-20] After tooth loss, the gingival tissues assume a different configuration, with the gingival concave architecture being substituted for a flattened plane along with loss of papillary tissue. The implant installation per se cannot guarantee that the tissues will return to their original positions. For this, the periimplant marginal gingival has to be redirected. Successive relining and tissue compression management given by the provisional crowns at pre-determined time intervals can retrieve the concave shape of the gingival papilla. The provisional restorations act like "architects" of gingival form and shape, and determine the esthetic excellence in the transition between white (crowns) and red esthetics (gingiva).[16]

How to sculpt tissues

The soft tissue conditioning can be made with customized healing abutments or provisional crowns. In the first case, the abutments have a divergent emergence profile. They exert pressure on the gingival tissue, which in turn surrounds the abutments for further prosthesis confection. After, the gingival information is transferred to the working cast where the prosthesis will be fabricated. Unfortunately, this technique leaves the gingival tissue with a configuration that differs from the natural tooth anatomy.

Tissue conditioning with provisional prosthesis

- The provisional prosthesis is installed applying small compression in the soft tissues. This generates ischemia around the margins.
- The provisional crown is removed after one week, and the obtained anatomy is verified. If the gingival tissue is not adequate, add acrylic resin to the cervical margins.
- The prosthesis is connected to the mouth. The soft tissue will show a slightly ischemic aspect.
- Wait for one or two weeks and verified the gingival anatomy.

- The procedure is repeated once again. Due to the existing esthetic conditions, the desired final aspect will be obtained within 3 months to one year period (Fig. 10.15 to 10.17).
- Prepare the patient for impression procedures.

Provisional restoration for immediate function

The success of immediate loading protocols has lead clinicians to expand its clinical applications for single and partial implant-fixed prosthesis.[21,22,23,24] In this way, provisional implant crowns for unitary tooth loss have been fundamental. In addition to provide adequate time for osseointegration, they also participate of gingival contouring. This represent less laboratory time for definitive prosthesis confection. The adjacent soft tissues could be directed during the osseointegration period, avoiding soft tissue management during fabrication of definitive prosthesis. The procedures for immediate function and the use of provisional restorations can be made over healed sockets or soon after tooth extraction (Fig. 10.18).


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Patient SL, 20 years-old, female. Teeth 12 and 13 were lost due surgical complications. The patient was scheduled for implant placement after the orthodontic treatment. There was insufficient space for the placement of two implants, and just one was inserted at the region of 13.

Fig. 10.15.1 – The transmucosal component was removed for impression transferring procedures.

Fig. 10.15.2 – Working cast with artificial gingiva.

Fig. 10.15.3 – Prosthetic component for prosthesis confection.

Fig. 10.15.4 – Diagnostic wax-up of teeth 12 and 13. It is not possible to place two implants at this area.

Fig. 10.15.5 – Palatal view of the diagnostic wax-up. The lateral and canine teeth are joined together.

Fig. 10.15.6 – acrylic provisional crown with artificial gingiva.

Fig. 10.15.7 – Try-in in the mouth.

Fig. 10.15.8 – Soft tissue conditioning 8 months later, showing the obtained papilla at the lateral incisor region.

Fig. 10.15.9 – Clinical aspect of soft tissue conditioning 8 months later.

Fig. 10.15.10 – The provisional crown was connected to the implant replica to copy the gingival emergence profile.

Fig. 10.15.11 – Silicon impression mould of the provisional crown.

Fig. 10.15.12 – Implant replica immersed in the silicon mould.

Fig. 10.15.13 – Transfer coping connected to the implant replica.

Fig. 10.15.14 – the transfer coping is customized by filling the mould with Duralay resin.


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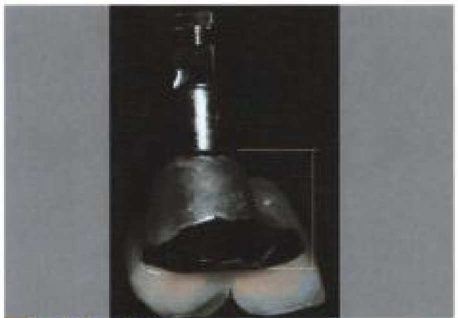
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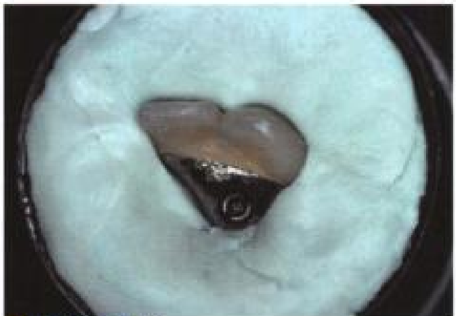
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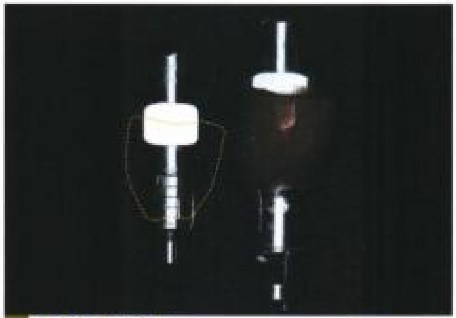

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Fig. 10.15.15 – Observe the normal and the customized transfer.

Fig. 10.15.16 – The customized transfer in the mouth.

Fig. 10.15.17 – Infra-structure try-in.

Fig. 10.15.18 – Definitive prosthesis.

Fig. 10.15.19 – Observe gingival contour one year after prosthesis delivery.

Fig. 10.15.20 – Final clinical aspect. Observe excellent esthetics.

Fig. 10.15.21 – Clinical aspect three years later. Observe excellent tissue integration at the region of 12.

Fig. 10.15.22 – Five years later.

Fig. 10.15.23 – Esthetic correction seven years later. The incisal borders of teeth 21 and 22 are high. Also, the embrasure between teeth11 and 12 is not adequate. The patient accepted to correct the incisal borders after esthetic correction in the study cast.

Fig. 10.15.24 – Observe the excellent aspect seven years later. Observe the area to be corrected.

Fig. 10.15.25 – The resin composite restoration will be placed at the distal of 11 and the incisal borders of teeth 21 and 22 corrected to the desired level.

Fig. 10.15.26 – After the esthetic correction.

Fig. 10.15.27 – Observe the initial situation.

Fig. 10.15.28 – Clinical aspect seven years later (Clinical case by Dr. Ronaldo Mendes A. Lucena).

Fig. 10.15.29 – Final result with esthetic improvement.

Fig. 10.15.30 – Final clinical aspect.

Fig. 10.15.31 – Patient smile after esthetic correction.

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Patient LB, 47 years-old, male. Agenesy of tooth 21 and root fracture at tooth 11. An implant was scheduled at the 11 region.

Fig. 10.16.1 – Clinical aspect. Note abscess at tooth 11.

Fig. 10.16.2 – Observe tissue inflammation at tooth 11 and the correspondent periapical radiograph.

Fig. 10.16.3 – Three months after removal of tooth 11 and preparation of teeth 12 and 22 for provisional prosthesis fabrication.

Fig. 10.16.4 – After soft tissue conditioning, observe excellent aspect of periimplant regions 11, 12, and 22.

Fig. 10.16.5 – Impression procedure.

Fig. 10.16.6 – The implant replica connected into the mould.

Fig. 10.16.7 – Pick-up impression procedure.

Fig. 10.16.8 – Working cast with artificial gingiva.

Fig. 10.16.9 – Metalloceramic crowns for teeth 21, 22 and 22. Pink porcelain was added to the implant crown to close the dark spaces, and the tooth 22 was transformed into a central incisor with pink porcelain added to fill the dark embrasure areas.

Fig. 10.116.10 – Observe excellent soft tissue quality and the emergence profile.

Fig. 10.16.11 – Cast UCLA abutment connected to the implant. Observe the soft tissue papilla.

Fig. 10.16.12 – The gold screw access was tight to 32Ncm and sealed with gutta-percha. Metalloceramic crown with pink porcelain added.

Fig. 10.16.13 – Observe excellent esthetics. The dark spaces were filled with pink porcelain.

Fig. 10.16.14 – Close of the black triangle area.

Fig. 10.16.15 – Before and after treatment.

Fig. 10.16.16 – Before and after definitive prosthesis.

Fig. 10.16.17 – Clinical aspect 8 years later. Observe the soft tissue condition.

Fig. 10.16.18 – Final esthetic aspect. The patient has low lip line.


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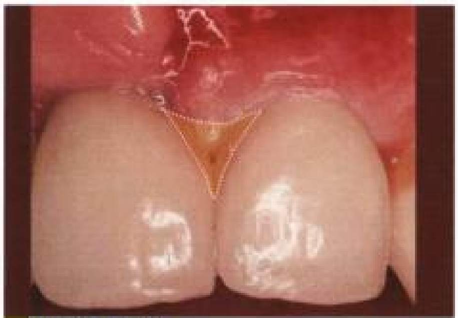
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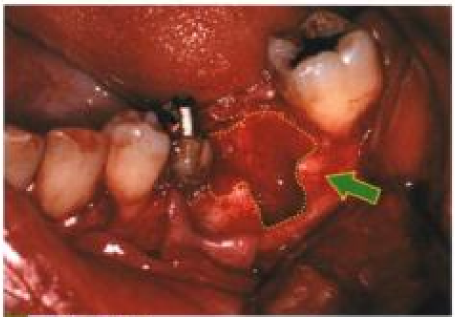
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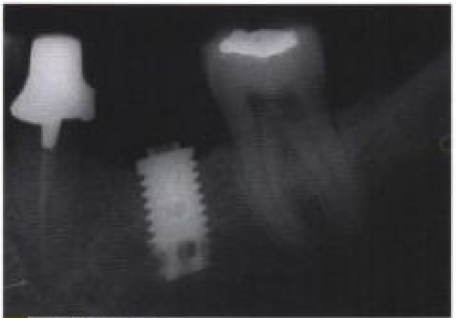
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Patient IMS, 43 years-old, female. Two unsuccessful root apicectomies at tooth 36. the patient was scheduled for implant placement.

Fig. 10.17.1 – Periapical radiograph. Observe combined periodontal and endodontic lesions, along with root perforation.

Fig. 10.17.2 – After the extraction of tooth 36 and sot tissue curettage. Observe the bone loss severity.

Fig. 10.17.3 – Six months after guided bone regeneration. Observe excellent bone quality.

Fig. 10.17.4 – At implant uncovering, there was bone over the cover screw.

Fig. 10.17.5 – Periapical radiograph, 4 months after implant placement.

Fig. 10.17.6 – The bone profile instrument removed the hard tissue overgrowth.

Fig. 10.17.7 – Large-diameter transmucosal component.

Fig. 10.17.8 – Three months after soft tissue maturation. Excellent tissue quality is seen.

Fig. 10.17.9 – Impression square coping at the implant 36 and gold infra-structure at tooth 35.

Fig. 10.17.10 – Impression transfer procedure.

Fig. 10.17.11 – Infra-structure try-in at 35 and 36. Observe the emergence profile.

Fig. 10.17.12 – Porcelain esthetic try-in.

Fig. 10.17.13 – Three years later. Excellent soft tissue and periodontal quality at 35 and 36.

Fig. 10.17.14 – Lingual view.

Fig. 10.17.15 – Clinical aspect after prosthesis delivery. A switching platform technique was used for emergence profile formation.

Fig. 10.17.16 – Periapical radiograph 7 years later. The 4.1mm-diameter implant received a 5mm-diameter abutment.


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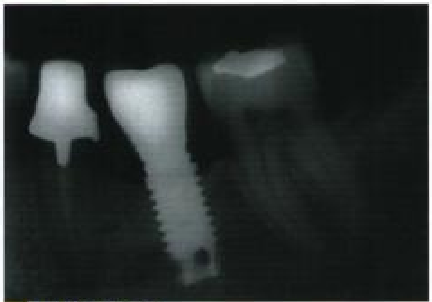
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Patient DS, 44 years-old, Caucasian female. Tooth 12 was fractured after car accident.

Fig. 10.18.1 – Clinical aspect of tooth 12.

Fig. 10.18.2 – Root fracture at tooth 12.


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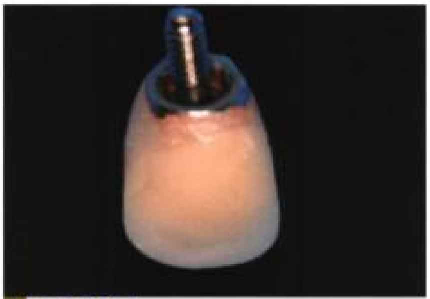
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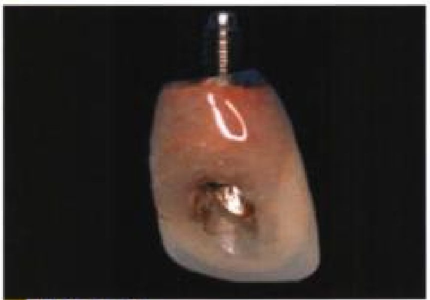
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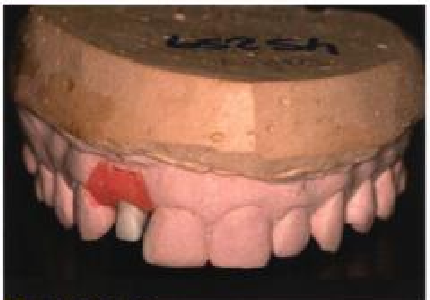
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Fig. 10.18.3 – Immediate implant. Soft tissue structure was preserved.

Fig. 10.18.4 – Immediate provisional crown.

Fig. 10.18.5 – Screwed implant prosthesis: palatal view.

Fig. 10.18.6 – Clinical aspect of immediate prosthesis on the same day.

Fig. 10.18.7 – Six months later. Observe soft tissue healing.

Fig. 10.18.8 – Customized impression transfer.

Fig. 10.18.9 – Periapical radiograph to confirm transfer fit to the implant.

Fig. 10.18.10 – abutment wax-up.

Fig. 10.18.11 – Palatal view of the wax-up.

Fig. 10.18.12 – Procera abutment scanned.

Fig. 10.18.13 – Procera crown cementation at tooth 12.

Fig. 10.18.14 – Clinical aspect 6 months after prosthesis placement. Now, a metal-free crown will be made for tooth 11.

Fig. 10.18.15 – Tooth preparation.

Fig. 10.18.16 – Frontal view of the tooth preparation.

Fig. 10.18.17 – A 0.5mm-thick Procera coping.

Fig. 10.18.18 – Coping try-in.

Fig. 10.18.19 – Porcelain try-in.

Fig. 10.18.20 – metal-free crown cemented at tooth 11.

Fig. 10.18.21 – Clinical aspect after three months.

Fig. 10.18.22 – One year later. Observe gingival leveling of tooth 12.


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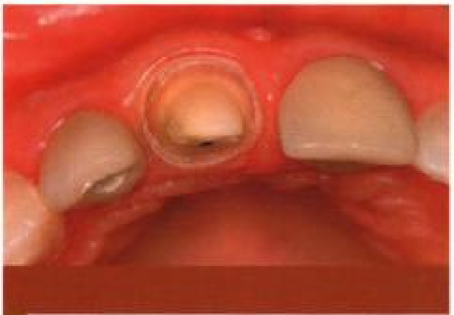
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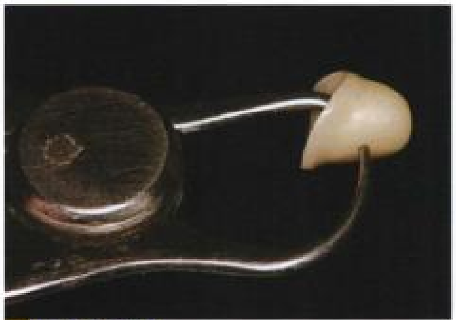
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Immediate short-term provisional restoration

The most common form of immediate provisional restoration is made at short-term. It is used for most cases before long-term provisional restorations, and must be installed on the same day that the teeth are prepared. Several types of materials can be used for provisional crown fabrication (acrylic resin teeth, vacuum preformed crowns, etc.) in the anterior and posterior teeth.

Provisional restoration in the long-term

The temporary prosthesis in the long term in indicated for cases where a long period is need to complete the treatment, for example, cases where a full treatment is necessary with a temporary protheses or in case when mucogingival periodontal treatment is necessary to completion the clinical case. These are situations where there is greater or lesser degree of dental procedure. It is also indicated by the rehabilitation required in case of dysfunction of the ATM. These two pathological processes are often present in the same case, making treatment more complicated. Thus, the method by which the provisional restoration is performed assumes fundamental importance and may be called "temporary reconstruction therapy".

This type or reconstruction has sophisticated expression in its provisional restorations, for adequate stability gnathologic. The provisional restoration is constructed of occlusal surfaces of gold, carved with the characteristics of the final restorations, to restore the harmonious relationship and to maintain unchanged the relationship occlusion and at the same time, allow the healing of tissues articulators. As the balance of tissues articulators inevitably involves a change in the relationship occlusal (result of the adjustment of the neuromuscular system), you need to back the restoration provisional. For that reason, the restoration is called "temporary therapy". The procedure is accompanied by the time the situation is fully stabilized, then, can be made a permanet restoration, according to the new die casting and occlusal records.

These are the reason why most are using temporary restorations relief to long term thermoplastic acrylic resin, which can be modified post - through a surgically, with a new relining. Moreover, the resins tougher with new formulas were developed and a low degree on the contraction of polymerization. The problems with this type of restoration in the long term are easy to hold on the pillars and the possibility of fractures, especially in areas edentulous. This force the surgeon-dentist to repair repeated throughtout the period of surgery and the subsequent minimum period of six weeks of healing, in the present these kind of treatment is change with implants therapy.

Provisional crown contouring

Form and arrangement: obtained through the diagnostic set-up.

Marginal adaptation: lesions at the dentogingival junction due to tooth preparation or impression procedures can be reverted with well polished and adapted provisional crowns. In most cases, impressions must be made three weeks after tooth preparation and provisional crown installation. Marginal adaptation of provisional crowns varies from 25 to 157µm. According to the resin type, an indirect confection technique can have superior marginal adaptation when compared to the direct technique –additional relining is needed in the direct technique. When the resin sets out of the oral cavity, values from 200 to 800µm can be found.

Clinical parameters derived from provisional crowns

The clinician must visualize the following parameters:

- anatomic contours;
- horizontal trespassing;
- vertical trespassing;
- smile line.[15]

Provisional crown confection technique

- Direct technique
- Indirect technique

The provisional prosthesis on the direct technique

The prostheses are made after healing abutment removal or immediately after the second surgical stage, or even implant placement.

Screwed implant prosthesis made with pre-fabricated artificial teeth

Technique

- select the adequate transmucosal component (e.g. UCLA);
- connect the component with the transfer screw; for unitary prosthesis, an anti-rotational mechanism is preferred;
- select the acrylic resin teeth that matches form, size, and shape of the desired tooth;
- trim the acrylic teeth and adapt over the component;
- mix resin powder and monomer in a dappen dish. Wait for the dough phase and add resin to the component; now, wait until polymerization;
- remove the transfer screw and the component;
- adapt the component to an implant replica and make the appropriate adjustments;
- install the provisional crown in the mouth;
- check occlusal contacts and mandibular eccentric movements;
- finish and polish the acrylic crown;
- the crown is now torqued to 10 Ncm.

Provisional prosthesis on the indirect technique

In the indirect technique, the provisional crown is made over the dental cast.

Tecnical

First clinical stage

- pick-up impression of the desired abutments;
- interocclusal registering and model transferring to the semi-adjustable articulator;
- put the protective caps over the transmucosal components;
- select tooth color;
- send to the laboratory: impression or models, plastic burnout cylinders, screws and annotations on the teeth form, shape and size.

Laboratorial stage

- screw the plastic cylinders onto the implant replicas;
- make diagnostic wax-up joining the prosthetic elements;
- verify occlusal relationship;
- remove the waxed-up prosthesis;
- investing and processing of the desired form;
- divest and remove the resin excess;
- finish and polishing;
- check occlusion on the articulator.

Second surgical stage

- remove the protective caps;
- adapt the prosthesis and secure with the screws;
- verify adaptation and stability; it is possible to cut and join later the desired crown to improve adaptation;
- adjust occlusal relationships;
- close the screw access with cotton pellets and gutta-percha; in the last case, if the prosthesis will be used for longer periods, seal the access with composite autopolymerizing resin.[10]

Final observations on provisional restorations

The reestablishment of dentogingival or periimplant relationships is only possible by means of correct anatomic contours. In prosthetic terms, it represents correct marginal adaptation, appropriate contour and surface texture that neither cause mechanical irritation nor allow dental plaque deposition. In other words, the provisional restorations must mimic and behave like a natural tooth.

The provisional restoration is fundamental to achieve gingival tissue health for impression procedures. The provisional restoration is a valuable information source for clinicians and patients, as well as for the definitive restorations, as long as it has been well fabricated.

Transfer impression components

The transfer components are devices adapted to the implants or prosthetic abutment, used to transfer the desired implant position in the impression mold.

Types

- round copings for closed tray;
- square copings for open tray.

Round transfer components

Tray type

Stock (metallic or plastic) and custom trays.

Impression material

Putty and wash materials from addition and condensation silicones are indicated. The polyether material can be used too.

Impression technique

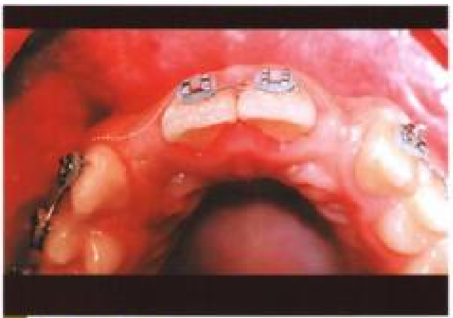
- Connect the transfers to the abutments or implant platforms.
- Syringe the wash impression material around the transfer components.
- Load the tray with the putty material and insert into the oral cavity.
- Wait for set time and remove the tray.
- Remove the transfers one by one, connect to the correspondent implant replica and insert them into the mold.
- Syringe artificial gingival tissue around the implants.
- Pour impression with a good quality gypsum material.
- Remove the cast from the mold;
- Remove the transfers.
- The model is ready.
- Occlusal registration record and semi-adjustable articulator procedures.

Square transfer copings

For customized acrylic trays. It is indicated for the impression of a single prosthetic element, when the patient will receive a screwed prosthesis (Fig. 10.19).

Impression technique with individual tray

- Install the desired transfers;
- A dental floss is passed around the transfers, further joined together with pattern acrylic resin.
- Perforate the tray in the region that corresponds to transfer positions.
- Try-in of the tray in the mouth.
- Syringe the wash material around the implants.
- Load the tray with putty material and insert into the mouth.
- Unscrew the transfers and remove the tray.
- Insert the implant replicas into the mold.
- Screw the transfer to the replicas.
- Put the protection caps over the prosthetic abutments.
- Add some artificial gingiva into the mold.
- Pour the impression with improved dental stone.



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Patient WJ, 20 years-old, male. After orthodontic treatment, the patient was scheduled for implant placement at the regions of 12 and 22.

Fig. 10.19.1 – After two mini-implants at teeth 12 and 22 along with guided bone regeneration, and 8 months after implant exposure. There is a lack of soft tissue at the buccal of 22.

Fig. 10.19.2 – Sot tissue pouch surgery to augment the buccal tissue. The implant was transferred for prosthesis fabrication.

Fig. 10.9.3 – Observe soft tissue augmentation at the buccal of 12 and 22; the healing abutments were connected.

Fig. 10.19.4 – Provisional crowns at teeth 12 and 22.

Fig. 10.19.5 – Three months after soft tissue conditioning. There is still a lack of papilla and soft tissue at the 22 region.

Fig. 10.19.6 – A connective tissue graft was made at the buccal of 22 region.

Fig. 10.19.7 – Bilaminar connective tissue.

Fig. 10.19.8 – three months after soft tissue conditioning at tooth 22. Excellent emergence profile can be found at teeth 12 and 22. Final impression transferring is now possible.

Fig. 10.19.9 – Provisional prosthesis 8 months after soft tissue conditioning.

Fig. 10.19.10 – Clinical aspect 8 months after soft tissue conditioning. Excellent papillary profile at tooth 12.

Fig. 10.19.11 – Clinical aspect 8 months after soft tissue conditioning. Excellent papillary profile at tooth 22.

Fig. 10.19.12 – The provisional crowns will be transferred to copy the emergence profile.

Fig. 10.19.13 – Long screws were secured to the provisional crowns.

Fig. 10.19.14 – An individual tray is seated. The screws must remain above the tray.

Fig. 10.19.15 – Adhesive layer applied to the impression tray.

Fig. 10.19.16 – Impression procedure.

Fig. 10.19.17 – The screws are 3 to 4mm above the tray.

Fig. 10.19.18 – Impression mould. The provisional crowns were captured in the impression material.

Fig. 10.19.19 – Working cast. Soft tissue emergence profile is captured.

Fig. 10.19.20 – Palatal view of the emergence profile transferred to the working cast.

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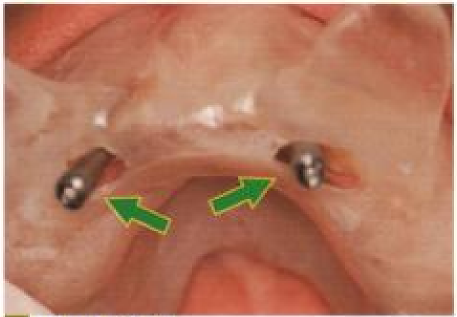

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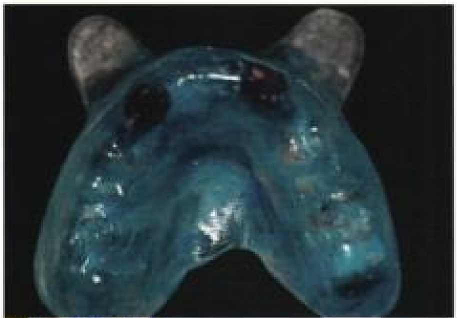

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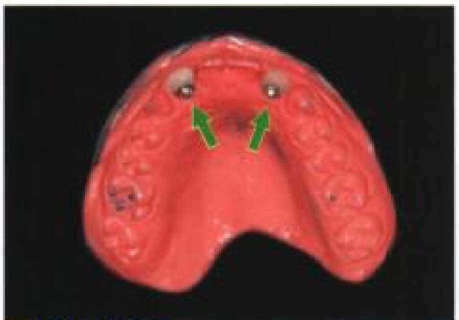

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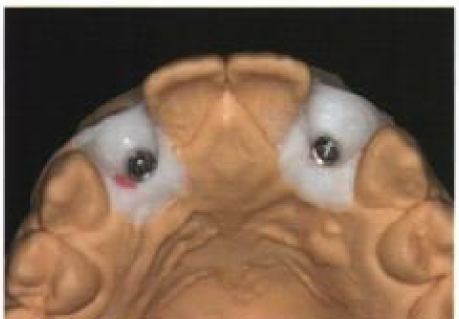

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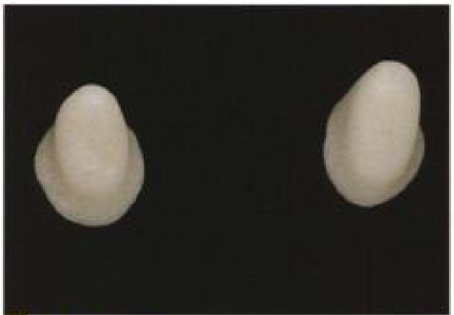
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Fig. 10.19.21 – Coping wax-up.

Fig. 10.19.22 – Palatal view.

Fig. 10.19.23 – Gold abutment.

Fig. 10.19.24 – Gold abutment try-in.

Fig. 10.19.25 – Procera coping.

Fig. 10.19.26 – intaglio surface of the Procera coping.

Fig. 10.19.27 – Gold abutments in the mouth.

Fig. 10.19.28 – The copings are tried in the mouth.

Fig. 10.19.29 – A 32Ncm torque is applied to the gold screw.

Fig. 10.19.30 – The screw access hole is sealed with gutta-percha and composite resin.

Fig. 10.19.31 – Procera metal-free crowns.

Fig. 10.19.32 – Palatal view.

Fig. 10.19.33 – The crowns are tried in the mouth.

Fig. 10.19.34 – Cementation process. A small amount of zinc phosphate cement is applied with a fine brush to the cervical third of the crowns.

Fig. 10.19.35 – The 12 and 22 crowns are cemented.

Fig. 10.19.36 – Periapical radiograph.

Fig.10.19.37 – Periapical radiograph.

Fig. 10.19.38 – Clinical control six months later. Observe excellent soft tissue contour.

Fig. 10.19.39 – Observe excellent esthetics at the Procera crowns.

Fig. 10.19.40 – Observe excellent esthetics at frontal view.


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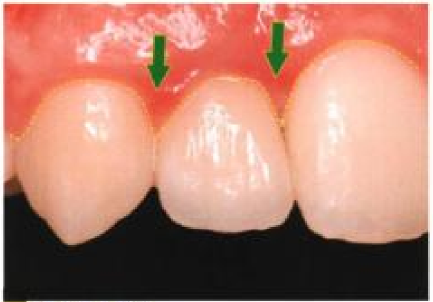

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Fig. 10.19.41 – Observe the soft tissue integrity at tooth 12.

Fig. 10.19.42 – Observe the soft tissue integrity at tooth 22.

Fig. 10.19.43 – Clinical aspect after 6 months at tooth 22.

Fig. 10.19.44 – Clinical aspect after 6 months at tooth 12.

Fig. 10.19.45 – Observe excellent esthetics after 6 months at the emergence profile of tooth 12.

Fig. 10.19.46 – Observe excellent esthetics after 6 months at the emergence profile of tooth 22.

Fig. 10.19.47 – Clinical aspect 6 months later. Patient smile line.

Fig. 10.19.48 – Before and after treatment. Frontal view.

Fig. 10.19.49 – Before and after treatment. Right lateral view of tooth 12.

Fig. 10.19.50 – Before and after treatment. Left lateral view of tooth 22.

- Allow sufficient time to unscrew the transfers and remove the cast from the mold.
- Prepare for interocclusal registration procedures.

Customized transfer technique

To obtain excellent esthetics, it is mandatory to customize the transfer component, because not only information about the three-dimensional implant position, but also the architecture of the surrounding gingival tissue, must be captured.

In this technique, the working cast has the exact position of the top of the implant and the soft tissues contours on both screwed and cemented implant prostheses. It is important to understand that the anatomy of the transfer component cannot capture the nuances of the gingival contouring.

After 3 to 6 months, when the gingival contouring is ready for impression procedures, the provisional crown is removed from the mouth and receives an implant replica, which in turn is immersed in a silicone mold to copy its emergence profile.[26]

Technique

- Use an indelible pen to mark the gingival contour at the cervical area of the provisional crown.
- Connect the prosthesis to the implant replica.
- The provisional crown is immersed into the silicone mold until the level of the cervical contour.
- Wait for material setting, unscrew the provisional crown.
- Now, connect a transfer component to the implant replica.
- Fill the space between the transfer and the silicone mold with Duralay resin.
- Remove the customized transfer.
- Insert the customized transfer component into the mouth, take a periapical radiograph to verify implant-transfer fit.
- Make an impression, wait for material setting.
- Unscrew the transfer, remove the impression, connect an implant replica.
- Apply some artificial gingival material (Truesoft), and pour with improved dental stone.
- Now, the working cast has the same characteristics of the implant position and soft tissues contour found in the oral cavity, which is fundamental to achieve a highly esthetic restoration.

Prosthetic components

Laboratorial and clinical phase for the definitive prosthesis

Laboratorial phase

The laboratory technician begins to develop the definitive prosthesis. it is important to have in mind that close communication between the clinician and the technician is fundamental for the success of the implant-supported prostheses. Also, the lab must know the principles and employ the indicated materials (titanium keys, etc.) to fabricate implant restorations.

The working cast must be mounted in a semi-adjustable articulator and, along with the plastic burnout/ metallic abutments and screws, sent to the laboratory.

Metallic cylinders

These cylinders can be cast with precious or semi-precious alloys. For these, a process called overcasting is made after the technician has waxed-up and invested the infrastructure. This procedure is made for both metalloceramic and metalloplastic prostheses.

Prosthetic abutments

Devices used to connect the prosthesis to the implants

Classification

Abutments for screwed prosthesis

UCLA
Estheticone
Angulated estheticone
Miruscone – Micruscone
Mult-unit or microunit

Abutments for cemented prosthesis

Metallic

– Pre-fabricated – Ceraone

– Customized – must be milled to conform with the desired characteristics.

Ceramic: also, the ceramic abutments can be milled to a conventional abutment for fixed prosthesis

Standard abutments

Indications: fixed prosthesis with several elements, in situations of less esthetic requirement, for overdentures with bar-clip attachments

- Cervical collar height :3, 4, 5.5mm, and 7mm
- Diameter: 4.5mm
- Torque: 20Ncm
- Manual screwdriver
- Protection caps
- Transfer components: taper and square
- Cylinders: machined
- Retention screw: gold, titanium with hex or slotted heads

Interocclusal height: ≥6mm.

Actually, this component has been substituted for the Estheticone or Microunit abutments, which have presented more esthetic results. however, due to the height of its platform, it can be used for implant supported fixed complete prostheses where the most distal implant is inclined.

Estheticone abutments

Some manufactures now fabricate the multi-unit rather than the esthetic one components.

Indications

Screwed, single or multiple prostheses, or in cases with a least 2mm of keratinized mucosa. Also, to correct implant angulation (30°) when the screw access hole compromise the final esthetic outcomes.[27]

Interocclusal height:>6.7mm

Cervical collar height: 1, 2, and 3mm

- Diameter: 4.8mm
- Torque: 20Ncm
- Manual screwdriver
- Protection caps
- Taper and square transfer components
- Smooth and hexed cylinders
- Retention screws: gold, titanium, with hex or slotted heads

Minimal interocclusal distance: 6.7mm

It is important to highlight that the components used for single prostheses must have an anti-rotational device (hex) at the top of the components. However, when the clinician wishes to fabricate an implant supported fixed partial denture (two or more abutments) the splinted infrastructure addresses this purpose.

Angulated estheticone abutments

Indications

Screwed, single or multiple prostheses, to correct 17 and 30° angulations, when the periimplant sulcus depth is at least 3mm.

This abutment is similar to the original estheticone, but now there is more chance to correct implant angulation in order to provide adequate screw access holes.

It is important to note that after screwing, the cervical portion of this abutment will face the buccal aspect, being contra-indicated when the patient has a thin mucosal tissue (less than 3mm). Minimal interocclusal distance: 7.4mm

- Abutments: 17° (2 to 3mm), 30° (3, 4, and 5mm)
- Diameter: 4.8mm
- Torque: 20Ncm
- Manual screwdriver: hexagonal
- Protection caps
- Transfers: taper and square components: estheticone
- Implant analogs: estheticone
- Retention screws: gold, titanium; hexagonal or slotted heads

Miruscone or Micruscone abutments

The miruscone or micrucone abutments are no longer fabricated due to the success of multi-unit and microunit abutments. However, it is important to highlight that many patients have prostheses with micruscone or miruscone abutments and thus, the clinician must understand its principles.

These abutments are similar to the estheticone, but used for reduced interocclusal dimensions,

- angulation :40°

- cervical collar height: 1,2, and 3mm
- Diameter:4.8mm
- Manual screwdriver
- Protection caps
- Transfer components
- Cylinders: plastic, metallic, alumina, zirconia
- Minimal interocclusal distance: 7.5mm

Customized abutments

This group is characterized by versatility. It can be adjusted to several conditions found after implant placement and before definitive prostheses confection. The lab work provided by the technician is similar to a tooth supported fixed prosthesis, since the abutments are milled to receive a cemented restoration.

There are several advantages:

- the emergence profile can be milled in the customized component;
- easy of handling due to its similarity with conventional fixed prosthesis;
- better management of the soft tissues;
- the porcelain is applied from the implant platform (ceramic abutments), or leaving a short metallic collar (0.1-0.2mm –metallic components), which is interesting when the mucosal thickness cannot masquerade the 1mm collar height of pre-machined components.

UCLA abutments

It was developed at the University of California, Los Angeles. It comprehends an acrylic tube directly fitted over the implant platform. In most cases, plastic burnout abutments are available to fabricate the implant prostheses.

The UCLA abutment has the following advantages:

- it can be trimmed and waxed-up to the desired situations;
- it can be cast with several alloys;
- low cost (when alternative alloys are used);
- it eliminates the intermediary abutment component;
- it creates an ideal emergence profile according to the existing anatomy of the periimplant sulcus;
- prosthetic reconstructions with appropriate angulations can be readily performed in the laboratory.

However, the marginal adaptation of the plastic burnout abutments can be compromised since the lost wax technique is used to fabricate the prosthesis. To overcome this problem, the Gold-UCLA abutment was introduced in the market. It has a gold machined portion fitted to the implant top, while the plastic tube can be modified according to the specific requirements (Fig. 10.20 to 10.22).

Patient JAC, 44 years-old, Caucasian female. The tooth 22 was lost due advanced periodontal disease. Implant placement was indicated.

Fig. 10.20.1 – Periapical radiographs before and 3 months after tooth extraction.

Fig. 10.20.2 – healing abutment at the 22 region after guided bone regeneration.

Fig. 10.20.3 – Square impression coping and periapical radiograph showing excellent fit.

Fig. 10.20.4 – Working cast with artificial gingiva.

Fig. 10.20.5 – Cast gold UCLA abutment. Observe fit and periodontal health.

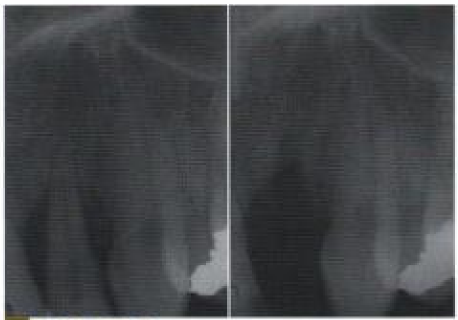
Fig. 10.20.6 – Cast gold infrastructure.

Fig. 10.20.7 – Metalloceramic crown in the mouth. Buccal view.

Fig. 10.20.8 – Metalloceramic crown in the mouth. Palatal view.

Fig. 10.20.9 – Metalloceramic crown. Observe the emergence profile.

Fig. 10.20.10 – Metalloceramic crown. Palatal view.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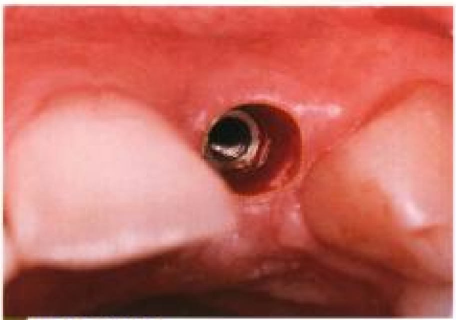
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Fig. 10.20.11 – Emergence profile three months after the healing abutment connection.

Fig. 10.20.12 – Final aspect. The tooth 12 was crowded; the same was applied to the implant crown.

Fig. 10.20.13 – Clinical aspect 9 years later. Observe excellent soft tissue contour and stability.


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Patient ESO, 44 years-old, Caucasian male. Tooth 16 had a perforation in the pulp chamber.

Fig. 10.21.1 – Pulp perforation in the tooth 16.

Fig. 10.21.2 – Periapical radiograph showing pulp perforation.

Fig. 10.21.3 – One year later. Observe periimplant health. Impression procedures can be made.

Fig. 10.21.4 – Impression square coping.

Fig. 10.21.5 – Periapical radiograph showing transfer component fit.

Fig. 10.21.6 – Impression mould.

Fig. 10.21.7 – Implant replica connected and artificial gingival tissue (Trusoft).

Fig. 10.21.8 – Observe excellent emergence profile.

Fig. 10.21.9 – Working cast with artificial gingiva.

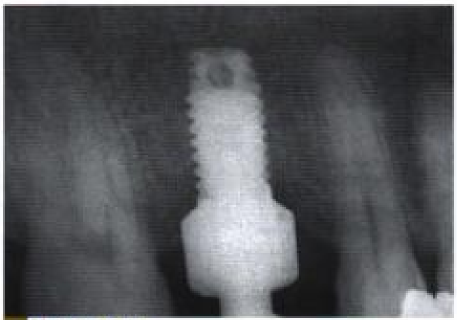
Fig. 10.21.10 – **A-** large-diameter transfer coping, **B-** large-diameter healing abutment, **C-** large-diameter implant replica, **D-** Gold machined UCLA abutment.

Fig. 10.21.11 – Wax-up of infra-structure.

Fig. 10.21.12 – Occlusal wax-up view.

Fig. 10.21.13 – Cast gold infra-structure.

Fig. 10.21.14 – The infra-structure is tried in the mouth.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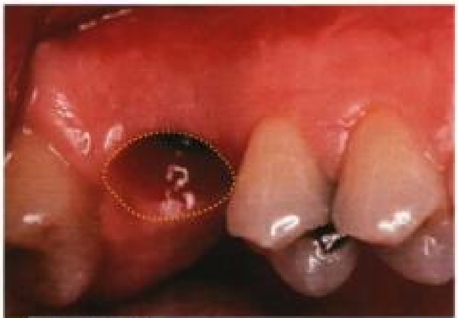
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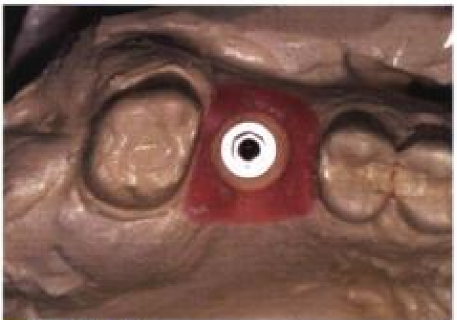
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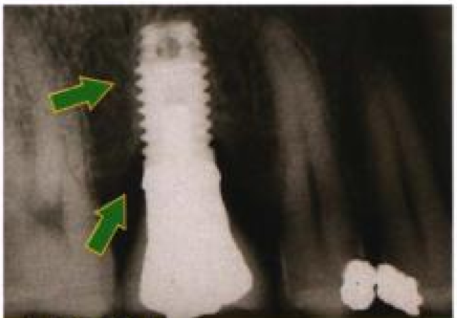

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Fig. 10.21.15 – Porcelain built-up.

Fig. 10.21.16 – Occlusal view of the metalloceramic crown.

Fig. 10.21.17 – Metalloceramic prosthesis at implant 16.

Fig. 10.21.18 – Periapical radiograph showing fit between the implant and the prosthesis.

Fig. 10.21.19 – Esthetics and final occlusion one year later.

Fig. 10.21.20 – Clinical aspect five years later.

Fig. 10.21.21 – clinical aspect seven years later.

Fig. 10.21.22 – Periapical radiograph 7 years later. Observe hard tissue maturation (remodeling bone).

Patient EC, 60 years-old, female. This patient had an extensive fixed bridge from teeth 14 to 23. Implant placement was scheduled.

Fig. 10.22.1 – Three months after implant uncovering from 14 do 23. Previously, guided bone regeneration was performed to obtain the desired results.

Fig. 10.22.2 – Three months after implant uncovering from 11 do 23. The same procedures already described were applied. The transmucosal components are too close.

Fig. 10.22.3 – Clinical aspect three months after abutment healing connection. Observe proximity between implants.

Fig. 10.22.4 – Observe ideal space between implants 11 and 21.

Fig. 10.22.5 – Impression square copings.

Fig. 10.22.6 – The transfer copings are splinted together with a dental floss.

Fig. 10.22.7 – Now, Duralay resin is applied over the dental floss.

Fig. 10.22.8 – Periapical radiographs showing excellent component fit for impression procedures.

Fig. 10.22.9 – An impression was made. Seven implants were placed in the positions of 14, 13, 12, 11, 21, 22, and 23.

Fig. 10.22.10 – Implant replicas connected to the impression square copings in the mould.


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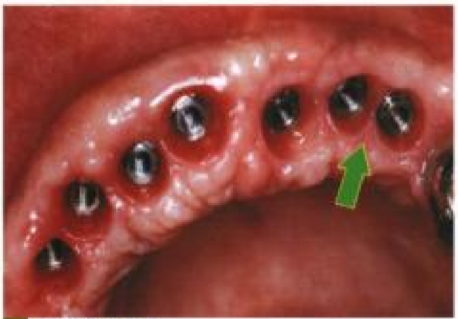
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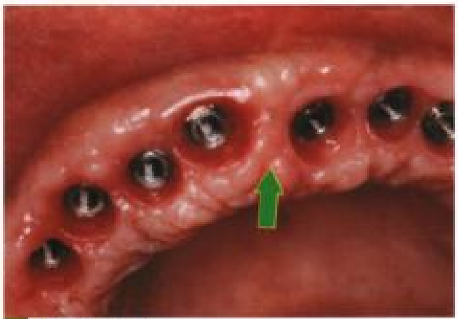
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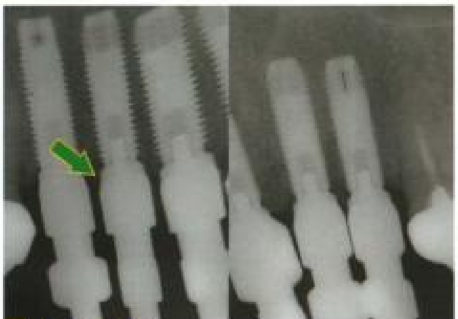
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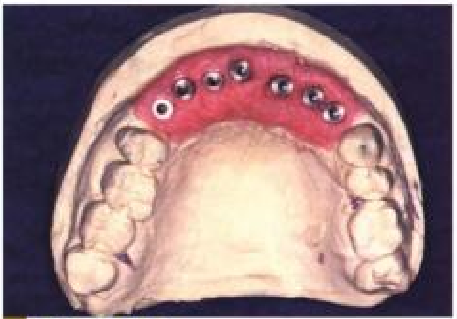
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Fig. 10.22.11 – Trusoft artificial gingival tissue applied to the intaglio surface.

Fig. 10.22.12 – Working cast.

Fig. 10.22.13 – Infra-structure wax-up. UCLA abutments were connected to the implant analogs.

Fig. 10.22.14 – Palatal view of the burn-out UCLA abutments.

Fig. 10.22.15 – Cast abutments tried in the mouth.

Fig. 10.22.16 – Occlusal registering for porcelain application.

Fig. 10.22.17 – Cast gold infra-structure.

Fig. 10.22.18 – Palatal view of the cast gold infra-structure.

Fig. 10.22.19 – The metallic infra-structure tried in the mouth.

Fig. 10.22.20 – Porcelain built up after the first firing cycle.

Fig. 10.22.21 – Palatal view.

Fig. 10.22.22 – Metalloceramic crowns in the mouth.

Fig. 10.22.23 – Palatal view.

Fig. 10.22.24 – Esthetic adjustment in the mouth.

Fig. 10.22.25 – Metalloceramic crowns already glazed.

Fig. 10.22.26 – Palatal view. Note porcelain characterization.

Fig. 10.22.27 – The crowns were cemented in their respective abutments.

Fig. 10.22.28 – Clinical aspect one year later.

Fig. 10.22.29 – Palatal view of the same clinical aspect.

Fig. 10.22.30 – Three years later. There is marked improvement on the gingival tissue contours.


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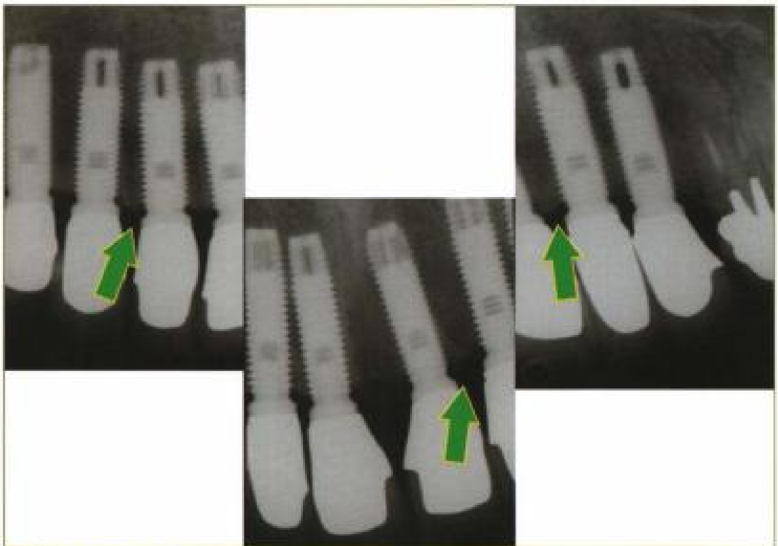

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Fig. 10.22.31 – Seven years later. Again, the gingival tissue has improved.

Fig. 10.22.32 – Close-up view of the same area.

Fig. 10.22.33 – Clinical aspect nine years later.

Fig. 10.22.34 – Before and after the cementation day.

Fig. 10.22.35 – Clinical aspect at 9 years.

Fig. 10.22.36 – Clinical aspect at 9 years. Frontal view.

Fig. 10.22.37 – Periapical radiographs before and after 9 years. Observe bone remodeling.

Customized metallic abutments

These components can be readily customized without extra laboratorial procedures. However, the region that contacts the implant cannot guarantee perfect fit. Still, it is not possible to wax-up over the abutments.

The abutments can be milled in the laboratory, the clinician adjusts them directly into the mouth, or both situations can be combined.

Customized ceramic abutments

Superb esthetics can be achieved when customized ceramic abutments are used. However, the clinician has to understand that incorrect reduction will compromise the final abutment strength. It is important to follow the manufacturer's recommendations regarding to the final ceramic dimensions in order to maintain its longevity (Fig. 10.23 to 10.25).

Patient IPA, 24 years-old, female. Orthodontic extrusion of the unerupted right upper canine was not possible. However, surgical attempts resulted in the loss of bone height and thickness. After the orthodontic treatment, an implant was scheduled at the region of 13.

Fig. 10.23.1 – Too much space exists for canine reconstruction.

Fig. 10.23.2 – After guided bone regeneration procedures; a free gingival graft was placed in the 13 region.

Fig. 10.23.3 – Three months later. Observe excellent soft tissue healing and surgery for implant uncovering.

Fig. 10.23.4 – The healing abutment is connected.

Fig. 10.23.5 – Transfer coping adapted to the implant.

Fig. 10.23.6 – Impression procedure.


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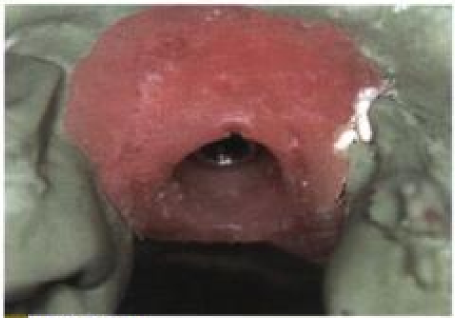

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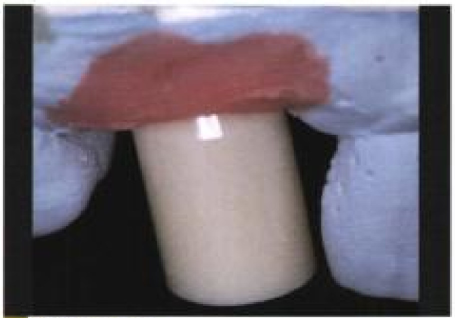

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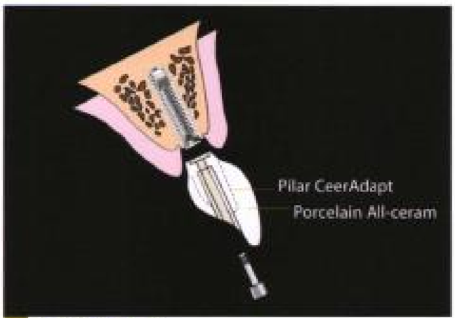

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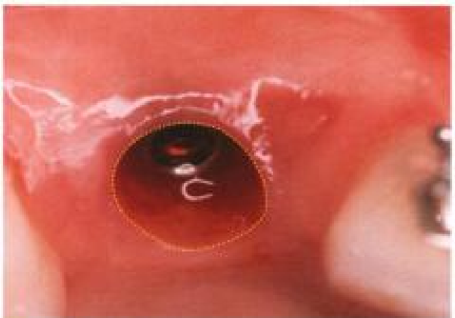

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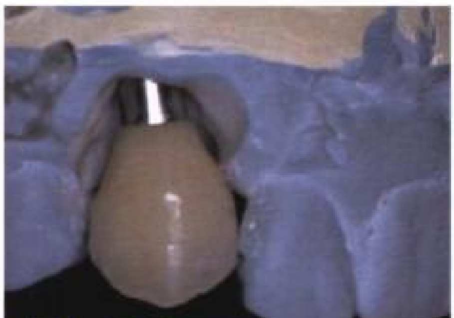

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Fig. 10.23.7 – Working cast.

Fig. 10.23.8 – Working cast with artificial gingiva at the region of 13.

Fig. 10.23.9 – The CerAdapt abutment in the working cast.

Fig. 10.23.10 – Schematic drawing of the CerAdapt abutment veneered with porcelain.

Fig. 10.23.11 – Provisional acrylic crown for soft tissue conditioning.

Fig. 10.23.12 – Six months after soft tissue conditioning. Observe excellent emergence profile obtained, as well as the quantity and quality of the keratinized mucosa.

Fig. 10.23.13 – Porcelain directly applied to the CerAdapt abutment.

Fig. 10.23.14 – Palatal aspect of the same crown. The prosthesis will be screwed to the implant.

Fig. 10.23.15 – The artificial gingival tissue is removed from the working cast. Porcelain already applied.

Fig. 10.23.16 – Procera crown connected to the implant.

Fig. 10.23.17 – Metal-free Procera crown at the region of 13.

Fig. 10.23.18 – Palatal view.

Fig. 10.23.19 – Clinical aspect after three years. Observe the esthetic aspect and soft tissue stability.

Fig. 10.23.20 – Patient smile before and after treatment.

Fig. 10.23.21 – Clinical aspect five years later. Observe the soft tissue papillae.

Fig. 10.23.22 – Patient's facial profile. There is esthetic harmony between metal-free crown and the implant.

Fig. 10.23.23 – Clinical aspect 7 years later. Observe excellent periimplant tissue at the area.

Fig. 10.23.24 – Frontal view.

Fig. 10.23.25 – Close-up view of implant 13 after seven years.

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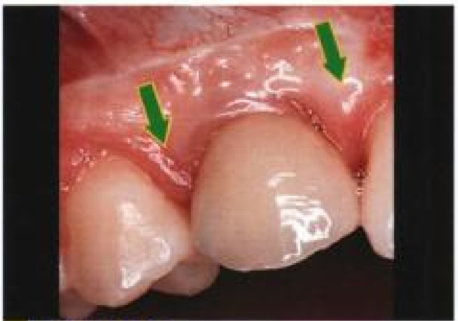

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Patitent EB, 44 years-old, Caucasian female. Tooth 15 was extracted due to root fracture.

Fig. 10.24.1 – clinical aspect. The gingival tissue is too thin and gingival recession can be observed on teeth 14 and 16. After tooth extraction, a bilaminar connective tissue graft was made to augment the band of keratinized mucosa.

Fig. 10.24.2 – Periapical radiograph six months after implant placement.

Fig. 10.24.3 – A ZiReal abutment was used to fabricate de implant provisional crown.

Fig. 10.24.4 – Procera coping over the ZiReal abutment. Procera coping on tooth 14.

Fig. 10.24.5 – Procera coping at implant 15 and tooth 14.

Fig. 10.24.6 – Procera crowns on tooth 14 and implant 15.

Fig. 10.24.7 – Occlusal view of Procera cemented crowns.

Fig. 10.24.8 – Observe the occlusal relationship.

Fig. 10.24.9 – Before and after treatment.

Fig. 10.24.10 – Clinical aspect one month later. Observe excellent soft tissue and papillae esthetics.

Fig. 10.24.11 – Clinical aspect of patient smile.

Fig. 10.24.12 – Clinical aspect two years later.

Fig. 10.24.13 – occlusal view two years later.

Fig. 10.24.14 – Clinical aspect four years later. Observe excellent soft tissue stability.


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Patient IPA, 24 years-old, female. The patient underwent iliac crest bone graft and soft tissue conditioning. Reasonable outcomes were observed, and now the tissue will be conditioned with provisional crowns.

Fig. 10.25.1 – Clinical aspect. Observe soft tissue quality.

Fig. 10.25.2 – impression procedure to fabricate the provisional crowns.

Fig. 10.25.3 – Periapical radiograph. Observe transfer coping fit to the implants.

Fig. 10.25.4 – Diagnostic wax-up.

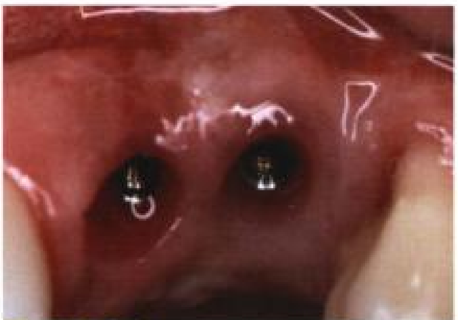
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Fig. 10.25.5 – Working cast with artificial gingival tissue.

Fig. 10.25.6 – Provisional acrylic crowns over the working cast.

Fig. 10.25.7 – Provisional resin composite prosthesis at teeth 22 and 23. Observe the lack of papillary tissue.

Fig. 10.25.8 – Provisional prosthesis. Occlusal view.

Fig. 10.25.9 – Periapical radiograph before final transferring procedures.

Fig. 10.25.10 – Working cast.

Fig. 10.25.11 – Customized titanium Procera abutment over the mini-implant at 22.

Fig. 10.25.12 – Procera coping and porcelain build-up.

Fig. 10.25.13 – Porcelain characterization.

Fig. 10.25.14 – The CerAdapt abutment on tooth 23.

Fig. 10.25.15 – Occlusal view of the CerAdapt abutment.

Fig. 10.25.16 – All-Ceram porcelain applied over the CerAdapt abutment.

Fig. 10.25.17 – Porcelain applied on teeth 22 and 23.

Fig. 10.25.18 – There is an implant screwed prosthesis on the 23 region.

Fig. 10.25.19 – Working cast with artificial gingival tissue. Observe component fit.

Fig. 10.25.20 – Occlusal view.

Fig. 10.25.21 – Clinical aspect in the mouth.

Fig. 10.25.22 – Clinical aspect two years later.

Fig. 10.25.23 – the CerAdapt abutment fractured on the region of 23.

Fig. 10.25.24 – Detailed view of the fractured region.

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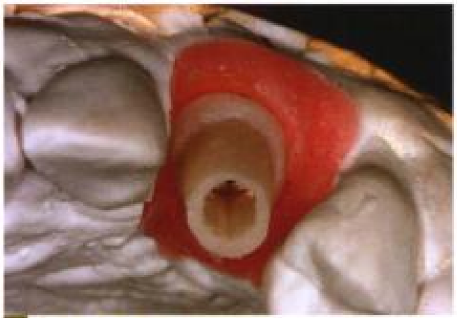
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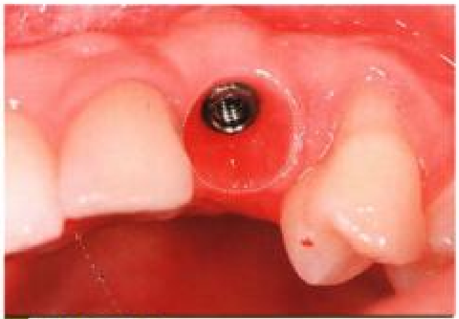
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Fig. 10.25.25 – The transfer coping is customized before final impression.

Fig.10.25.26 – Zirconia customized abutment.

Fig. 10.25.27 – Observe excellent soft tissue contour two years after prosthesis delivery.

Fig. 10.25.28 – Procera metal-free crown at tooth 23.

Fig. 10.25.29 – Clinical aspect of metal-free crown.

Fig. 10.25.30 – Observe excellent esthetics.

Fig. 10.25.31 – Clinical aspect three years later. Soft tissue stability is seen.

Fig. 10.25.32 – Frontal view after three years.

Fig. 10.25.33 – Clinical aspect after 4 years. Observe soft tissue stability.

Fig. 10.25.34 – Clinical aspect 4 years later. Observe excellent esthetics.

Indications:

- for more biocompatible restorations;
- to connect the ceramic sub-gengival over screw or cement prothesis;
- thin keratinized mucosa that compromises esthetic appearance;
- when the abutment need to be prepared intra-orally;
- to reconstruct long teeth with simulation of root cervical exposure;
- the abutment axial inclination must be less than 30°.

Minimal dimensions for customized ceramic abutments:

- occlusal or incisal dimension: 7.0mm
- diameter: ≥4.0mm
- axial wall thickness = 0.7mm
- angulation: less than 30 degrees
- deep chamfer or rounded shoulder finish line.[28]

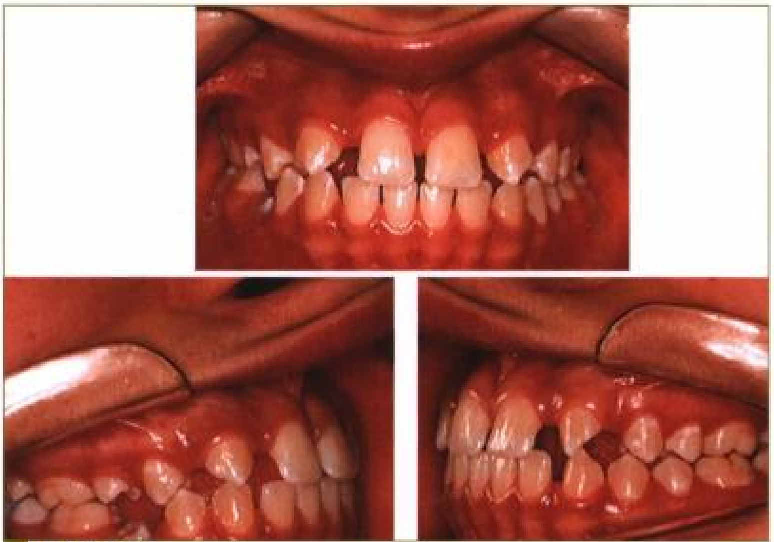
CAD/CAM customized abutments

The Procera system is based on the CAD/CAM technology. It can produce all-ceramic unitary or large titanium infra-structures. The CAD (computer Aided Design) uses three-dimensional information obtained after die scanning. All scanned points in the die represent the contours of the prepared abutment in the computer screen. After, a software program can define the thickness of the desired infra-structure, cervical collar, as well as the internal space for the appropriate cement. Information about the gypsum die is transmitted by internet. The Procera system comprises the All-Ceram and the All-Titan divisions for single crowns and titanium frameworks, respectively. The advantages are: excellent esthetics, color stability, adequate strength, reduced laboratory time for infra-structure fabrication, excellent margin fit to the die and the prepared abutment, and greater flexural resistance when compared to the traditional ceramic systems. The disadvantages include: equipment cost, laboratory know-how needed, accredited technicians required, limited use for unitary crowns and three-element fixed prosthesis. Initially, the recommended thickness for copings was 0.6mm, allowing excellent physical and mechanical properties, as well as good esthetic outcomes. However, the thickness was reduced to 0.4mm, keeping in mind the biologic principles of tooth preparation and to provide more room for porcelain application. These infra-structures have compression and flexural resistances 30% lower than the 0.6mm copings.

The Procera All-Ceram 0.4mm copings are indicated for anterior regions, first and second premolars. Advantages of these copings include: more room for porcelain application, conservative tooth reduction, and excellent esthetics. Also, there is no need to adjust the infra-structure, and the working time is reduced. In addition, the system can be used for patients with increased vertical trespassing since the palatal aspect of the infra-structure is not compromised. The 0.4mm-thick coping can be made in two versions: translucent or opaque, with different optical properties.[28]

In the CAD system, the operator selects the appropriate contours and dimensions of the copings, the desired finish line and angulation. In the CAM (Computer Aided Machining) the infra-structures are made by milling, spark erosion, compacted under high pressures, etc.

Virtually, any desired form can be applied to both ceramic and titanium abutments to create the appropriate emergence profile, which will address the esthetic demands in each case. The abutments are available for all Nobel Biocare products. Other implant systems with similar hexagonal platforms can benefit from the CAD/CAM technology (Fig. 10.26).



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Patient RPRC, 13 years-old, female. Tooth agenesis (12, 22). Orthodontic treatment was indicated to provide enough room for implant placement.

Fig. 10.26.1 – Clinical aspect before orthodontic treatment: frontal, right and left lateral views.

Fig. 10.26.2 – Clinical aspect after orthodontic treatment (Cortesy of Dr. Onofre Mendes Neto). Implants placed at 12 and 22 regions. The patient has fake teeth attached to the orthodontic wire because the osseointegration period has not been established yet.

Fig. 10.26.3 – Transmucosal component at the region of 12 and adequate space for implant placement.

Fig. 10.26.4 – Transmucosal component at the region of 22 and adequate space for implant placement.

Fig. 10.26.5 – Initial soft tissue conditioning at tooth 12.

Fig. 10.26.6 – Initial soft tissue conditioning at tooth 22.

Fig. 10.26.7 – Working cast to fabricate the provisional crowns.

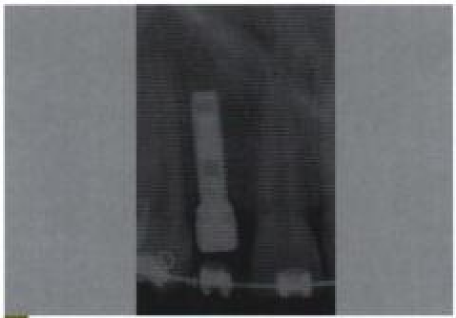
Fig. 10.26.8 – Soft tissue conditioning after three months.

Fig. 10.26.9 – Final clinical aspect. Observe the periimplant tissue.

Fig. 10.26.10 – Clinical aspect of implant papillae (12) six months after soft tissue conditioning. Mesial papillary aspect is still not adequate.

Fig. 10.26.11 – Six months after soft tissue conditioning. Observe the quality of periimplant soft tissue at element 22.

Fig. 10.26.12 – The mesio-distal space is not adequate for metalloceramic crowns at teeth 12 and 22. Cast gold UCLA abutment connected to the implants.



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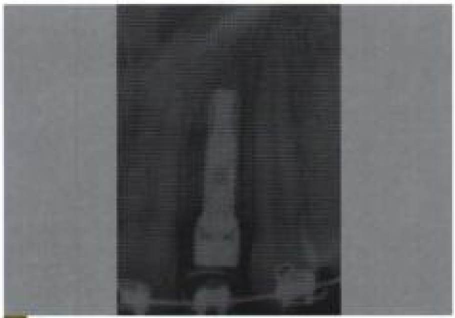

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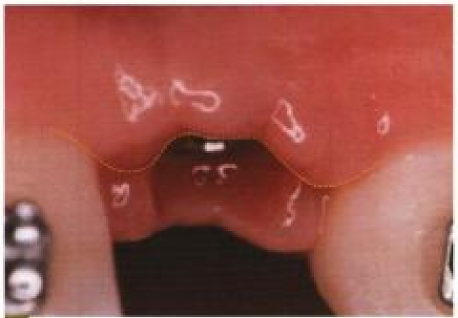

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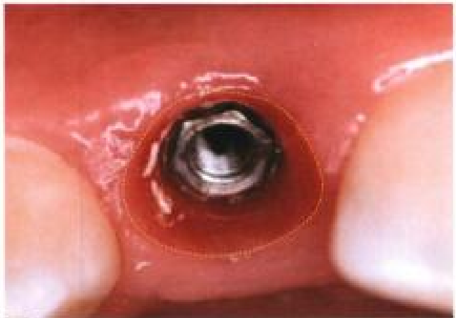

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Fig. 10.26.13 – Procera copings over the abutments.

Fig. 10.26.14 – The copings are tried into the mouth.

Fig. 10.26.15 – Metalloceramic definitive prostheses.

Fig. 10.26.16 – Frontal, right and left lateral views. The patient was not satisfied with the grayish aspect of the metalloceramic crowns. Also, periodontal plastic surgeries will be necessary to improve the cervical contours of teeth 15, 14, 13, 11, 21, 23, 24, and 25. A connective tissue graft will be placed at the region of 21 to improve the implant emergence profile and papillary tissue. At this time (year 2000) we didn't have customized abutments in the Brazilian market. According to this, Procera abutments would be further inserted in the treatment planning.

Fig. 10.26.17 – Lack of soft tissue at buccal aspect of 12.

Fig. 10.26.18 – Bilaminar connective tissue graft at the implant 12.

Fig. 10.26.19 – Sutures placed at teeth 25, 24, 23, and 22, after clinical crown lengthening and connective tissue graft.

Fig. 10.26.20 – Clinical crown lengthening at teeth 11 and 21. Papillary tissue is preserved.

Fig. 10.26.21 – After clinical crown lengthening et teeth 11 and 12.

Fig. 10.26.22 – Sutures placed at teeth 23, 24, and 25 after clinical crown lengthening.

Fig. 10.26.23 – Six months after connective tissue graft. Observe excellent soft tissue profile at the implant 12.

Fig. 10.26.24 – Six months after soft tissue conditioning with metalloceramic crown at implant 22; observe excellent soft tissue profile.

Fig. 10.26.25 – Customized impression copings for final transferring of implants 12 and 22.

Fig. 10.26.26 – Periapical radiographs to confirm impression transfer fit.

Fig. 10.26.27 – Working cast with artificial gingival tissue. Buccal view.

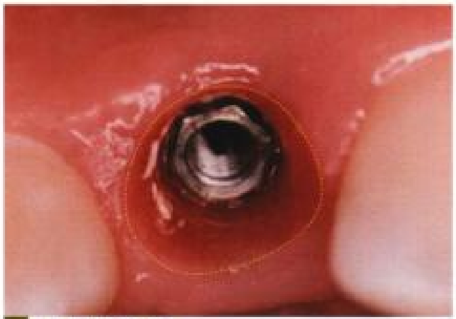
Fig. 10.26.28 – Working cast with artificial gingival tissue. Palatal view.

Fig.10.26.29 – Procera customized abutments at implants 12 and 22.

Fig. 10.26.30 – Procera coping at implant 12.

Fig. 10.26.31 – Procera coping at implant 22.

Fig. 10.26.32 – Porcelain build-up and glazing.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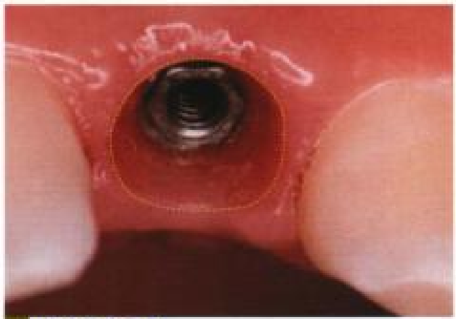
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Fig. 10.26.33 – Procera metal-free crowns cemented on the abutments. Perfect light transmission can be seen after halogen lamp irradiation.

Fig. 10.26.34 – Frontal, right and left lateral views after Procera crowns.

Fig. 10.26.35 – Final clinical aspect with excellent esthetics.

Fig. 10.26.36 – Final clinical aspect. The patient has a high lip line.

Fig. 10.26.37 – Initial and final clinical aspect.

Fig. 10.26.38 – Initial and final frontal aspect.

Fig.10.26.39 – Observe patient smile.

Fig. 10.26.40 – Clinical aspect after 2 years with Procera crown at implant 12. Soft tissue and papillary stability is observed.

Fig. 10.26.41 – Clinical aspect after 2 years with Procera crown at implant 22. Soft tissue and papillary stability is seen.

Fig. 10.26.42 – Frontal view two years later.

Fig. 10.26.43 – Clinical aspect four years later.

10.26.43

Prosthetic component installation

The above cited abutments (except of Multi-unit or microunit) have an internal hex that fit to the external hex of the implants. However, we have experienced that these abutments are sometimes incorrectly installed.

The pre-fabricated abutments have a counter-torque device which adds during abutment fit and final torque. However, a periapical radiograph can confirm whether fit at the top of the implant is adequate or not.

Torque driver

Manual or electronic devices are used to screw or unscrew the abutments to the desired torque levels

Protection caps

All pre-fabricated prosthetic abutments have plastic or metallic protection caps, installed after implant placement, when a provisional prosthesis is not available. The 1.7mm digital screwdriver matches the top of the protection caps.

Cementation protocol

The prostheses must be cemented with zinc phosphate luting agents, applying a thin cement layer at the cervical aspect of the internal axial walls, seated to the abutments and ultra-sonically vibrated for10 seconds with the aim to reduce the cement film thickness.[29] To facilitate the excess cement removal, a thin vaseline layer is applied to the outer cervical aspect of the crown (Fig. 10.27).


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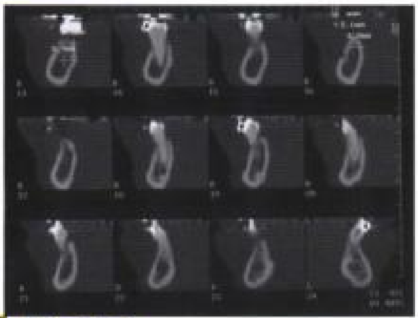
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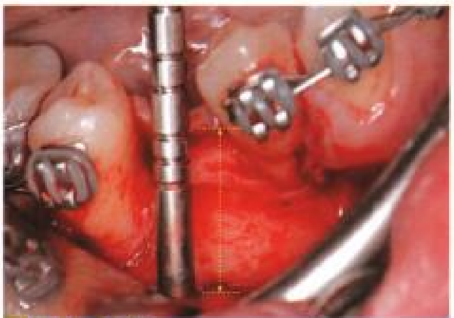
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Patient LAR, 29 years-old, Caucasian female. The patient was unsatisfied with her esthetics. Orthodontic treatment is indicated.

Fig. 10.27.1 – Lateral view. Observe diastema at the lower posterior teeth.

Fig. 10.27.2 – Periapical radiograph after space opening for implant placement.

Fig. 10.27.3 – Computerized tomography. Axial slices for implant planning (4 x 8.5mm).

Fig. 10.27.4 – Clinical aspect showing the lack of keratinized mucosa and buccal vestibule.

Fig. 10.27.5 – Observe the mental nerve.

Fig. 10.27.6 – The implant was placed.

Fig. 10.27.7 – Sutures.

Fig. 10.27.8 – Four months after implant placement. Observe the lack of keratinized mucosa quantity and quality.

Fig. 10.27.9 – Impression transferring procedure.

Fig. 10.27.10 – Working cast with artificial gingiva.

Fig. 10.27.11 – Zirconia customized Procera abutment.

Fig. 10.27.12 – Detailed view of the same abutment.

Fig. 10.27.13 – Procera coping.

Fig. 10.27.14 – Porcelain material over the abutment.

Fig. 10.27.15 – Glazed porcelain.

Fig. 10.27.16 – Procera metal-free crown.

Fig. 10.27.17 – Occlusal view. Procera crown.

Fig. 10.27.18 – Observe the excellent health of periimplant tissues regardless of insufficient keratinized mucosa.

Fig. 10.27.19 – Zirconia abutment. No grayish shade is seen at the cervical margin.

Fig. 10.27.20 – Mechanical torque driver.

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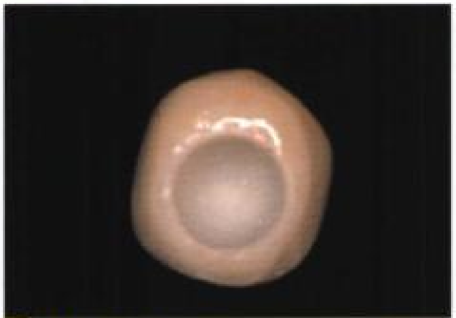

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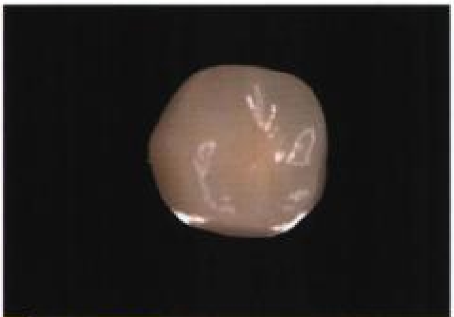

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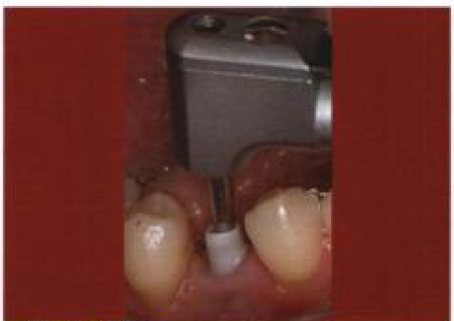

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Fig. 10.27.21 – Vaseline layer applied at the crown margins to facilitate cement excess removal.

Fig. 10.27.22 – Zinc phosphate cement applied at the cervical area of axial walls.

Fig. 10.27.23 – Sonic Flex at the top of the crown for 10 seconds.

Fig. 10.27.24 – Cement excess seen after ultra-sonic vibration.

Fig. 10.27.25 – The cement excess is removed. Observe the excellent clinical aspect.

Fig. 10.27.26 – Clinical aspect. Excellent esthetics provided by the metal-free crown.

Fig. 10.27.27 – Periapical radiograph. Note excellent fit at the crown-implant junction.

Fig. 10.27.28 – Clinical aspect before and after treatment. Observe the occlusal relationships.

Fig. 10.27.29 – Finalized case. Frontal view.

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