



Implant Dentistry at a Glance

Jacques Malet

Francis Mora

Philippe Bouchard

 **WILEY-BLACKWELL**

Implant Dentistry at a Glance

Jacques Malet

Assistant Professor of Clinical Dentistry, Functional Unit in Pathology-Oral Surgery-Periodontics, Rothschild Hospital, A.P.-H.P., Paris, France

Francis Mora

Associate Professor, U.F.R. of Odontology, Paris Diderot-Paris 7 University France
Functional Unit in Pathology-Oral Surgery-Periodontics, Rothschild Hospital,
A.P.-H.P., Paris, France

Philippe Bouchard

Professor, U.F.R. of Odontology, Paris Diderot-Paris 7 University France,
Head of the Functional Unit in Pathology-Oral Surgery-Periodontics, Rothschild
Hospital, A.P.-H.P., Paris, France

This edition first published 2012
© 2012 by John Wiley & Sons, Ltd

Wiley-Blackwell is an imprint of John Wiley & Sons, formed by the merger of Wiley's global Scientific, Technical and Medical business with Blackwell Publishing.

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
2121 State Avenue, Ames, Iowa 50014-8300, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

The right of the author to be identified as the author of this work has been asserted in accordance with the UK Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Library of Congress Cataloging-in-Publication Data
Malet, Jacques.

Implant dentistry at-a-glance / Jacques Malet, Francis Mora, Philippe Bouchard.
p. : cm. – (At a glance)
Includes bibliographical references and index.
ISBN 978-1-4443-3744-0 (pbk. : alk. paper)
I. Mora, Francis. II. Bouchard, P. (Philippe) III. Title. IV. Series: At a glance series
(Oxford, England)
[DNLM: 1. Dental Implantation. 2. Dental Implants. 3. Oral Surgical
Procedures—methods. WU 640]
617.6'93—dc23

2011034242

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Set in 9/11.5 pt Times by Toppan Best-set Premedia Limited, Hong Kong

Contents

Preface	5
List of abbreviations	7
1. The basics: osseointegration	8
2. The basics: the peri-implant mucosa	10
3. The basics: surgical anatomy of the mandible	12
4. The basics: surgical anatomy of the maxilla	14
5. The basics: bone shape and quality	16
6. Implant macrostructure: shapes and dimensions	18
7. Implant macrostructure: implant/abutment connection	20
8. Implant microstructure: implant surfaces	22
9. Success, failure, complications, and survival	24
10. The implant team	26
11. Patient evaluation: medical evaluation form and laboratory tests	28
12. Patient evaluation: the patient at risk for surgery	30
13. Patient evaluation: the patient at risk for dental implant failure	32
14. Patient evaluation: local risk factors	34
15. Patient evaluation: dental history	36
16. Patient evaluation: dental implants in periodontally compromised patients	38
17. Patient evaluation: esthetic considerations	40
18. Patient evaluation: surgical considerations	42
19. Patient evaluation: surgical template	44
20. Patient evaluation: imaging techniques	46
21. Patient records	48
22. The pretreatment phase	50
23. Treatment planning: implant selection	52
24. Treatment planning: the provisional phase	54
25. Treatment planning: immediate, early, and delayed loading	56
26. Treatment planning: single-tooth replacement	58
27. Treatment planning: implant-supported fixed partial denture	60
28. Treatment planning: fully edentulous patients	62
29. Treatment planning: edentulous mandible	64
30. Treatment planning: edentulous maxilla	66
31. Surgical environment and instrumentation	68
32. Surgical techniques: socket preservation	70
33. Surgical techniques: the standard protocol	72
34. Surgical techniques: implants placed in postextraction sites	74
35. Surgical techniques: computer-guided surgery	76
36. Bone augmentation: one-stage/simultaneous approach versus two-stage/staged approach	78
37. Bone augmentation: guided bone regeneration	80
38. Bone augmentation: grafts materials	82
39. Bone augmentation: block bone grafts	84
40. Bone augmentation: split osteotomy (split ridge technique)	86
41. Bone augmentation: sinus floor elevation	88
42. Bone augmentation: alveolar distraction osteogenesis	90
43. Soft tissue augmentation	92
44. Dental implants in orthodontic patients	94
45. Prescriptions in standard procedure	96
46. Postoperative management	98
47. Life-threatening surgical complications	100
48. Surgical complication	102
49. Dental implant maintenance	104
50. Peri-implant diseases	106
Appendices	109
A. Glossary	109
B. Basic surgical table and instrumentation	111
C. Preparation of the members of the sterile team	112
D. Medical history form	113
E. Consent form for dental implant surgery	118
F. Postoperative patient records: stage 1	121
G. Postoperative patient records: stage 2	122
H. Postoperative instructions	123
I. Treatment planning: fully edentulous patient	125
J. Overdenture supported by two implants: surgical procedure	127
K. Overdenture supported by two implants: prosthetic procedure	128
L. Fixed prosthesis (mandible) supported by four implants	129
M. Fixed prosthesis (maxilla) supported by four implants	130
N. Bone regeneration	131
References and further reading	132
Index	139

Preface

In the 1970s, the biological concept of osseointegration applied to the dental field changed the face of dentistry by offering us a completely new approach to the treatment of edentulism (Branemark *et al.*, 1977). However, dental implant therapy is a relatively young area of interest in dentistry. This textbook, designed to cover the essentials of dental implant therapy, was a challenging undertaking because unknowns still exist, and part of the decision-making process is based on personal experience of clinicians. We made an effort to emphasize the evidence-based approach when information was available. Nevertheless, some of the chapters are based on our personal experience in dental implant therapy and may therefore be challenged by other clinicians according to their skills.

Based on the above considerations, the present book does not deal with all types of dental implants but with the threaded root-form osseointegrated implants, which are the most used in practice and the best documented in the medical literature.

Our work is adapted to the needs and use of the general practitioner and students; consequently all the surgical procedures described in the present volume can be performed under local anesthesia. In the same vein, we do not include sophisticated procedures such as zygomatic implants that are beyond the scope of our intention. However, we also hope that this book may help the specialist in his/her decision-making process.

The number of dentists placing dental implants is increasing annually. Markets for dental implants are anticipated to reach \$8.1 billion by 2015 (WinterGreen Research Report, 2009). More than 1000 types of dental implants are commercially available and are manufactured by competing companies. In Europe, four companies capture close to 60% of the market (Millennium Research Group, 2009). It is understandable that companies actively participate in basic and clinical research as well as in the continuing education of general practitioners. We have tried, as much as possible, to avoid the pitfalls of commercial pressure, striving to avoid brand citations and adhering closely to the basic principles of implant therapy.

Dental implant therapy deals with two inter-related components: dental implant placement and achievement of the implant-retained prosthesis. The first is a surgical procedure; the second is the visible part of the iceberg, i.e. the procedure of replacing missing teeth by artificial reconstructions that mimic natural ones. It may be assumed that any general practitioner or, preferably, any integrated dental team can perform, with minimal training, both the surgical and the prosthetic procedures in simple cases. However, tremendous advances in dental implant surgery have increased the complexity of the techniques and the indications for dental implant therapy. We thus decided to emphasize the surgical part of this textbook in order to highlight the broader indications that are nowadays possible thanks to new surgical approaches. Excellent textbooks that detail prosthetic procedures in dental implant reconstruction are available.

It is evident that the biological concept of osseointegration has introduced one of the most significant breakthroughs in clinical dentistry over the past quarter century. The use of osseointegrated dental implants is now considered as a predictable treatment of partial and full edentulism. Bone and soft tissue augmentation procedures have expanded the treatment options, allowing dental implant placement in almost all clinical situations. Advances in the use of growth factors

for the treatment of localized ridge augmentation are promising. Recent data on the survival rate of short implants (less than 10mm) may challenge the use of sophisticated surgeries. In addition, new ultrasonic surgery units, surgical instruments, and products have improved the quality of the procedures and patient comfort. Thus, a functional and cosmetic implant-borne restoration can be provided to the wide majority of patients, even if esthetics remains the most challenging criterion to fulfill.

Apart from rare, strict medical contraindications, dental implant therapy seems to be a “no-limit” approach for the replacement of missing teeth. The extraordinary confidence in dental implants has positioned implant dentistry at the forefront of treatment choices for any type of edentulism, leading to extraction of teeth that may be treatable using conventional procedures. Although an overall 19-year survival rate of 82–94% has been reported in oral implants, we must keep in mind that tooth longevity in well-maintained periodontal patients surpasses implant longevity after 10 years of observation (Holm-Pedersen *et al.*, 2007). Thus, the dentist should counsel the patient to retain their teeth if possible.

Finally, one of the major drawbacks of dental implant therapy is its immediate cost. Several studies have found that the prevalence of tooth loss was higher in low socio-economic groups than in high socio-economic groups. Consequently, dental implant therapies are strongly beneficial for low-income patients. In the 1990s, the tendency of some clinicians to install as many implants as possible in full edentulism was questioned (Branemark *et al.*, 1995). Currently, a mandibular two-implant overdenture is the minimum standard of care for edentulous patients (Feine, 2002). In other situations, it has been shown that the retention throughout life of a minimum of 20 teeth with 9–10 pairs of contacting units, including anterior teeth, is sufficient for adequate masticatory efficiency and masticatory ability (WHO, 1992; Gotfredsen & Walls, 2007). This minimum goal can often be achieved by implant-supported prostheses. Based on these findings, it is possible to improve the quality of life of edentulous patients by using a limited number of implants, which reduces the overall cost of the procedure.

We hope that this book will help the reader to better understand the clinical advantages and technical limits of this revolution that is dental implant therapy. We also hope that the reader will never forget that *any elective procedure in the field of medical care aims to improve quality of life*, and therefore must be centered on patient expectations.

Philippe Bouchard

References

- Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, Ohman A. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg* 1977; 16(Suppl):1–132.
- Brånemark PI, Svensson B, van Steenberghe D. Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism. *Clin Oral Implants Res* 1995;6(4):227–231.
- Feine JS, Carlsson GE, Awad MA *et al.* The McGill Consensus Statement on Overdentures. Montreal, Quebec, Canada. May 24–25, 2002. *Int J Prosthodont* 2002;15(4):413–414.

Gotfredsen K, Walls AW. What dentition assures oral function? Clin Oral Implants Res 2007;18(Suppl 3):34–45.

Holm-Pedersen P, Lang NP, Muller F. What are the longevities of teeth and oral implants? Clin Oral Implants Res 2007;18(Suppl 3):15–19.

Millennium Research Group. European markets for dental implants 2009. www.mrg.net.

WinterGreen Research Report. Worldwide nanotechnology dental implant market shares, strategies, and forecasts, 2009 to 2015. www.researchandmarkets.com/reportinfo.asp?report_id=941893&t=d&cat_id=.

World Health Organization. Recent advances in oral health. WHO Technical Report Series No. 826. Geneva: WHO, 1992, pp.16–17.

Acknowledgments

We would like to acknowledge the following colleagues for providing the figures listed:

- Dr Catherine Artaud: Chapter 13, Figure 3.
- Dr May Feghali: Chapter 19, Figure 3.
- Dr Murielle Molla: Chapter 13, Figure 2.
- Dr Alexandre Sueur: Chapter 24, Figure 3.

We are very grateful to Professor Pierre Carpentier (Chapters 3 and 4), Dr Olivier Fromentin (Chapter 26), Dr Leonardo Matossian (Chapter 44), Professor Jean-Michel Sautier (Chapter 1), and Mrs Elyse Michael-Berger for their contribution to our book.

Dedications

Dr Jacques Malet wishes to thank his children, Jeanne, Lou, Leo and Victor for their love and support; and would like to dedicate this book to his wonderful wife Lisa.

Dr Francis Mora wishes to thank his wife Anne-Sophie, his wonderful children, Paul-Louis, Victor and Josephine, for their ever-present love and devotion; he dedicates this book to his mother and to the memory of his father who has taught him the importance of the family.

Professor Philippe Bouchard dedicates this book to his children, Raphaële, Benjamin and Clément, parents, Jacques and Jacqueline, for

the invaluable love they have shared over the years; and to Catherine for her love, support and encouragement in the preparation of this book.

The authors also wish to thank the teachers, post-graduate students, and staff at the Department of Periodontology at the Hospital Rothschild (AP-HP, France).

A special debt of gratitude to Professor Jean Pierre Ouhayoun and Dr Daniel Etienne, our mentors, without whom this book would not have been.

List of abbreviations

AED	automated external defibrillator	FPDP	fixed partial dental prosthesis
APF	apically positioned flap	GBR	guided bone regeneration
BBM	bovine bone mineral	IRO	implant-retained overdenture
BIC	bone-to-implant contact	ISC	implant single crown
BMP	bone morphogenetic proteins	ISR	implant survival rate
BOP	bleeding on probing	NSAID	non-steroidal anti-inflammatory drug
BRONJ	bisphosphonate-related osteonecrosis of the jaw	OFD	open flap debridement
CBCT	cone beam computed tomography	OR	odd ratio
CT	computed tomography	PD	probing depth
DBB	deproteinized bovine bone	PRP	platelet-rich plasma
DFDB	demineralized freeze-dried bone	PTFE	polytetrafluoroethylene
e-PTFE	expanded polytetrafluoroethylene	RF	rotational flap
FGG	free gingival graft	SECTG	subepithelial connective tissue graft
FPD	fixed partial denture		

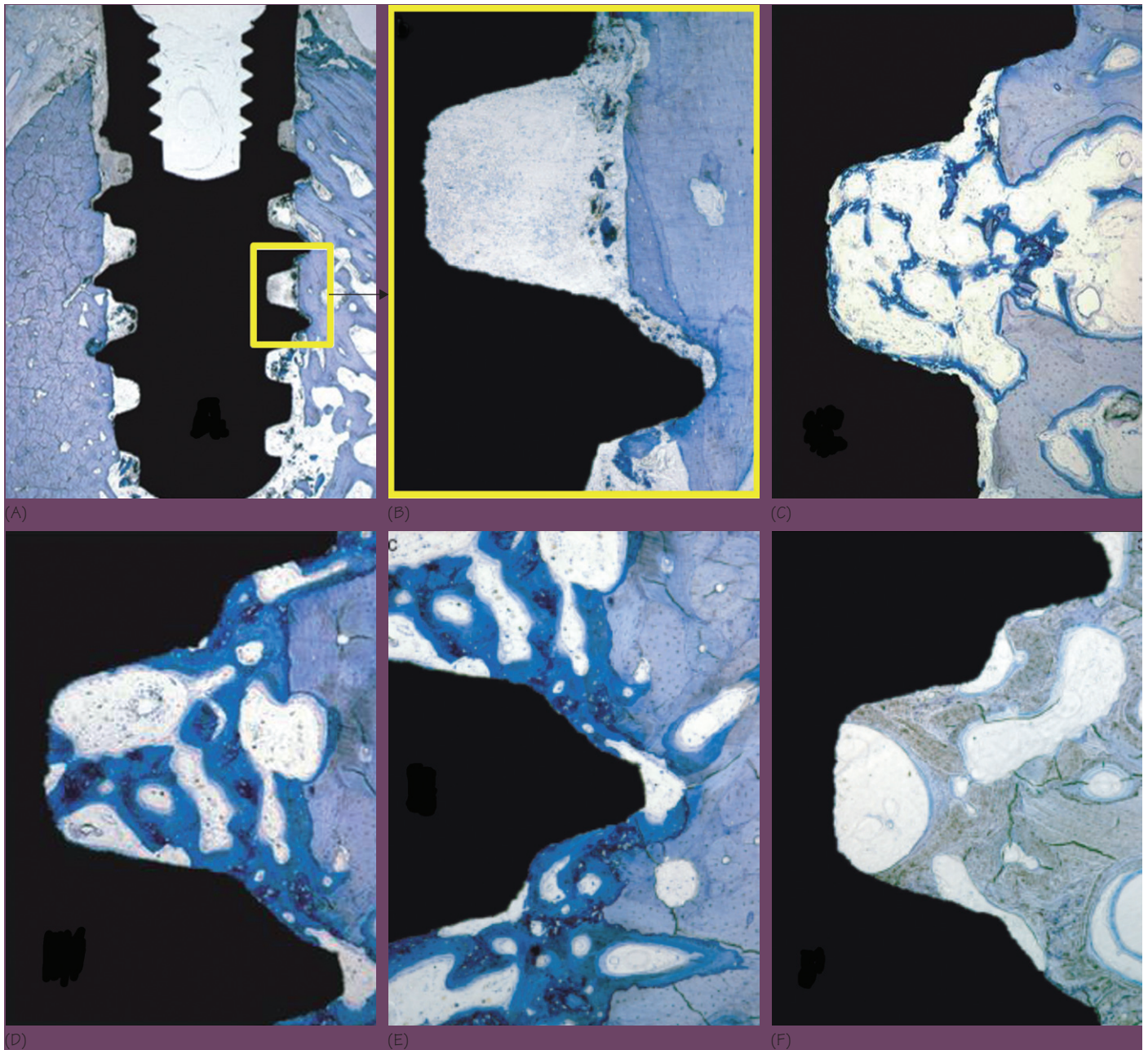


Figure 1.1 Healing phases of “non-cutting” dental implants placed in Labrador dogs (Berglundh *et al.*, 2003). (A,B) Four days of healing. The fibrin clot has been replaced by granulation tissue. (C) One week. Woven bone formation. (D,E) Four weeks. The newly formed bone includes woven bone combined with lamellar bone. In the pitch regions, the bone remodeling appears to be intense (E). (F) Twelve weeks. Mature bone (lamellar bone and marrow) is in close contact with the implant and covers most of the surface. Reproduced with permission from John Wiley and Sons.

The aim of the surgical procedure for implant placement is to prepare, in an atraumatic manner, an intraosseous bed into which a dental implant is inserted. Following soft tissue elevation, a channel is drilled into the cortical and spongy bone and the dental implant (screw type titanium device), slightly wider than the channel, is slowly inserted within the “implant bed” (the channel) surgically created.

The compression of the bone surrounding the implant reduces the peripheral vasculature, and the lack of an adequate blood supply leads to a non-vital tissue at the bone/implant interface. The inflammatory response to the surgical injury aims to remove the damaged tissues and to initiate the healing process leading to osseointegration, i.e. *the direct connection between newly formed bone and the metal device*.

Implant neck

The initial stability of the interface between the implant and the mineralized bone is a critical factor to initiate the osseointegration process. The primary stability of the dental implant is often achieved at the cortical bone level. In the cortical compartment at the implant neck, the non-vital lamellar bone is first resorbed before new bone formation occurs onto the implant surface.

Implant body

At the implant body, in the cancellous compartment, the wound healing includes the following phases (Berglundh *et al.*, 2003; Abrahamsson *et al.*, 2004).

1 Clot formation

The blood fills the space between the threads of the implant. Erythrocytes, neutrophils, and macrophages are trapped in a fibrin network. The fibrin clot is replaced by granulation tissue. Mesenchymal cells and blood vessels proliferate in the new granulation tissue, which is rich in collagen fibers (Fig. 1.1A,B).

2 Bone modeling

A first line of osteoblasts, migrating from bone marrow, invades the granulation tissue. After one week an osteoid matrix is observed in the mesenchymal tissues surrounding the blood vessels. In the osteoid, deposition of hydroxyapatite leads to woven bone formation (immature bone). Woven bone formation (Fig. 1.1C) is associated with increased local angiogenesis. The woven bone is characterized by randomly oriented collagen fibrils, numerous osteocytes, and low mineral density. It fills the space between the implant threads, constructing the first bony bridges between the inner bony wall of the surgical channel and the external surface of the dental implant. This

direct contact between the woven bone and the implant surface represents the first phase of the osseointegration. Gradually, woven bone covers most of the implant surface.

3 Bone remodeling

During subsequent weeks, concentric layers of lamellar bone (osteon) are seen in the newly formed tissue (Fig. 1.1D,E). Woven bone is progressively replaced by lamellar bone and marrow (mature bone) (Fig. 1.1F). The lamellar bone is the strongest type of newly formed bone, and the most elaborate type of bone tissue; it is composed of collagen fibrils densely packed into parallel layers with alternating courses.

Implant loading

Micromovements along the bone/implant interface have a tolerance limit during the healing phase, and micromotion beyond this tolerance limit may result in connective tissue encapsulation of the implant body. On the other hand, it has been shown that immediate occlusal loading can present a high level of bone-to-implant contact (BIC) in humans. It must be understood that the degree of achieved primary stability depends on several factors including bone density and quality, implant shape, design and surface characteristics, and surgical technique.

Once the healing phase completed, i.e. after about 3 months, BIC is not 100%. It has been shown that functional loading of dental implants may enhance BIC value (Berglundh *et al.*, 2005). This important finding indicates that the biological process of osseointegration is continuous, related to bone remodeling, and does not stop with the healing phase, and that a site-specific bone adaptation response to mechanical loading may result in increasing osseointegration over time. This emphasizes the importance of controlling the occlusal load as well as the bacterial load during the maintenance phase.

Key points

- The surgical technique should be as atraumatic as possible.
- Good primary stability is a key factor in the osseointegration process.
- The degree of achieved primary stability depends on several factors.
- After the healing phase, functional loading of dental implants may enhance BIC value.

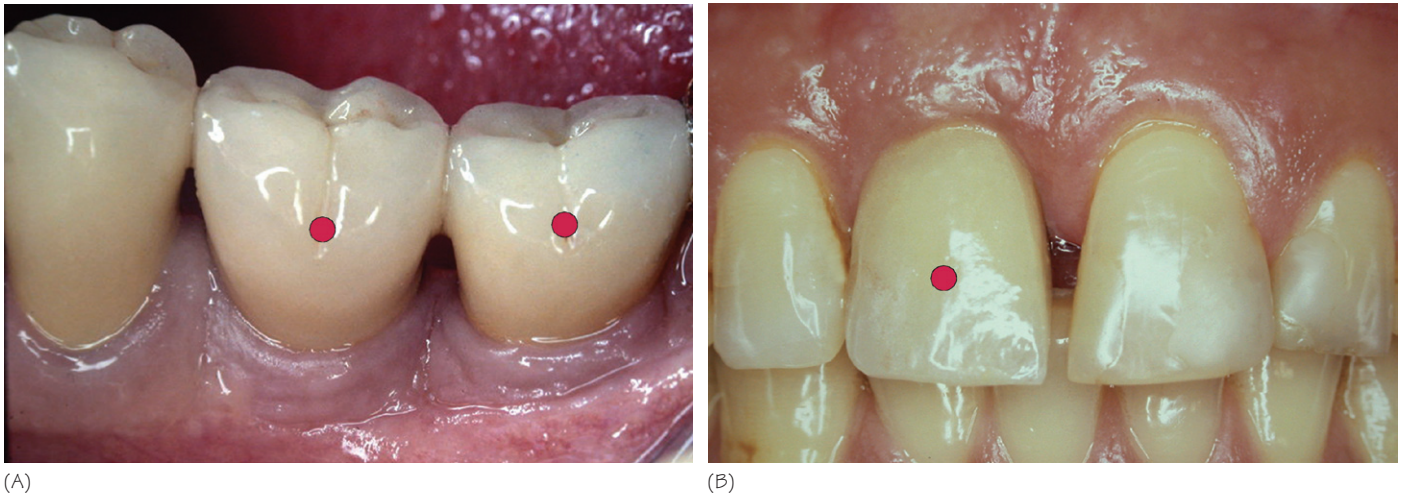


Figure 2.1 (A,B) Clinical appearance of the peri-implant mucosa. Red circles indicate the implant-supported prosthesis.

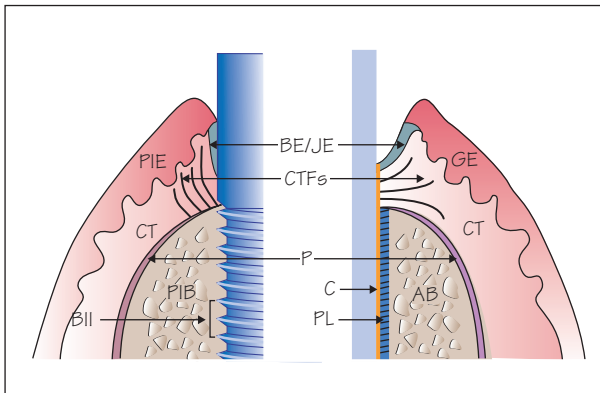


Figure 2.2 Histological differences between tooth and dental implant. AB, alveolar bone; BE, barrier epithelium; BII, bone/implant interface; C, cementum; CT, connective tissue; CTF, connective tissue fibers; GE, gingival epithelium; JE, junctional epithelium; P, periosteum; PIB, peri-implant bone; PIE, peri-implant epithelium; PL, periodontal ligament.

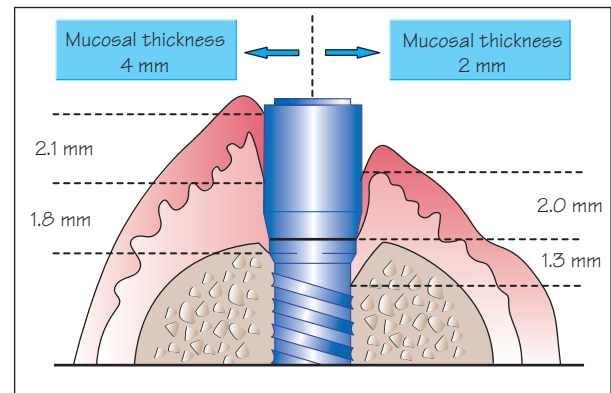


Figure 2.3 The biological width around dental implants.

After implant placement, a delicate mucosal attachment is established. The peri-implant mucosa is sealed to the implant surface to protect the bone tissue, and to prevent the penetration of micro-organisms and their products. Limited data exist in humans. Most of the following information is extrapolated from animal studies. Thus, data on healing time might not always be directly transferable to the clinical situation.

The peri-implant mucosa results from the healing process of the soft tissues surrounding the implant following the closure of the flap around the transgingival part of the implant.

From a clinical point of view, the outer surface of the peri-implant mucosa is covered by a keratinized oral epithelium. It has a pink color and a firm consistency, and does not differ from the clinical appearance of the gingiva (Fig. 2.1A, B). The peri-implant mucosa clinical dimension tends to be thicker and lower in height than the gingiva surrounding teeth.

From a histological point of view, compared to the periodontal model, the dental implant model has the following main features (Fig. 2.2):

- lack of cementum
- lack of periodontal ligament
- the attachment apparatus is different
- the collagen/fibroblast ratio is different.

Soft tissue interface dimensions

The epithelium barrier is about 2 mm long, and the connective tissue seal is 1–1.5 mm high.

These dimensions are maintained whatever the thickness of the mucosa. This means that when the mucosa is thin (i.e. ≤ 2 mm), bone resorption occurs to maintain these soft tissue dimensions. In short, as for teeth, a *biological width* must be respected around implants (Fig. 2.3).

Soft tissue seal

The epithelium barrier is sealed to the implant surface via hemidesmosomes and must be considered as identical to that of the epithelial seal around teeth.

The connective tissue compartment is in direct contact with the implant surface. The connective fibers are parallel to the implant surface without attachment to the metal body (adhesion). Consequently, the resistance to probing around implants is decreased as compared to that around teeth. However, when probing in healthy tissues, the tip of the probe seems to reach similar levels at the implant and tooth sites. Marginal inflammation around implants is associated with a deeper probe penetration as compared to that around teeth.

Soft tissue components

Compared to the gingiva, the peri-implant mucosa exhibits more collagen fibers, fewer fibroblasts, and fewer vessels.

Soft tissue healing

Due to the lack of the vascular plexus of the periodontal ligament, the implant blood supply comes from two sources: the peri-implant mucosa and the suprapariosteal blood vessels.

A mature barrier epithelium is seen after 8–9 weeks of healing, and the collagen fibers are organized after 4–6 weeks of healing.

The potential for repair is limited due to the:

- lack of periodontal ligament
- reduction of the cellular components of the mucosa
- reduced vascularization.

Key points

- The peri-implant mucosa is sealed, and not attached to the implant.
- A biological width is maintained, whatever the thickness of the mucosa.
- Compared to the gingiva, the peri-implant mucosa is a scar-like tissue, rich in collagen fibers, poor in fibroblasts, and with limited blood supply.
- The potential for repair is more limited than with gingival tissue.

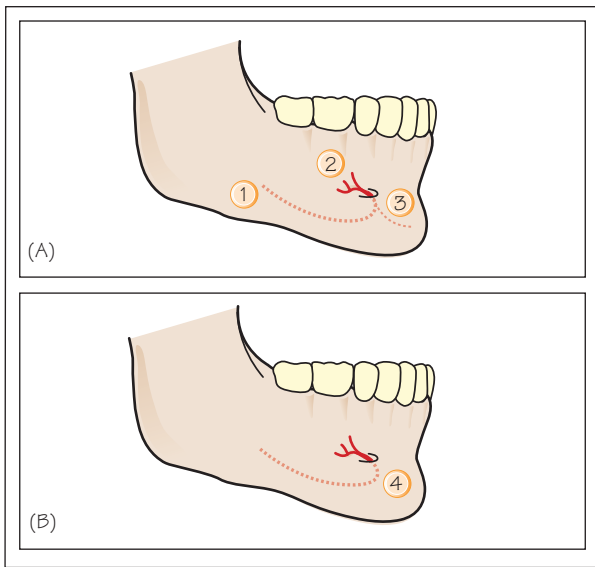


Figure 3.1 Mandible: mental foramen. Two anatomical variations of the inferior alveolar nerve. (A) Anterior extension: incisive canal. (B) Anterior loop. 1. Inferior alveolar nerve; 2. mental nerve; 3. incisive canal; 4. anterior loop of the inferior alveolar nerve.

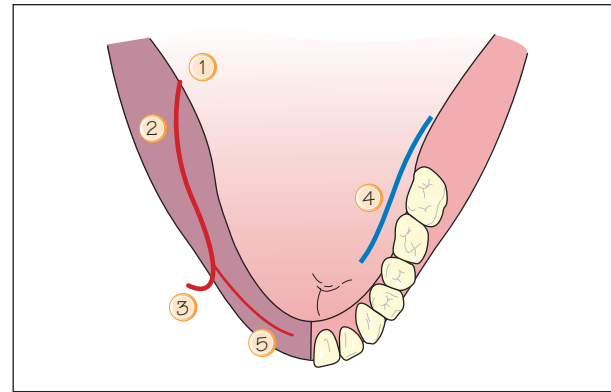


Figure 3.2 Mandible: horizontal section/occlusal view. 1. Mandibular foramen; 2. mandibular canal (inferior alveolar nerve); 3. mental foramen; 4. lingual nerve; 5. incisive canal.

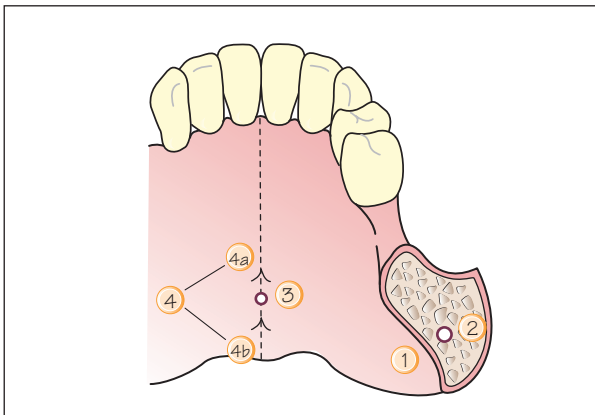


Figure 3.3 Mandible: posterior vertical section. 1. Lingual cortex concavity: submandibular fossa; 2. mandibular canal (inferior alveolar nerve); 3. lingual foramen; 4. mental spines: (a) genioglossus, (b) geniohyoid.

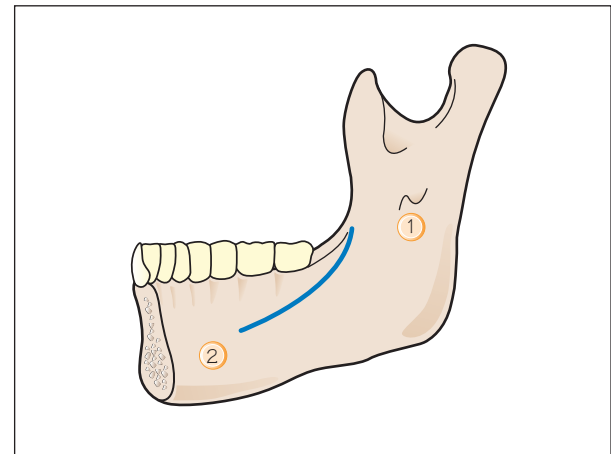


Figure 3.4 Mandible: lingual view. 1. Mandibular foramen; 2. lingual nerve.

Placing dental implants requires access to bone tissue (usually by raising a flap) to achieve an osteotomy. The handling of soft tissues (gingiva and alveolar mucosa), and bone osteotomy must respect some anatomical structures to avoid injuries leading to damage which may be difficult to manage: reversible or irreversible nerve injury, hemorrhage, and intrusion into unwanted anatomical areas. The risk level (high, moderate, low) and the approach to prevention will be described.

ANTERIOR AREA

This region is usually considered at low risk for surgical damage. However, some anatomical structures have to be identified.

The *incisive canal* (Figs 3.1 and 3.2) is an anterior extension of the *mandibular canal* with neurovascular content. The lesion of this structure usually has no clinical consequences except in the first premolar area and sometimes in the canine area.

The *lingual foramen* (Fig. 3.3) can be observed on X-rays or CT scan in more than 80% of subjects near the *mental spines*. A branch of the sublingual artery enters the foramen to supply the bone.

Neurovascular structures

Osseous: *incisive nerve* in the *incisive canal*

Buccal: *mental artery, submental artery, mental nerve*

Lingual: *sublingual artery*

Key points

Sublingual and submental artery (moderate risk). In the lateral incisor or canine region, the risk of damage to the artery cannot be ignored when a basal mandibular perforation is performed during osteotomy, resulting in potential bleeding in the oral floor and the parapharyngeal space. Elevation of the periosteum of the lingual aspect during surgery and adequate compression or ligature will prevent problems.

POSTERIOR AREA

The *inferior alveolar nerve* (see Fig. 3.2) enters the mandibular ramus distally through the *mandibular foramen* and runs in the *mandibular canal*, from the lingual to the labial side. At the *mental foramen* (most often between the first and second premolar) it becomes the *mental nerve* which divides into three branches for the skin and gingiva. The mean distance between alveolar crest and superior margin of the mental foramen is about $10\text{mm} \pm 5\text{mm}$, in non edentulous areas. Occasionally, the *inferior alveolar nerve* describes an anterior loop (see Fig. 3.1).

Rare variations (bifid mandibular canal, multiple foramina) have been described.

The posterior area of the mandibular body often shows lingual concavities (see Fig. 3.3) facing the submandibular gland.

The *lingual nerve* (Figs 3.2 and 3.4) runs near the inner surface of the mandible in the region of the wisdom tooth, and then has an oblique course forward and inward, down to the tip of the tongue.

Neurovascular structures

Osseous: *inferior alveolar nerve, inferior alveolar artery*

Buccal: *buccal nerve, facial artery branches, mental nerve*

Lingual: *lingual nerve*

Key points

- *Inferior alveolar nerve* (high risk): laceration or compression of the nerve in the *mandibular canal* or section of the anterior loop during osteotomy will result in permanent paresthesia. Precise 3D preoperative imaging (CT scan or CBCT) is thus essential in this region.
- *Mental nerve* (moderate risk): section (during dissection) or compression (with instruments) of the *mental nerve* can occur. This is why good visualization of the *mental foramen* is recommended during surgery.
- *Lingual nerve* (moderate risk): injury or compression of the *lingual nerve* can occur when raising a full-thickness lingual flap, if the technique is not careful enough.

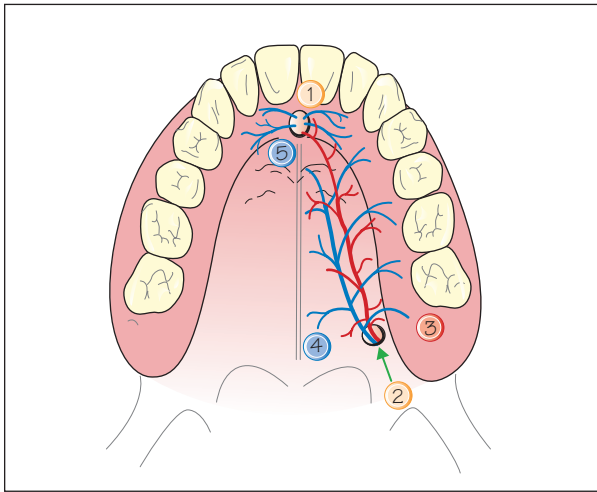


Figure 4.1 Maxilla: palatal view. 1. incisive foramen; 2. greater palatine foramen; 3. descending palatine artery; 4. greater palatine nerve; 5. nasopalatine nerves.

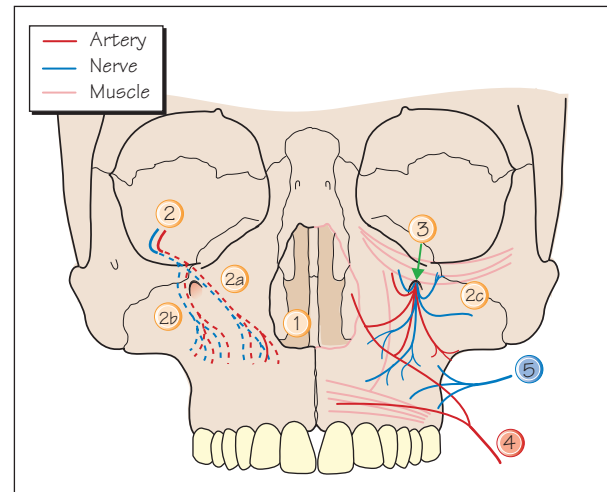


Figure 4.2 Maxilla: front view. *Right side:* intra-bony structures: 1. Nasal cavity; 2. infraorbital artery and nerve; 2a. anterior superior alveolar arteries and nerves; 2b. middle superior alveolar arteries and nerves; 2c. infraorbital artery and nerve branches; 3. infraorbital foramen; 4. facial artery and superior labial artery; 5. facial nerve.

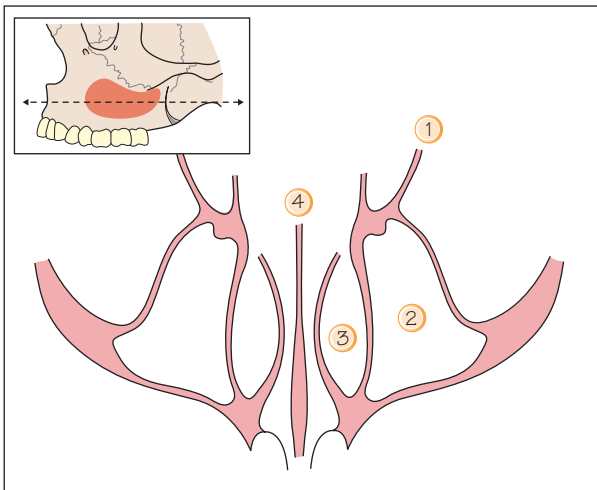


Figure 4.3 Maxilla: horizontal section. 1. Lateral pterygoid plate; 2. maxillary sinus; 3. inferior nasal meatus; 4. nasal septum.

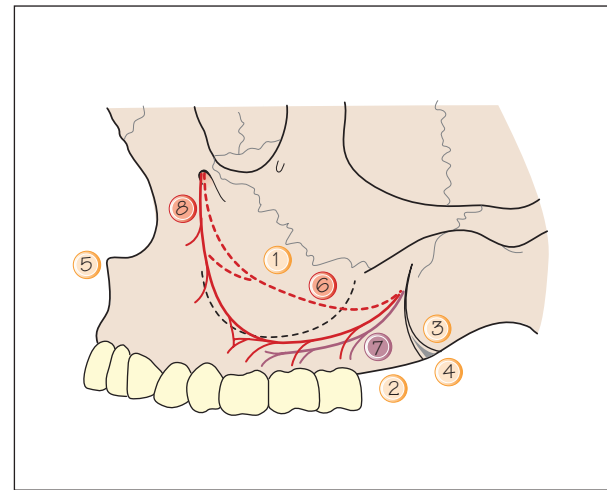


Figure 4.4 Maxilla: lateral view. 1. Maxillary sinus; 2. maxillary tuberosity; 3. lateral pterygoid plate; 4. palatine bone (pyramidal process); 5. anterior nasal spine; 6. alveolar antral artery; 7. posterior superior alveolar artery and nerve; 8. infraorbital artery branch.

ANTERIOR AREA

Located between the anterior walls of the maxillary sinus, this area is usually of good bone quality. The region is apically limited by the *nasal cavity* (Fig. 4.1) that communicates with the *maxillary sinus* (through the middle meatus). Slight penetration or perforation of the *nasal floor* may be uneventful.

The canine region is a strategic area due to mechanical stress dispersion.

The *incisive foramen* (continuous with the *incisive canal*) is located between the two medial incisors, slightly palatal (see Fig. 4.1). Its volume can prevent implant placement. Its content is not essential (accessory vascularization and innervation) and can be replaced by a bone graft or substitute to improve the bone bed.

Neurovascular structures

Buccal (Fig. 4.2)

Intra-bony structures:

- *infraorbital artery* branches: *anterior superior alveolar arteries*
- *infraorbital nerve* terminal branches: *anterior superior alveolar nerves*.

Soft tissue structures (labial vestibule):

- *infraorbital artery* branches
- *infraorbital nerve* terminal branches
- *facial artery* (*superior labial artery*) and *facial nerve* branches.

Palatal (see Fig. 4.1)

Incisive foramen and *incisive canal*: final branches of the *greater palatine artery* running to the *nasal cavity*, and *nasopalatine nerves* coming from the *nasal cavity*.

Key points

The risk is low, but we recommend avoiding penetration of the nasal floor and staying away from the incisive foramen (or removing its content if necessary).

POSTERIOR AREA

This region is characterized by limited bone volume (due to the presence of the *maxillary sinus*) and poor bone quality.

The *maxillary sinus* is a large aerial cavity lined with a thin membrane. Slight penetration or perforation of the sinus floor in a healthy sinus can be uneventful.

Maxillary sinus and advanced surgeries

Sinus lift procedures are indicated to augment bone volume in this region. This surgery is frequently complicated by the presence of septa in the *maxillary sinus*. Septa occur in about 30% of sinuses, and they are most commonly located in the first and second molar area. The permeability of the *maxillary sinus ostium* must be checked before surgery.

Tuberosity and *pterygopalatine* region (Figs 4.3 and 4.4): in order to avoid the sinus region, the *tuberosity* can be used for implant placement. Occasionally, primary stabilization could be necessary in the suture (*palatine bone-ptyergoid process-maxillary tuberosity*).

Neurovascular structures

Buccal (see Fig. 4.4)

Maxillary artery branches: *posterior superior alveolar artery*, *alveolar antral artery*.

Maxillary nerve branches: *posterior superior alveolar nerve*, *middle or anterior superior alveolar nerve*.

Cheek: *facial artery* and *facial nerve* branches.

Palatal (see Fig. 4.1)

Greater palatine artery branches, *greater palatine nerve* branches, *greater palatine foramen*:

on the palatal side the *greater palatine foramen* (located in the hard palate near the second or third molar apex) contains a large vessel: the *greater palatine artery*. The artery runs along the alveolar process and hard palate corner in a more or less deeper groove, to reach and penetrate the incisive canal after giving off a lot of small branches.

Key points

- *Alveolar antral artery* (moderate risk): hemorrhage during sinus lift procedures (see Chapter 41) can occur, by sectioning the artery during the osteotomy. It is recommended to locate the artery on CT scan and then in the sinus wall during osteotomy, and to avoid it if possible.
- *Greater palatine artery* (moderate risk): hemorrhage during soft tissue graft harvesting. The risk is limited if the technique is performed carefully. Incisions must be distant from the *greater palatine foramen*. (High risk): hemorrhage during posterior implant placement into the greater palatine canal will reach the soft palate and the parapharyngeal space. Precise knowledge of the *greater palatine canal* localization and of the pathway of the neurovascular pedicle is recommended.

5

The basics: bone shape and quality

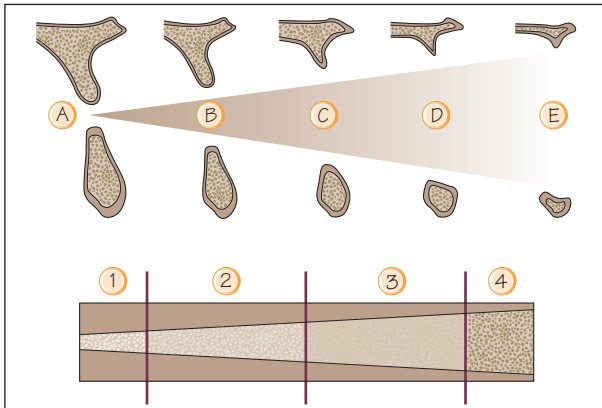


Figure 5.1 Classification of the host bone. (A-E) Bone shape. (Group 1 to Group 4) Bone quality: 1. cortical bone; 2. dense cortico-cancellous bone; 3. sparse cortico-cancellous bone; 4. thin cortical and very sparse medullar bone.

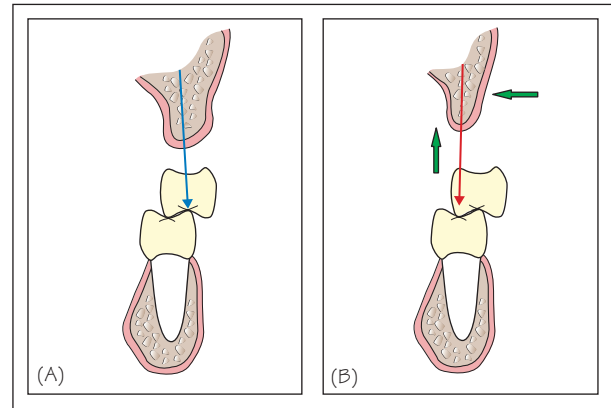
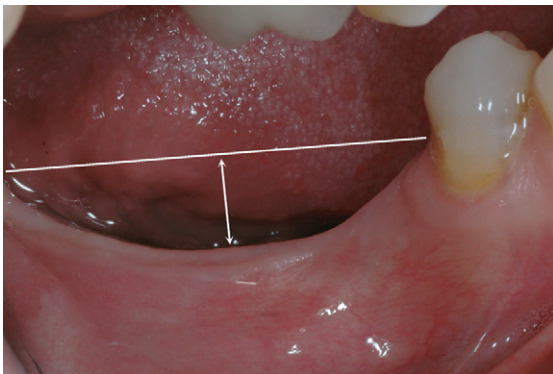
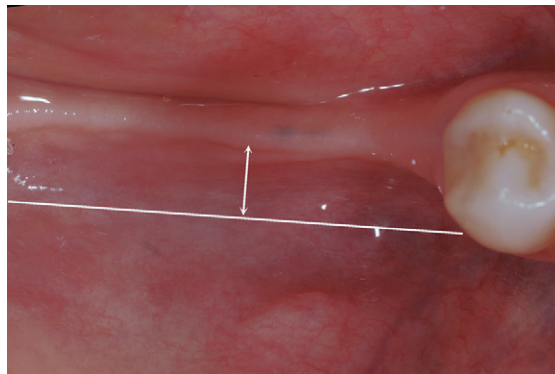


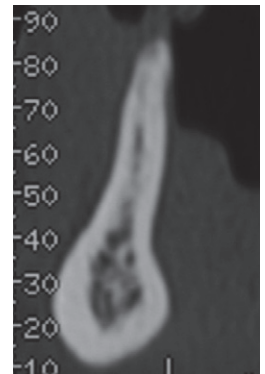
Figure 5.2 Bone volume resorption and interocclusal relationship. (A) The axis of the dental implant and the natural axis of the tooth are similar (blue arrow) when the postextractional bone resorption is moderate. (B) After advanced vertical and horizontal bone resorption, the axis of the implant (red arrow) does not allow an adequate interocclusal relationship.



(A)



(B)



(C)

Figure 5.3 (A,B) Clinical examination shows a thin edentulous alveolar ridge with horizontal and vertical bone resorption. (C) The clinical conditions are confirmed by tomography.

The volume, shape, and quality of the bone are important parameters in establishing the treatment plan. They strongly influence the choice of surgical procedure and implant dimensions.

The bone volume determines the available bone, i.e. the bone dimension that can be used for dental implant placement. The quality of the bone, i.e. the density, strength, and elasticity, may determine the ability of the bone to support the stress induced by the prosthetic restoration.

Bone shape

Bone volume atrophy depends on numerous factors such as tooth loss, trauma, infection, periodontitis, and tooth extraction procedures. After tooth extraction, the alveolar bone resorption is more important at the facial aspect than at the palatal/lingual cortical plates, irrespective of the alveolar preservation techniques. The alveolar bone loss is almost 10 times greater 3 months postoperatively than in the years following tooth extraction. The resorption is higher at the posterior maxilla than in other areas of the jaws.

Several classifications have been proposed. The classification of Lekholm and Zarb (1985) is based on the residual jaw morphology and deals with the insertion of dental implants. They described five levels of jaw resorption in edentulous patients, ranging from minimal to severe osseous atrophy (Fig. 5.1).

Bone quality

The quality or density of the internal structure of bone exhibits a number of biomechanical properties. Poor bone quality may be associated with implant failure. According to Wolff's laws (1892), the shape and function of bone depend on biomechanical concepts based on mathematical models. Consequently, the mandible is designed as a force absorption unit with a dense outer cortical bone and a coarse or dense trabecular bone. The maxilla is a force distribution unit: the zygomatic arch and palate dissipate mechanical stress to protect the brain and orbit. The maxilla has thin cortical and trabecular bone when teeth are present. Bone modeling and remodeling processes are considered as adaptive phenomena associated with alteration of the mechanical stress and strain environment in the bone.

Lekholm and Zarb (1985) classified bone density using a four-point ordinal scale (see Fig. 5.1). The G1 density is localized in the anterior area of the mandible. G2 is the most common bone density observed in the mandible. G3 is very common in the anterior maxilla. G4, the poorest bone quality, is found in the posterior maxilla.

Several studies using finite element analysis models with various implant designs and bone quality have evaluated the stress/strain distribution. The titanium/cortical bone interface shows less microstrain than the titanium/sparse medullar bone interface.

According to the type of bone density, the surface and design of dental implant can be selected. It is also important to evaluate the bone quality to determine the optimal drilling sequence, the healing time, and the implant loading protocol.

Clinical examination

The horizontal discrepancies between the upper and lower arches must be assessed to prevent biomechanical complications (Fig. 5.2). The difference between vertical bone level at the adjacent teeth bordering the edentulous area and the bone level at the dental implant site must also be evaluated (Fig. 5.3A). The interocclusal distance is measured as the height between the antagonist teeth and bone crest.

The available bone volume may be evaluated by clinical palpation to assess the shape of the alveolar crest and the depth of the vestibule (Fig. 5.3B). A CT scan confirms the clinical examination (Fig. 5.3C).

Osseous bone density may be assessed by probing through the mucosa, under local anesthesia and/or during the implant surgical site preparation. Strong correlations have been found between tactile perception and osseous density during bone drilling.

Key points

- The shape and quality of the bone strongly influence treatment planning in dental implant therapy.
- Bone shape can be evaluated before radiographic analysis, during the clinical examination.
- Bone quality cannot be evaluated during the clinical examination.

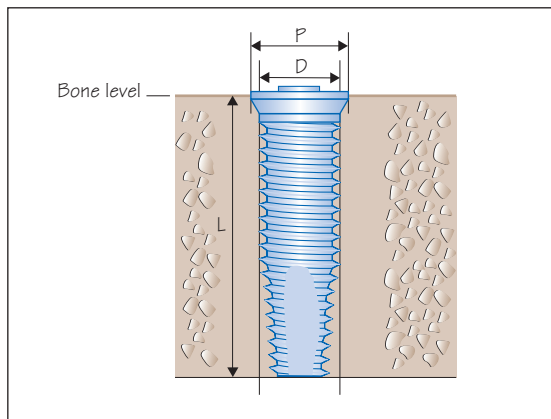


Figure 6.1 Implant dimensions. L, length; D, diameter; P, platform.

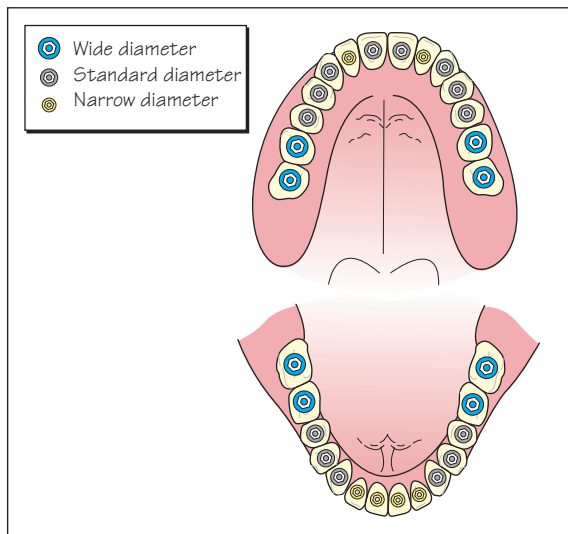


Figure 6.2 Selection of implant diameter depending on the location (tooth dimension).

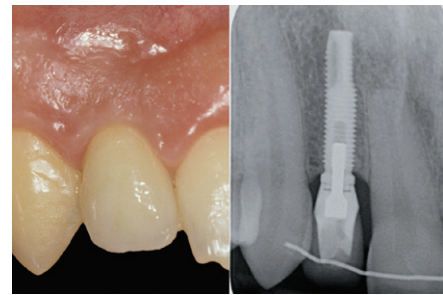


Figure 6.4 Narrow implant (length 13 mm, diameter 3.3 mm).

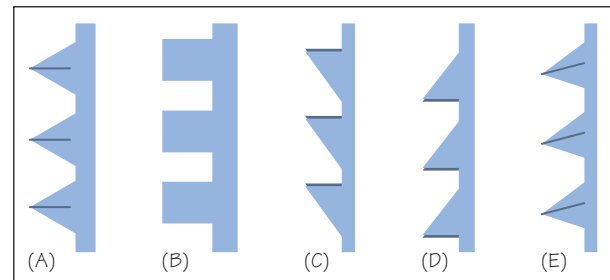


Figure 6.5 Currently available implant thread patterns. (A) V threads. (B) Square threads. (C) Buttress threads. (D) Reverse buttress threads. (E) Spiral threads. Adapted from Abuhussein H, et al., 2010.

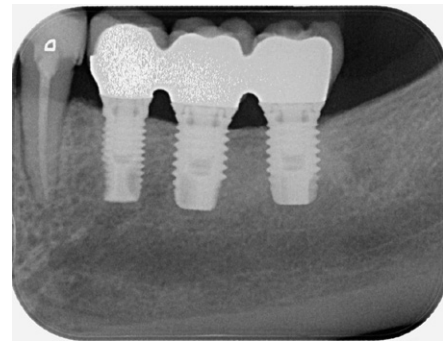


Figure 6.3 Wide implants (teeth 36 and 37, diameter 5 mm, length 8.5 mm).

Table 6.2 Implant length and diameter: indications compared to standard implants

	Advantages	Disadvantages	Indications
Long implants (>10)	Primary stability	Apical overheating risk	Immediate implant Bone defect Tilted implants Poor bone quality
Short implants (<9)	Alternative to bone grafts	Primary stability difficult to obtain	Limited bone height
Wide implants (>4)	Primary stability Cortical anchorage Crestal bone contact Stress distribution Resistant components	Lateral overheating risk	Limited bone height Poor bone quality Molar Bruxism Wide sites (failure)
Narrow implants (<3.7)	Alternative to bone grafts	Low mechanical resistance	Small diameter teeth Limited space

Most screw-type implant systems are available in different shapes and dimensions. This allows clinicians to select the most appropriate implants according to the clinical situation (see Chapter 23).

Treatment planning in implant dentistry aims to maximize the implant surface in contact with the bone bed, to provide a good *bone-implant contact* (BIC). This surface increases with the length, diameter, and design of the implant, but also with the surface characteristics (see Chapter 8). Most of the time, an optimal contact can be obtained with a standard implant.

Another major goal of implant surgery is to achieve a good *primary stability*. In this view, numerous dental implants dimensions and designs are commercially available (Table 6.1).

Standard implants are well documented in the literature, and show excellent success rates in normal conditions, i.e. sufficient amount and a good quality of bone. In case of limited bone volume (height or width), an alternative to bone augmentation is to adapt the implant at the existing anatomy, through the use of narrow, short or wide implants.

Limited evidence is available regarding the impact of dental implant dimensions on the survival/success rate. Therefore, except for the standard dimensions, clinical guidelines are based on biomechanical theories confirmed (or not) by clinical trials.

Implant length

The length of an implant can be defined as the distance from the most coronal part of the implant inserted into the bone, to the more apical part of the implant (Fig. 6.1). Most implant systems provide implant length from 4 mm to 20 mm or greater.

Long implants (more than 10 mm) are indicated in particular situations where primary stability requires an apical anchorage: immediate implant, bone defect, tilted implants, poor bone quality. Otherwise, they are not recommended, particularly at the lower jaw, because of the risk of apical overheating.

Short implants can be a good alternative to bone augmentation procedures (see Chapter 23).

Implant diameter (Fig. 6.2)

Implant diameter represents the distance between the external parts of the threads engaged into the bone. It can be different from the diameter of the prosthetic platform (see Fig. 6.1).

Most implant systems provide implant diameters ranging from 3 mm to 6 mm (Figs 6.3, 6.4). The optimal diameter selection should allow:

- engagement of sufficient amount of bone (cortical plates)
- respect for adjacent roots (distance >1.5 mm)
- adequate emergence profile for esthetic and oral hygiene.

The use of *wide diameter implants* (5 mm or greater) has benefits and risks (Table 6.2).

Table 6.1 Commercially available dental implants

	Length (in mm)	Diameter (in mm)
Minimum	5	2
Standard implant	10	3.75–4.1
Maximum	20	6.9

Scientific data are limited for wide implants. Higher failure rate in the literature is described with implants placed in compromised sites, poor bone density, or during an operator learning curve.

An adapted surgical protocol is recommended to assure primary stability (soft bone) and avoid overheating (dense bone). A one-stage procedure is recommended for wide implants.

The use of *narrow diameter implants* (3–3.3 mm) is a good alternative to horizontal bone reconstruction (bone width <5 mm). Narrow implants are particularly adapted to the replacement of mandibular incisors and maxillary lateral incisors, and when mesiodistal prosthetic or bone space is limited.

The reduced mechanical resistance of these implants implies a good control of occlusal loading.

Implant shape

As implant shape can modify *surgical outcomes* (primary stability, bone compression) as well as *biomechanical parameters* (force distribution during occlusal function), different designs of commercially available screw-type implants have been developed.

Thread design of implants

The shape of the implant thread is designed to optimize force distribution at the bone/implant interface on one hand, and to increase bone implant contact on the other hand (primary stability and quantity of osseointegration).

Different thread patterns are commercially available (Fig. 6.5).

It seems that a square thread design enhances the quality of osseointegration (BIC and reverse torque) (Steigenga *et al.*, 2004), and transmits better shear forces compared to other designs.

Greater thread depth enhances implant surface in contact with bone and therefore is indicated in cases of poor bone quality and high occlusal loading conditions, while shallow thread depth allows easier insertion in dense bone.

Data on implant design should be interpreted with caution since most of them come from finite element analysis studies (theoretic models).

Cylindrical versus tapered dental implants

Tapered implants are supposed to lead to a reduced need for bone augmentation and an improved primary stability in immediate implant placement, as the shape is more similar to the extraction socket. However, such differences could not be detected (Lang *et al.*, 2007).

There is no evidence that a particular implant has a better success rate or a clinical advantage than another (Esposito *et al.*, 2007). The surgeon's individual perception is the major selection criterion for a specific implant design.

Key points

- Standard implants are the best documented.
- Wide implant use requires an adapted surgical protocol.
- Narrow implants are not recommended with excessive occlusal load.
- There is no evidence that implant shape is a factor that may influence the survival rate of dental implants.

7 Implant macrostructure: implant/abutment connection

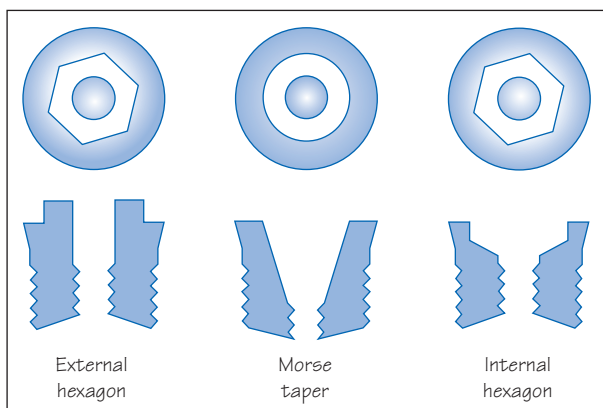


Figure 7.1 Three types of implant/abutment connection. Coronal part of the implant.

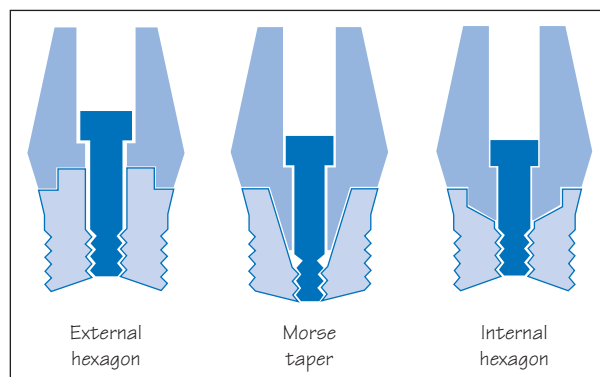


Figure 7.2 Three types of implant/abutment connection. Schematic abutment connected.

Table 7.1 Some commercially available implant connection designs

	Connection type	Index device
External		
Nobelbiocare (Branemark)	Hexagon	Hexagon
Internal		
Straumann (massive abutment)	Morse taper	No
Straumann (Synocta)	Morse taper	Octagon
Astra	Morse taper	Dodecagon
Biomet 3i (Certain)	Hexagon + dodecagon	Hexagon + dodecagon
Nobelbiocare (Replace)	Cylinder	Three channels
Zimmer (Screw vent)	Hexagon friction-fit	Hexagon
Ankylos	Morse taper	Six channels

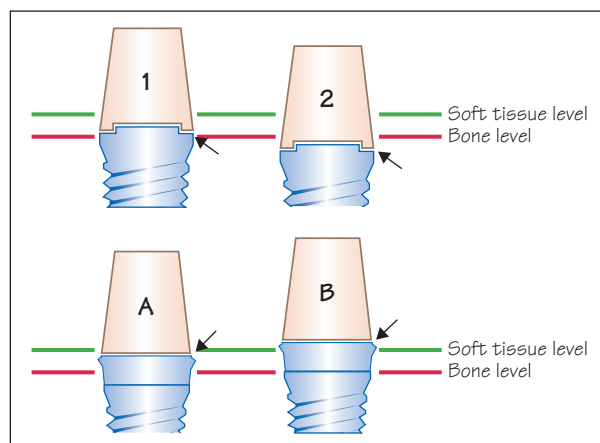


Figure 7.3 Interface location (arrows) for submerge-designed implants (1, subcrestal; 2, crestal) and transmucosal-designed implant (A, sulcular; B, supragingival).

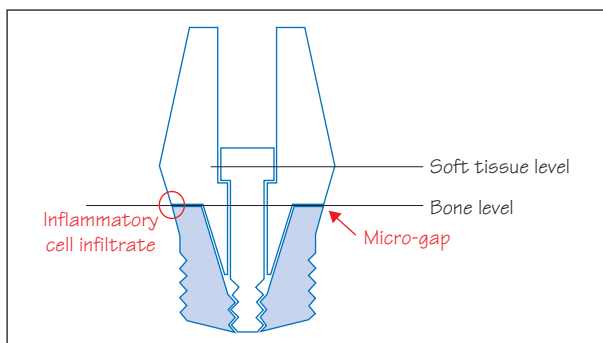


Figure 7.4 The standard implant/abutment interface.

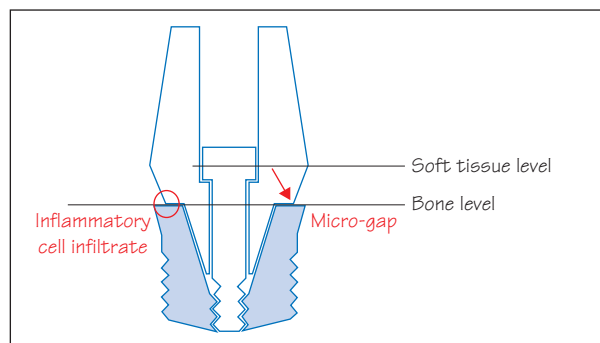


Figure 7.5 The platform switching concept.

Abutment connection

This is defined as the interface between the fixture and the prosthetic abutment. This interface may have different designs (Fig. 7.1) and is always secured by an abutment screw (Fig. 7.2). The implant/abutment connection must be precise and stable. It includes an antirotation device for single tooth restorations.

The connection should allow mechanical stability and adequate occlusal load distribution at the implant/abutment interface, over time.

From a clinical point of view, the connection should allow the clinical recording of the three-dimensional implant position during prosthetic impression (indexing).

The relevant question is: does the connection design influence implant survival rate, marginal bone loss, and implant complications?

External connection

Historically, the first implants were designed with a flat butt-joint interface and an *external hexagon* to allow for the recording of the implant location and to avoid rotation for single unit restorations. This very well-documented connection allows some micromotion of the interface and less rigidity during occlusal load transmission.

Internal connection

Different designs of internal connections are available: internal hexagon, Morse taper, cylinder (Table 7.1).

Several implant systems include a Morse taper connection, i.e. an internal connection with a conical design (5–10° of conicity) frequently supplemented by a geometric recording device (triangle, hexagon, octagon, dodecagon . . .). The Morse taper design offers a very intimate contact between implant and abutment. It is intended to prevent rotation of the abutment and eliminate the microgap.

Load transmission (finite element analysis)

Occlusal forces (horizontal and axial) are essentially transmitted at the coronal part of the marginal bone. This phenomenon could explain some marginal bone resorption. With a Morse taper connection located at the bone level, it seems that axial loads are transmitted deeper in the bone (Hansson, 2003). This separation of horizontal and vertical stresses could be beneficial for bone stability.

Abutment screw loosening

This is the most common mechanical complication in single tooth restorations. Screw loosening is the result of stress distribution at the interface (connection design) but it is also influenced by the screw design and material. Machined titanium screws tend to loosen.

Contrary to what could be expected, internal connections whatever the design, and external connections have a similar resistance to screw loosening (Piermatti *et al.*, 2006). In fact, it seems that abutment screw material (gold alloy, coated titanium) and design prevent screw loosening more than connection type does.

Interface location (Fig. 7.3)

Depending on the system or the surgical procedure, the implant-abutment connection can be located at the bone level (crestal or sub-

crestal) or at the soft tissue level (above or below the soft tissue interface).

For implants initially designed to be used in a submerged protocol (two-stage surgery), the implant/abutment interface is positioned crestally or subcrestally. These implants can also be inserted with a non-submerged protocol (one-stage surgery). In any case, a microgap exists between the abutment and the implant, near the bone level.

On the other hand, transmucosal implants are designed to be placed with a one-stage procedure. For these implants, the fixture/abutment interface is located above the bone level, i.e. below or up to the soft tissue margin. Thus transmucosal implants eliminate the microgap at the bone level.

Bacterial colonization

When the prosthetic abutment is connected to the fixture, there is a bacterial invasion into the microgap between implant and abutment. Theoretically, implant connection design can influence this colonization. Depending on the location of the microgap and the level of micromotion, a potential risk of inflammatory reaction and bone resorption occurs.

However, the clinical relevance of this phenomenon is not clear, since marginal bone loss is described during the first year of function, even for non-submerged implants, and it stabilizes during subsequent years for most implant systems.

Platform switching

The implant/abutment connection is associated with an inflammatory cell infiltrate localized at the microgap, near the bone crest (Fig. 7.4). This phenomenon could explain some crestal bone loss. Reduction of the diameter of the prosthetic component (*platform switching*) has been proposed to displace the inflammatory infiltrate horizontally, and prevent the crestal bone loss (Fig. 7.5). Furthermore, the platform switching concept could modify some biomechanical aspects of dental implants by reducing stress distribution in the compact bone in favor of the cancellous bone.

It should be noted that evidence supporting this concept is weak. In a recent study, implants placed in fresh sockets showed no difference in bone level changes between conventional and platform switching configurations (Crespi *et al.*, 2009).

Key points

- There is no evidence that internal connections have better biomechanical properties than external connections.
- There is no evidence that the type of implant/abutment connection has an impact on the survival rate of dental implants.
- The connection design seems to influence stress distribution.
- The location of the microgap influences peri-implant bone morphology.
- Screw loosening is more influenced by the material and the design of the screw than by the type of the implant/abutment connection.

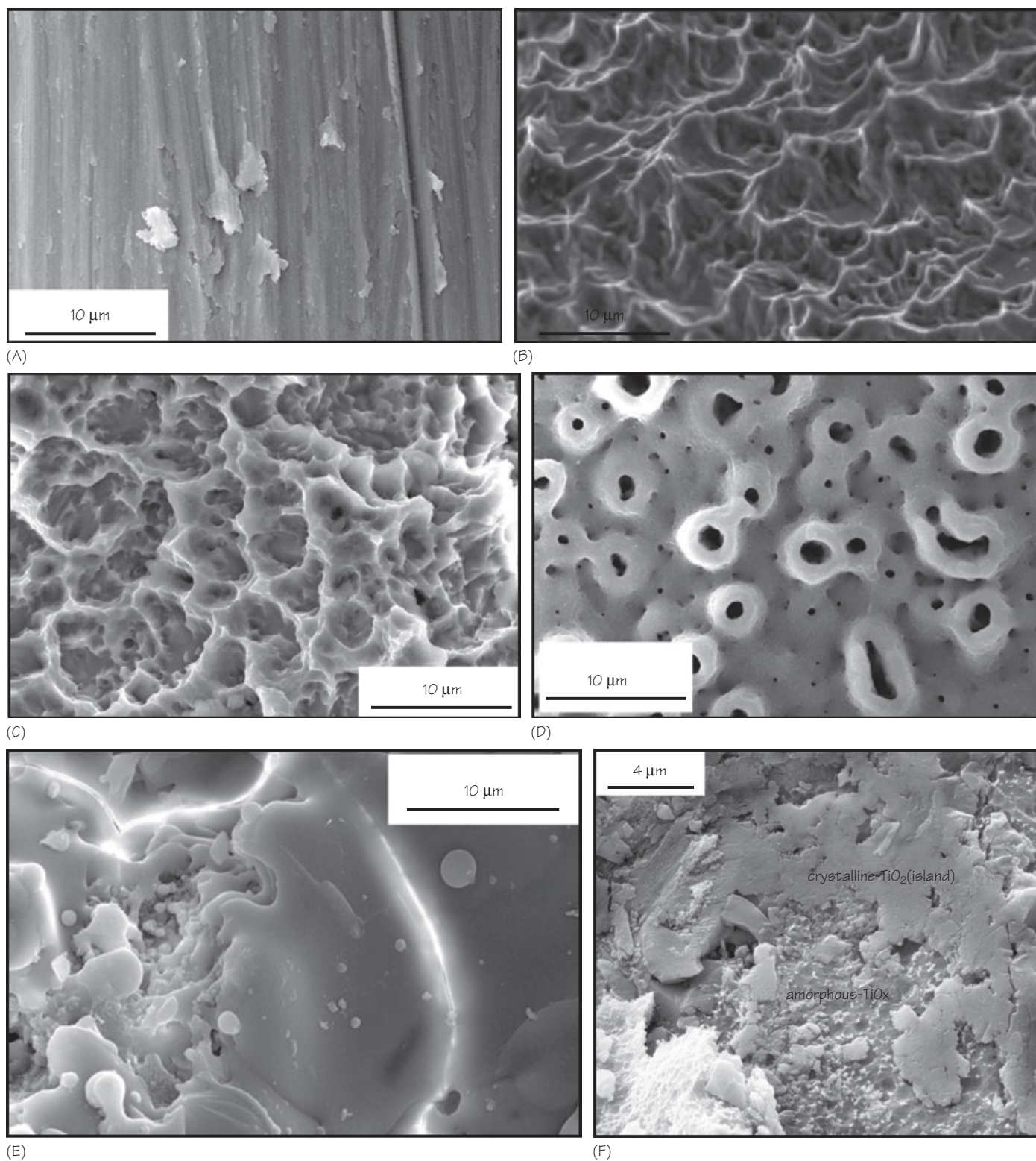


Figure 8.1 Scanning electron microscopy images showing the surface morphology of some commercially available implants. (A) Machined surface (Jamar *et al.*, 2008). (B) Osseotite™ surface (data from www.biomet3i.com.br/implantenanotite_pg04.asp). (C) SLA™ surface (Jamar *et al.*, 2008). (D) TiUnite™ surface (Jamar *et al.*, 2008). (E) HA-coated surface (Jamar *et al.*, 2008). (F) OsseoSpeed™ surface (Jamar *et al.*, 2008).

Implant Dentistry at a Glance, First Edition. Jacques Malet, Francis Mora, Philippe Bouchard.
© 2012 John Wiley & Sons, Ltd. Published 2012 by John Wiley & Sons, Ltd.

Titanium is commonly used for dental implants. There is ongoing development to obtain better anchorage and surface properties. The first generation of dental implants had smooth machined (turned) surfaces (Fig. 8.1A). The extensive use of dental implants has led to more and more challenging clinical situations, i.e. implant placement in fresh extraction sockets, grafted bone, low bone density, and immediate loading. The attachment of transitory structural proteins, such as fibrin, to the machined surfaces was quite poor, and increased failure rates were reported in challenging clinical situations.

The employment of microtextured-surface implants has been shown to improve the retention of these proteins at the implant surface, and to facilitate contact osteogenesis. It has also been demonstrated that microtopographically complex surfaces could increase the BIC compared to smooth (machined) surfaces.

Consequently, rough surface implants have been proposed because they integrate more rapidly, and have a better BIC than machined implants.

Surface topography

Surface roughness is characterized in terms of amplitude, spacing, and hybrid. Spatial parameters describe the texture of the surface. Hybrid parameters describe a combination of spatial and amplitude characteristics. The use of three-dimensional scanning electron microscopy (3D-SEM) provides a set of parameters for detailed description of all kinds of engineering surfaces.

The amplitude is considered to be the most important property of surface topography, and the average height parameter (S_a) is the parameter most frequently used for describing dental implant surfaces. Minimally roughened surfaces ($S_a < 1.0 \mu\text{m}$), such as those of machined implants ($S_a = 0.71 \mu\text{m}$), have been abandoned in favor of moderately roughened surfaces ($S_a = 1\text{--}2 \mu\text{m}$).

A surface can be characterized according to the microtopography, nanotopography, and surface chemistry. However, it is not easy to document *in vivo* if the biological response to a surface modification is specifically due to one of the characteristics mentioned above.

Surface configurations of some commercially available implants

Some machining procedures aim to create surfaces with bumps (convex surfaces) in contrast to other techniques that create pores

(concave surfaces) (Wennerberg & Albrektsson, 2009). Therefore, the machining process is subtractive or additive. In addition, a previously roughened implant surface can be chemically modified.

Blasting

Topography created by blasting by particles of titanium dioxide (TiOblast™).

Acid etching (see Fig. 8.1B)

The surface is etched in a two-step procedure (Osseotite™).

Blasting+acid etching (see Fig. 8.1C)

The surface is modified by sand-blasting followed by acid etching (SLA™; $S_a = 1.98 \pm 0.08 \mu\text{m}$).

Anodic oxidation (see Fig. 8.1D)

The surface is oxidized progressively by increasing the thickness of the oxidized layer in the “apical” direction (TiUnite™; $S_a = 1.55 \pm 0.01 \mu\text{m}$).

Hydroxyapatite-coated surface (see Fig. 8.1E)

The surface of the dental implant is coated with a deposit of more or less fine particles of hydroxyapatite by a chemical process (Nobel Biocare Steri-Oss® HA-coated; $S_a = 3.29 \pm 1.15 \mu\text{m}$).

Surface chemistry

Different surfaces are commercially available, including NanoTite™ (nano-scaled calcium phosphate crystals incorporated to the surface of the implant), OsseoSpeed™ (see Fig. 8.1F) (fluoride modification of titanium-blasted surface), SLActive™ (hydrophilic modification of the SLA™ surface).

Key points

- Surface modifications have shortened the healing time.
- Rough surfaces may improve the short-term prognosis of the immediate loading protocol.

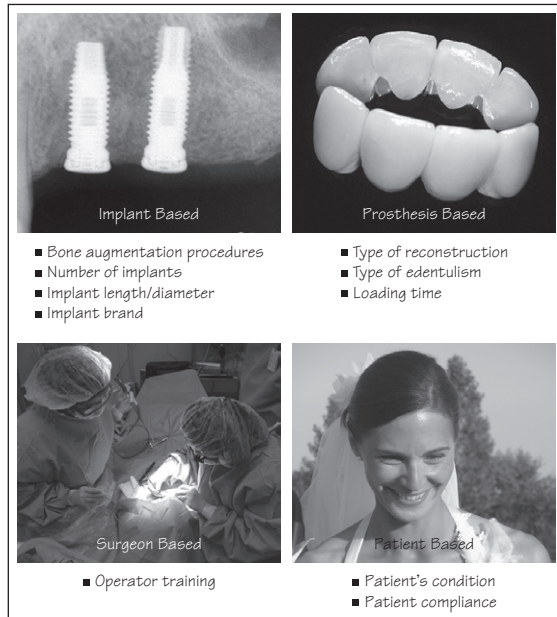


Figure 9.1 Factors that may influence implant longevity.

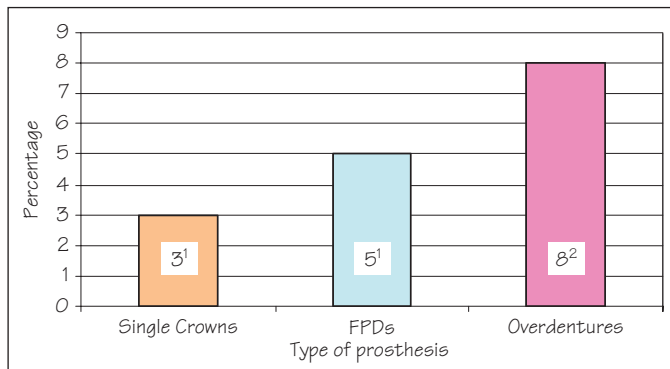


Figure 9.2 Estimated implant loss after 5 years of function according to the type of prosthesis (data source: ¹Lang et al., 2004; ²Berglund et al., 2002).

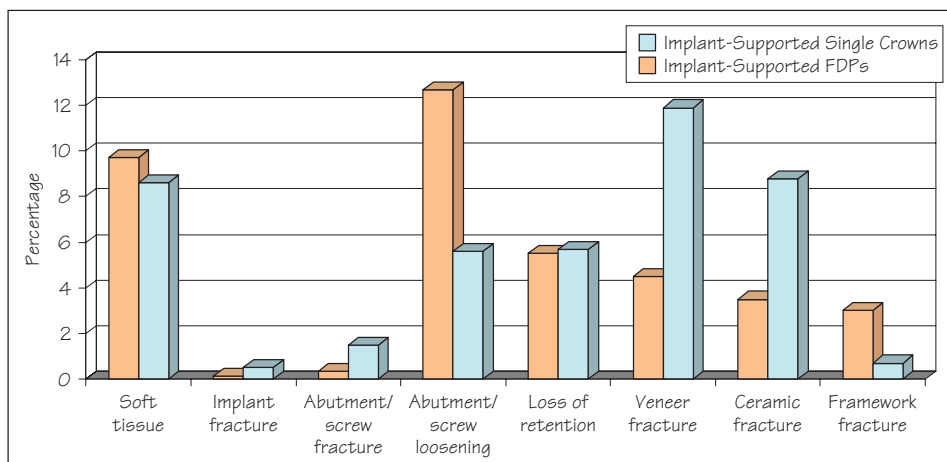


Figure 9.4 Cumulative 5-year biological and mechanical complications (data source: Pætursson, 2008).

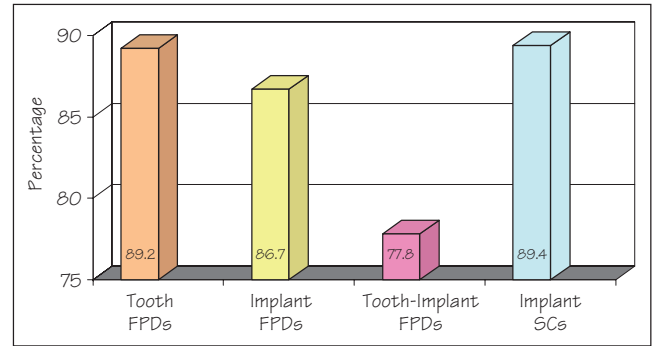


Figure 9.3 Ten-year survival estimate of tooth-supported FPDs, implant-supported FPDs, tooth-implant FPDs, and implant-supported single crowns (data source: Pætursson, 2008).

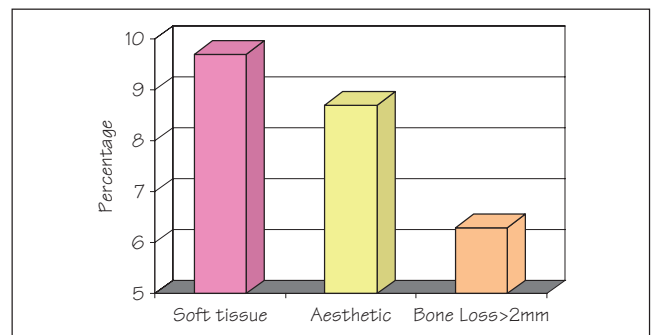


Figure 9.5 Implant-supported single crowns: cumulative 5-year biological complications (data source: Pætursson, 2008).

Box 9.1 Criteria of success (Karoussis et al., 2004)

- Absence of mobility
- Absence of persistent subjective complaints (pain, foreign body sensation and/or dysesthesia)
- No probing pocket depth > 5 mm
- No probing pocket depth = 5 mm and no bleeding on probing
- Absence of continuous radiolucency around the implant

Different factors may influence implant longevity (Fig. 9.1). Therefore, from a statistical point of view, it is difficult to draw a definitive conclusion on the percentage of “success” of a dental implant. However, Figure 9.2 gives some data that provide a picture of the longevity of dental implants according to the type of reconstruction.

The first attempts to evaluate dental implant “success” were the measurement of the overall survival of implants using life-table analyses. The statistical unit was the dental implant. Nowadays, the evaluation of dental implant success takes into account the lack of complication.

Dental implants: the best treatment option?

It is clear that the School of Bern (Switzerland) has produced the most accurate information on this topic. Regarding the single tooth replacement, there is no doubt that the implant single crown is the dominant strategy (less costly, more efficient and more cost-effective) when compared with tooth-supported FPDs (Bouchard *et al.*, 2009; Popelut *et al.*, 2010a). In other cases, the literature indicates that the success rate of dental implant therapies is predictable (Fig. 9.3).

What is a success?

Taking into account that dental implant therapy is an elective procedure, a patient-centered approach may be the best choice in terms of evaluation. Thus, it seems that the modern definition of “success” can be simply stated as follows: *A dental implant therapy is successful when there is no complication over time and when the patient is satisfied.*

Nowadays, the definitions below, related to implant stability after surgical placement, are commonly used.

Success

Definition: the dental implant and the prosthetic reconstruction are present in the mouth of the patient without any complications.

Many attempts have been made to establish success criteria for implants. The most up-to-date definition corresponding to the current available literature is that of Karoussis *et al.* (2004) (Box 9.1).

Failure

Failures can be divided into two types, depending on whether they relate to the dental implant or to the prosthetic reconstruction.

Implant failure (syn. implant loss)

Definition: the dental implant and the prosthetic reconstruction, if any, cannot be used or are no longer present in the mouth of the patient.

Traditionally, two types of implant failures can be observed:

- primary failure (syn. early failure¹): failure to establish osseointegration
- secondary failure (syn. late failure): failure to maintain the achieved osseointegration.

Prosthetic failure

Definition: the reconstruction cannot be used or is no longer present in the mouth of the patient.

Trends indicate that implant single crowns perform better than FPDs and overdentures (see Fig. 9.2). A systematic review dealing with the loading times, i.e. including immediate, early and conventional loaded implants, indicates that, after 1 year of function, 2.6% of placed dental

¹The terms “early” and “late” failure relate to the implant loss before or after loading. The immediate loading procedure has changed this approach. Thus, the terms “primary” and “secondary” failures are nowadays more appropriate.

implants failed (48/1852), and 4.7% of placed restorations failed (36/767) (Esposito *et al.*, 2009). The authors indicate that the risk of failure depends on patient selection and operator training. More failures occur among the early than the immediately loaded implants, which appear to be at higher risk of failure than conventional loaded implants.

A recent pooled analysis of systematic studies indicates a mean annual implant failure rate of about 1% (Popelut *et al.*, 2010b). The annual failure rate was 2.73% when the studies were not sponsored by the industry and 0.88% when the studies were supported by the industry.

Survival

Theoretically, survival rates should be divided into two types, depending on whether they relate to the dental implant or to the prosthetic reconstruction.

Implant survival

Definition: the dental implant is present at the follow-up examination.

Prosthetic survival

Definition: the prosthetic reconstruction is present at the follow-up examination.

Complication

Definition: the dental implant and/or the reconstruction show problem(s) that compromise their prognosis or their normal use by the patient.

Data indicate that complications occur in about 50% of patients after 5 years of function (Lang *et al.*, 2004a).

Complications can be divided into two types, depending on whether they are related to the surrounding tissues (biological complications) or to the prosthetic restoration (technical complications) (Figs 9.4, 9.5).

Biological complications

- *Mucositis*: reversible peri-implant inflammation limited to the soft tissues.
- *Peri-implantitis*: non-reversible peri-implant inflammation extended to the bone, and characterized by bone loss around the dental implant
- *Peri-implant abscess*: acute peri-implant infection with localized collection of pus.

Technical complications (syn. mechanical complications)

- *Fractures*: implant, screw, abutment, veneer, metal framework
- *Loosening*: screw, abutment
- *Loss of retention* (fracture of the luting cement)

Data indicate that implant-supported reconstructions may have up to a threefold higher incidence of technical complications than tooth-supported reconstructions (Lang & Salvi, 2008).

The crown/implant ratio does not seem to influence peri-implant crestal bone loss (Blanes, 2009).

Key points

- The risk of failure can be substantially minimized by proper patient selection and well-trained operators.
- Complications are frequent (50% after 5 years).
- More failures occur among the early than the immediately loaded implants.

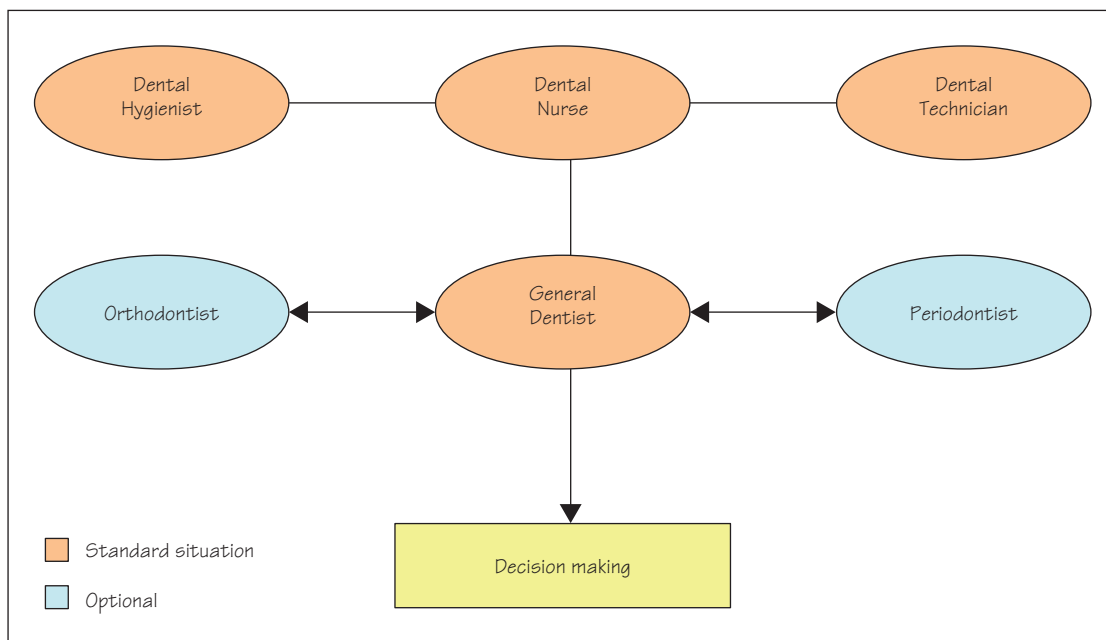


Figure 10.1 The basic team.

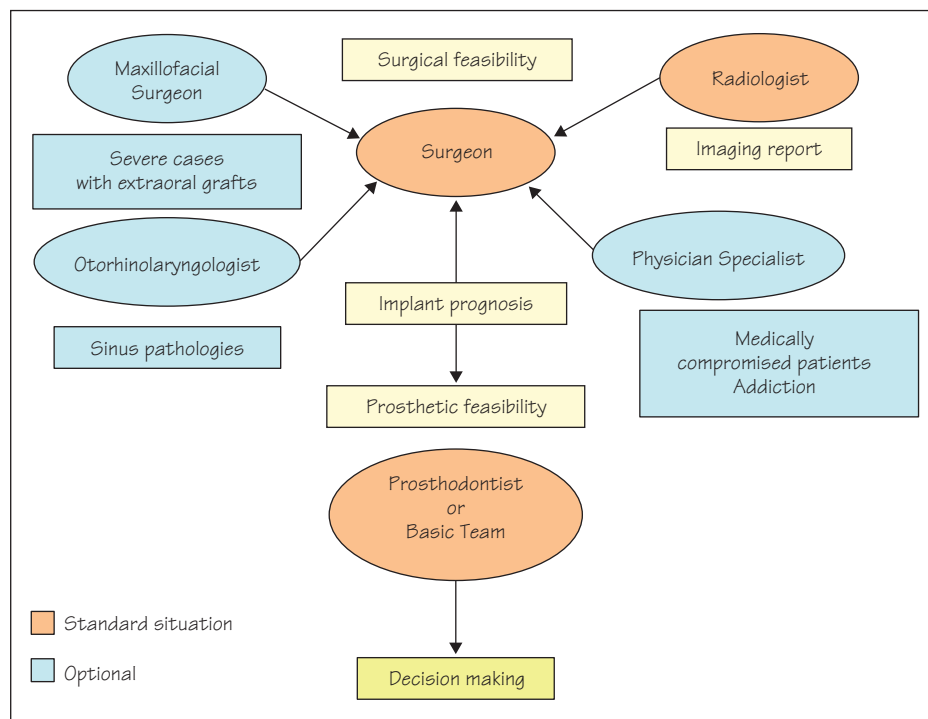


Figure 10.2 The extended team.

Basically, dental implant therapy combines (1) surgical treatment aiming to place the implant in the jaws, and (2) restorative treatment aiming to replace the teeth supported by the implants. In addition, prior to the treatment, a radiographic examination is mandatory.

Over time, the sophistication of the surgical and prosthetic techniques has led to unlimited possibilities for the placement of dental implants in the oral cavity. Therefore, apart from some drastic medical contraindications, from a technical point of view, *it is always possible to place implants*, even when there is a lack of supporting bone. Consequently, patient demands are now higher in terms of success. The term “success” not only includes a functional demand but also an esthetic result, and minimum complications.

In the dental implant team, a well-trained general dentist may assume the full treatment of simple cases, i.e. when a sufficient amount of bone is present in non-esthetic areas, and when the periodontal status of the patient does not require a specialist. In other cases, which are increasingly frequent, a more extended team approach must be considered.

The basic dental implant team should include at least (Fig. 10.1):

- a general dentist competent in basic dental implant diagnosis and therapy, basic periodontal diagnosis and therapy, basic dental implant surgery and prostheses
 - a dental nurse competent in surgical assistance and perioperative care
 - a dental hygienist competent in dental implant maintenance
 - a dental technician competent in dental implant prostheses.
- In addition, some cases may necessitate the collaboration of dental specialist consultants such as:
- a periodontist
 - an orthodontist
 - an endodontist
 - a specialist in pediatric dentistry.

The extended team should include at least (Fig. 10.2):

- a radiologist competent in dental digital imaging
- a surgeon competent in the surgical management of advanced periodontal diseases and conditions, and dental implant placement and ancillary intraoral grafting procedures
- a prosthodontist or a general dentist competent in dental occlusion and esthetics.

In addition, some advanced cases may require the collaboration of the following:

- a maxillofacial surgeon competent in autogenous bone grafting from extraoral sources
- an otorhinolaryngologist competent in maxillary sinus pathologies
- physician specialist(s) competent in the patient’s condition and in the management of addiction such as tobacco smoking, alcohol consumption, and drug abuse.

Who is the head of the team?

In all cases, *the general dentist/prosthodontist should be the team captain*, i.e. the person who collects the information and ensures treatment follow-up in accordance with the patient’s need. They are the cornerstone of the decision-making process because they are the project manager.

Before surgical decision making, the surgeon must answer the following questions.

- What is the periodontal status of the patient?
 - Does the patient need a periodontal treatment before the implant placement?
 - What is the risk of loss of the teeth bordering the implants?
- What are the surgical constraints of the prosthetic treatment plan?
 - What are the surgical risks for the patient?
 - What percentage of success can be expected following the surgical procedure(s)?
 - What is the full length of the surgical procedure(s)?
 - What are the total fees for the surgical part of the treatment?
- What are the alternative surgical options if the patient does not accept the initial treatment plan?

Key points

- A simple case is one where a sufficient amount of bone is present in non-esthetic areas.
- There is no need for an extended team in simple cases.
- For complex cases, patient demand and conditions determine the team composition.
- In all cases, the general dentist/prosthodontist is the head of the team.
- A periodontal examination is mandatory before implant placement.



Figure 11.1 Basic physical examination that can be performed in the dental practice. (A) Body Mass Index: scales and a measuring rod should be used to calculate the BMI of patients. (B) High blood pressure: the blood pressure should be measured with a sphygmomanometer and stethoscope. The patient must be in a sitting position and at rest. (C) Diabetic patients: home glucose meters may be used by the surgeon to measure the glucose level before a surgical procedure.

Table 11.1 International normalized ratio (INR) for specific conditions

Patient condition	INR value
Normal	1.0
Prevention of myocardial infarction	2.0–3.0
Treatment of pulmonary embolism	2.0–3.0
Treatment of atrial fibrillation	2.0–3.0
Pulmonary embolism	2.0–3.0
Prosthetic heart valves	2.5–3.5
Prevention of venous thrombosis	2.5–3.5

Box 11.1 Routine laboratory screening and vital signs that may be useful before dental implant surgery

Laboratory tests

- Complete blood count
- Prothrombin time (INR test)
- Glycemic control: glycated hemoglobin measurement (normality: 4–6%)

Vital signs

- Blood pressure (normality: 140/90 mmHg)
- Pulse rate (normality: 60–80 bpm)
- Oral temperature (normality: $36.8 \pm 0.7^\circ\text{C}$ or $98.2 \pm 1.3^\circ\text{F}$)
- Respiration rate (normality: 12–20 breaths per minute)

The information on medical history in Chapters 11 and 12 is not to be construed as a standard of care or guidelines, which may legally vary based on locale. In view of the relatively low prevalence rate of postoperative complications in the general population, limited evidence is available to guide clinicians in regard to possible increased risks of dental implant procedures associated with non-healthy patients.

The major difference between dental implant surgery and most of the other oral surgeries is that, in contrast with other surgeries, it does not treat an ongoing disease or a current infection, but treats an oral condition (edentulism). The implant failure may induce an unexpected infection that may have serious consequences in patients with poor health. Therefore, the famous precept of Hippocrates, *primum non nocere*, is particularly relevant to this type of elective surgery. Consequently, the medical history of candidates for implant therapy is mandatory and must be included in the medical records.

The medical history informs the surgeon on:

- the surgical risk (Chapter 12)
- the implant failure risk (Chapter 13).

Box 11.2 American Society of Anesthesiologists physical status classification system

P1	A normal healthy patient
P2	A patient with mild systemic disease
P3	A patient with severe systemic disease
P4	A patient with severe systemic disease that is a constant threat to life
P5	A moribund patient who is not expected to survive without the operation
P6	A declared brain-dead patient whose organs are being removed for donor purposes

A medical evaluation form is requested to obtain a written record for every individual patient (Appendix D). The past medical history and medication usage within the preceding 6 months are of particular importance. This form is not a blank check but rather a support for the medical interview. It is reviewed with the patient by the implant surgeon. Any health conditions/problems must be documented in the patient records (Chapter 21).

Dental implant surgery is not specific in terms of contraindications as compared to other intraoral surgeries. There are very few absolute contraindications. However, there are many risk situations that must be carefully evaluated.

As a rule of thumb, dental implant placement should be postponed in patients who have a disease that can be treated, until the patient is cured or stabilized. This is also true for oral conditions such as dental caries or periodontal diseases that must be treated *before* dental implant placement.

The clinical risk assessment for perioperative complications must be individually based on the medical history of the individual patient. In light of the interview and the medical examination (Fig. 11.1), if necessary, the surgeon may record vital signs and prescribe common laboratory tests (Box 11.1, Table 11.1). The American Society of Anesthesiologists (ASA) classification system (Box 11.2) may also be used, but this classification only provides a general idea of patient risks during surgery. In addition, only P1 patients are safe candidates for dental implant placement.

It must be understood that the lists indicated on the medical evaluation form are not all-inclusive and represent the more commonly occurring diseases and conditions. In addition, physician approval is required for all medically compromised patients.

Key points

- Dental implant placement should be postponed in patients with a treatable disease until the patient is cured or stabilized.
- Physician approval is required for all medically compromised patients.

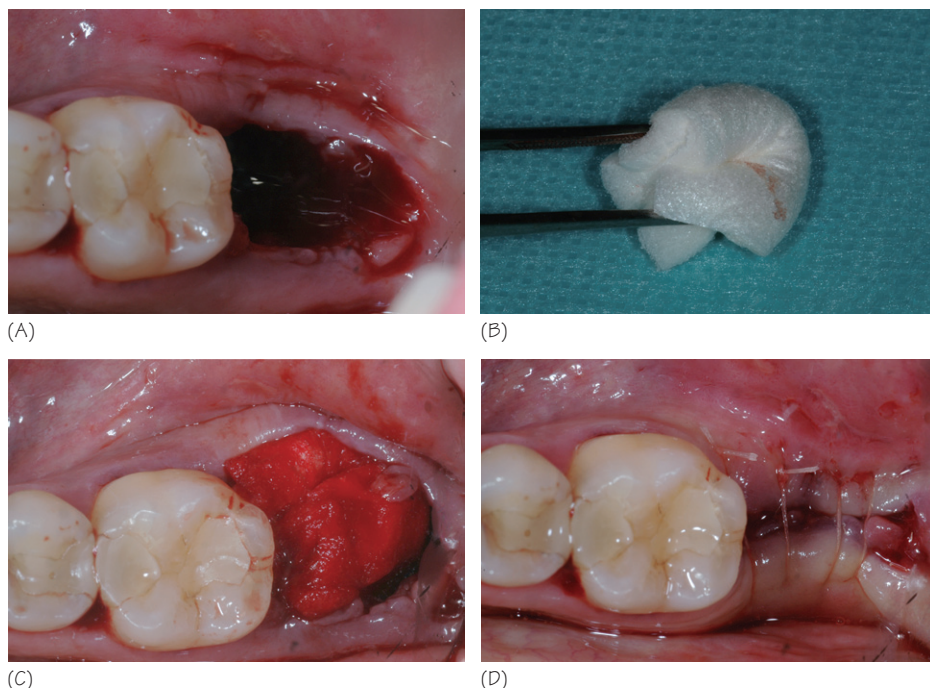


Figure 12.1 Patient at risk during the surgical procedure: the bleeding risk. (A) Extraction socket in an anticoagulated patient. (B) A collagen sponge is inserted in the socket. (C) Clinical view of the collagen sponge in situ. (D) The soft tissues are tightly sutured over the resorbable material. Note the immediate cessation of bleeding.

Absolute contraindications¹

ASA P5 and P6 patients

Chemotherapies in malignancies

The potential side-effects, including immunosuppression and myelosuppression, prevent any dental implant surgery during the active phase of chemotherapy.

Radiotherapy

The risk of osteoradionecrosis exists, even 6 months after the treatment (Brasseur *et al.*, 2006). Hyperbaric oxygen therapy does not seem to offer an evident clinical benefit (Esposito, 2008).

Cardiac conditions

The most critical risk is infective endocarditis, which is a life-threatening infection. The following cardiac conditions associated with the highest risk of adverse outcomes from endocarditis prohibit any dental implant surgery:

- Prosthetic cardiac valve or prosthetic material used for cardiac valve repair
- Previous infective endocarditis
- Congenital heart disease (CHD)
 - Unrepaired cyanotic CHD, including palliative shunts and conduits
 - Completely repaired congenital heart defect with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first 6 months after the procedure

¹A condition which makes a particular treatment or procedure absolutely inadvisable.

- Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)

- Cardiac transplantation recipients who develop cardiac valvulopathy.

Transplantation

After a transplant, patients are given immunosuppressive medications to prevent the body from rejecting the new organ. Therefore, they may have an increased risk of infection, especially during the first months when dosages are higher because of the increased risk of rejection. The dental implant surgery must be postponed, and the dental implant indication must be discussed at a later time with the specialists.

Dialysis catheters

Catheter-related infection is one of the major causes of morbidity in dialysis patients such as those treated for end-stage renal disease (ESRD). Thus, any non-vital surgery that may potentially induce bacteremia must be postponed.

Intravenous bisphosphonates

These are administered to patients with breast cancer, multiple myeloma, hypercalcemia of malignancy, bone metastasis in breast, prostate, lung, and other cancers. Nowadays, dental implant surgeries are contraindicated for patients who take intravenous bisphosphonates because they have been associated with the onset of bisphosphonate-related osteonecrosis of the jaws (BRONJ). The prevalence of BRONJ in patients receiving IV bisphosphonates is 5–12% (Sanz & Naert,

2009). When bisphosphonate treatment has started before dental implant placement, it has been shown that clinical signs of BRONJ may appear more than 1 year after dental implant surgery (Lazarovici *et al.*, 2010).

Relative contraindications²

ASA P3 and P4 patients

The indication for dental implant surgery must be discussed with the physician according to the level of the surgical treatment (number of dental implants, preimplant surgery) and the severity of the systemic disease.

Cardiac conditions

Cardiovascular diseases which are not an absolute contraindication (see above) may constitute relative contraindications that must be discussed with the cardiologists.

Oral bisphosphonates

These are used in the treatment of diseases such as osteoporosis (postmenopausal and steroid induced) and Paget's disease of bone. The prevalence of BRONJ in patients receiving oral bisphosphonates is 0.01–0.04% (Sanz & Naert, 2009). The placement of an implant may be considered in patients taking oral bisphosphonates (Madrid & Sanz, 2010). However, there are no diagnostic techniques to identify those at increased risk of developing BRONJ.

Diabetes

Severe type 1 diabetes or uncontrolled type II diabetes are significant relative contraindications as healing is delayed due to poor peripheral blood circulation.

Box 12.1 How to prevent the bleeding risk in anticoagulated patients

Before the surgery

- Good plaque control is important before performing the surgical procedures
- The surgery should ideally be scheduled at the beginning of the day and early in the week

During the surgery

- A local anesthetic containing a vasoconstrictor should be administered
- Regional nerve blocks should be avoided
- Efforts should be made to make the procedure atraumatic
- Absorbable hemostatic dressings (Surgicel®, Haemocollagen®, Spongostan® or others) should be used
- Resorbable sutures are preferable as they attract less plaque
- Following closure, the patient bites down on a wet gauze pad for 20 minutes. The gauze may be soaked with tranexamic acid (Exacyl®)

After the surgery

- Patients should be given clear written instructions on management of the clot
- The following medications should be avoided because they may interact with the anticoagulants: metronidazole, aspirin and NSAIDs

²A condition which makes a particular treatment or procedure somewhat inadvisable but does not rule it out, unless it is absolutely necessary. Dental implant therapy is never absolutely necessary. Thus, the relative contraindications may not exist *per se* in this area. However, for ease of understanding of the reader, a gradation can clarify the medical risk in implant therapies.

Chronic kidney disease

The healing process is deeply modified. The specialist must be consulted.

AIDS/HIV

Limited published scientific evidence is available to guide clinicians with regard to possible increased risks of dental implant procedures associated with the HIV status of the patient. However, patients who are immunocompromised due to viral infection (HIV) or medication have a clearly reduced wound-healing capacity and an inappropriately responding immune system.

Patients at risk for poor wound healing

Gastroesophageal reflux disease creates an acid reflux, which may modify the oral pH and thus compromise the healing process.

Lichen planus, erythema multiforme, and lupus erythematosus may compromise soft tissue healing. A fixed prosthesis will be preferred to a removable prosthesis to avoid any soft tissue compression.

Long-term, high doses of glucocorticoids inhibit the immune system, which may lead to severe infections following dental implant surgery.

Patients at risk during the surgical procedure (Fig. 12.1)

Regarding the blood coagulation disorders and medications that may modify the coagulation process (anticoagulants and antiplatelet agents), the INR should be checked within the 24 hours before surgery. For patients who have a stable INR, an INR measured within 72 hours before the procedure is acceptable (RPSGB/BMA, 2006; NPSA, 2007). There is no need to withdraw continuous oral anticoagulant therapy for ordinary surgical implant procedures with an INR <3.5 (Sanz & Naert, 2009). However, special attention must be given to the anticoagulated patients (Box 12.1).

Hypertensive and epileptic patients need a stress reduction protocol (Box 12.2). Some respiratory diseases can make the surgical procedure impossible.

Box 12.2 How to prevent stress

Before the surgery

- Premedication on the night before the appointment (anxiolytic)
- Setting an early morning appointment
- Minimize waiting room time

During the surgery

- The duration of the surgery does not exceed the patient's limits
- Profound anesthesia

After the surgery

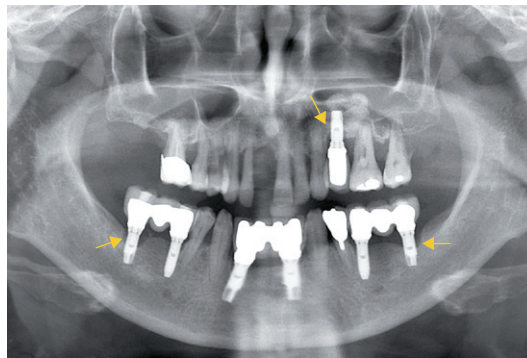
- Excellent postoperative pain control

Key points

- Decision making for surgery in medically compromised patients should be the result of a consensus among treating professionals, i.e. dentists and physician specialists.
- It is the surgeon, not the physician, who makes the final decision.



(A)



(B)

Figure 13.1 Patient at risk for implant failure: combination of smoking and periodontitis.

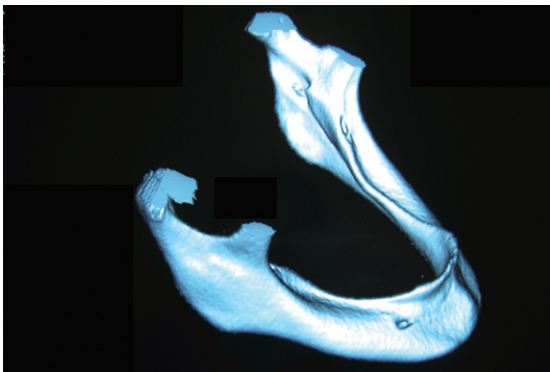
(A) Clinical view of a periodontitis patient 4 years after implant placement. The patient is a heavy smoker, and has not received a periodontal treatment. (B) The panoramic radiograph indicates bone loss around teeth and implants (yellow arrows).



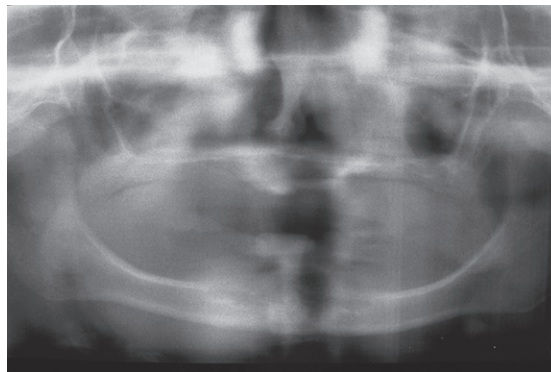
(A)



(B)



(C)



(D)

Figure 13.2 Complete edentulism in a 9-year-old boy with ectodermal dysplasia. (A) Clinical view of the maxilla. (B) Clinical view of the mandible. (C) Three-dimensional reconstruction of the mandible. Note the thin edge of the alveolar ridge that may preclude the placement of temporary dental implants. (D) Panoramic radiography. Courtesy of Dr Muriel Mola, Rothschild Hospital, Paris, France.



Figure 13.3 Complete edentulism of the mandible in a 3-year-old boy with ectodermal dysplasia. This young boy, born in 2000, was implanted in 2003. The clinical view was taken in 2007. The lower denture has been stabilized by two implants placed between the mental foramina. Courtesy of Dr Catherine Artaud, Rothschild Hospital, Paris, France.

We have not identified in the literature an individual risk factor that might be a contraindication for implant survival. Most studies indicate that dental implants can be successfully placed and maintained in patients exhibiting a variety of systemic diseases and congenital defects. However, the level of evidence indicating a risk of dental implant failure or complication associated with the health state of the patients is low, i.e. restricted to case reports and case series. Thus, dental implant indications must be thoroughly and *individually* evaluated, according to the patient's profile. The decision-making process must include the severity of the risk factors and/or, maybe most importantly, their combination in the same individual (Fig. 13.1). In any case, patients need to be informed of the possibility of implant complications.

The following list indicates potential risk factors that have been adequately documented, and the overall conclusions that can be drawn.

Age

There is no upper limit in terms of age. As a general rule, the lower limit for implant placement is 18–19 years, when an adolescent's jaw growth and development can be considered to be complete. However, this rule can be broken with children suffering from hypondontia or anodontia, such as in ectodermal dysplasia, because the benefit/risk analysis is in favor of implant placement.

Smoking

There is strong evidence that smokers are at greater risk for peri-implantitis (OR 3.6–4.6) and radiographic marginal bone loss (OR 1.95–10) than non-smokers (Mayfield *et al.*, 2009). However, the majority of the studies report implant survival rates of 80–96% in smokers (Cochran *et al.*, 2009). There is some evidence for a dose effect of cigarette smoking. There is an increased risk of implant failure when sinus augmentation procedures are used.

History of treated periodontitis

There is evidence that the history of treated periodontitis increases the risk for peri-implantitis. Implant survival rates ranged from 59% to 100% in patients who have regular periodontal maintenance (Mayfield *et al.*, 2009). However, the majority of the studies report high implant survival rates (>90%) (Cochran *et al.*, 2009).

Ectodermal dysplasia (Figs 13.2, 13.3)

Studies indicate significantly lower survival and success rates in the maxilla than in the mandible (Bornstein *et al.*, 2009). Implant survival rates vary between 88.5% and 97.6%. Implants placed in patients younger than 18 years have a higher risk of failure (Yap & Klineberg, 2009).

AIDS/HIV

Several case reports have shown successful dental implant therapies in HIV-positive, immunologically stable patients receiving highly active antiretroviral therapy. However, there are limited published data

available to guide clinicians on possible increased risks of dental implant failure associated with the HIV status of the patient.

Diabetes

There is evidence that diabetes increases the risk for peri-implantitis (Ferreira *et al.*, 2006). There are more diabetic patients experiencing dental implant failures than non-diabetics but the overall percentage of failing implants is within a normal range (Bornstein *et al.*, 2009). Thus, it may be assumed that the failure risk in diabetes is patient dependent. It may depend on the severity of the disease and the glycaemic status.

Bone diseases

Severe bone diseases such as Paget's disease of bone, rheumatoid arthritis, osteomalacia or osteogenesis imperfecta must be considered as high-risk factors.

There is no evidence for higher failure rates and complications in osteoporotic patients. The major problem is associated with the use of bisphosphonate in these patients. Nevertheless, the intake of oral bisphosphonates does not influence short-term (1–4 years) implant survival rates (Madrid & Sanz, 2009).

Radiotherapy

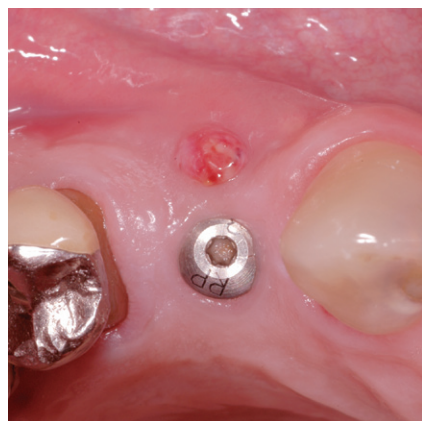
A similar failure rate has been shown for implants placed after radiation and those placed before radiation (3.2% and 5.4%, respectively). The implant failure was lower at the mandible (4.4%) than at the maxilla (17.5%). However, the sample size was small and the heterogeneity of the included studies was high.

Miscellaneous

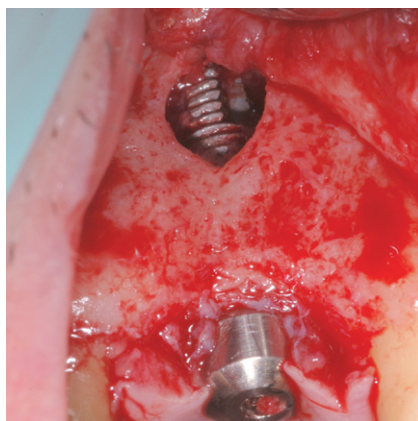
The following non-exhaustive list indicates factors that have been suggested as being detrimental for dental implant survival, and where no conclusion can be drawn due to the paucity of evidence: hypertension, xerostomia, alcohol consumption, drug abuse, Sjögren's syndrome, cardiac disease, Crohn's disease, Down's syndrome, autism, Huntington's disease, schizophrenia, Parkinson's disease, inadequate calcium intake, genetic predisposition, menopause, asthma.

Key points

- Patient candidates for dental implants must be informed of the increased risk for dental implant failure and potential complications associated with their individual health profile.
- Smoking, history of treated periodontitis, glycaemic control and severe bone diseases can be considered as risk factors for dental implant complications.
- Further studies are required to define the true effect of other medical parameters on the dental implant survival rate or biological complications.



(A)

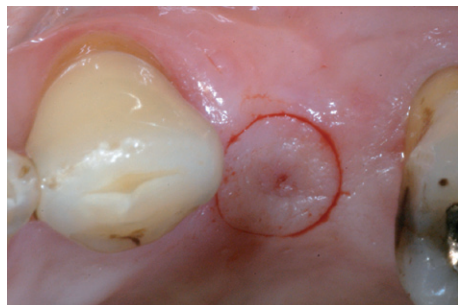


(B)

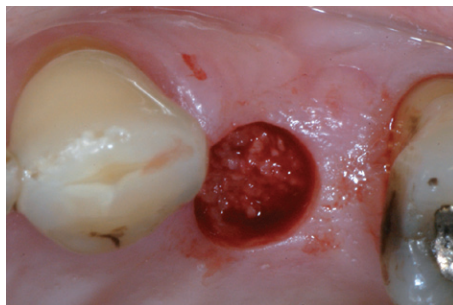
Figure 14.1 Apical peri-implantitis. (A) The dental implant has been inserted in a completely healed site. The tooth had been extracted for endodontic reasons. Note the presence of a fistulous tract 2 months after implantation. (B) A flap is raised. Note the apical localization of the bone defect.



Figure 14.2 Mucosal recession due to a thin tissue biotype.



(A)



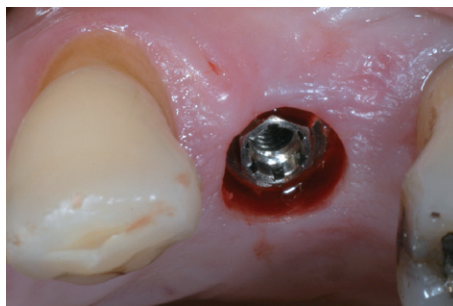
(B)



(C)



(D)



(E)



(F)

Figure 14.3 The minimally invasive flapless procedure. (A) The alveolar mucosa is punched out over the implant site. (B) The tissue punch is removed to expose the alveolar ridge. (C) After drilling, a direction indicator is placed in the implant bed. (D) The dental implant is inserted. (E) Clinical view of the implant platform. (F) A prosthetic abutment is placed at the end of the surgery (one-stage procedure).

Any situation that poses a risk to successful osseointegration and restoration of a dental implant at the level of the implant site and surrounding teeth must be considered.

Implant stability

The primary stability of the implant is a critical factor for implant survival. Several methods and devices are used to measure implant stability, including subjective evaluation, resonance frequency analysis (RFA), and insertion torque. However, they are insufficient to assess the primary stability, or to provide any predictive value of implant outcome. From a clinical point of view, insertion torque value is routinely used. The surgeon should strive to achieve high insertion torque values whenever possible (35 Ncm).

Bone density

Poor bone quality must be considered as a local risk factor. In the scientific literature, bone quality is often referred to as bone density. It is defined in terms of metabolism, cell turnover, mineralization, maturation, and vascularity; each of these factors plays a role in the osseointegration success of dental implants. Bone density is measured according to histological and morphometric analyses (Molly, 2006). The clinical evaluation of bone quality is questionable since no commercial instrument is currently available to measure bone density. Bone quality can only be evaluated by radiographic examination and confirmed during preparation of the surgical site.

Interproximal space

The three-dimensional position of the dental implant shoulder is defined as the relationship to bone crest level of the teeth adjacent to the implant. This critical factor influences the position of the interdental papillae surrounding the implants.

Tooth-implant

The risk of proximal bone resorption increases when the distance between the implant shoulder and the adjacent tooth is less than 1.5 mm. In esthetic areas, this lack of bone support may compromise papilla preservation. In narrow spaces, this risk can be prevented with the use of narrow implants. Decreased implant survival rate has been reported when the implant is placed too close to the tooth.

Implant-implant

Similarly, a 3 mm horizontal distance between two dental implant shoulders is the minimum required to prevent soft and hard tissue loss.

Infected sites

The evidence regarding implant placement into infected sites is poor. Dental implants should be placed in non-infected site(s). However, the reasons for tooth loss are multiple, including endodontic infections, periodontal infections, and fractures or trauma. Consequently, the implant site(s) cannot be considered as sterile. Micro-organisms might persist in the trabecular bone. Therefore, sites of neighboring teeth with endodontic pathology, or extraction sites of infected teeth, constitute a risk for successful osseointegration (Fig. 14.1). This risk can be pre-

vented by a thorough examination of radiographs prior to implant insertion. The vitality of neighboring teeth should also be evaluated.

The lack of infection at extraction sites is of particular importance for immediate extraction-implantation procedures in fresh extraction sockets. Thus, the procedure is deemed questionable in clinical situations with infected teeth. Nevertheless, there is no detectable difference between the percentages of BIC for immediate implant placement in infected versus non-infected fresh extraction sockets (92–100% survival rate at 12 months; Martin *et al.*, 2009).

Soft tissue thickness

Periodontal biotype must be considered a potential risk factor. A thin tissue biotype increases the risk of recession (Fig. 14.2). Peri-implant recessions are dependent on bone thickness surrounding the implant body as well as the three-dimensional position of the dental implant. In the esthetic zone, the reinforcement of soft tissue with connective tissue graft contributes to an esthetic result for the implant-supported prosthesis. However, the presence of keratinized attached peri-implant mucosa poses a challenging question in the health maintenance of peri-implant soft tissue. It seems that increasing the soft peri-implant tissue is advisable in order to limit marginal inflammation (Bengazi *et al.*, 1996). Nevertheless, there is no evidence to support soft tissue thickness as a risk factor in implant survival (Cochran *et al.*, 2009).

Keratinized soft tissue

It is often recommended that dental implants be surrounded by keratinized tissue to improve their long-term survival. There is no evidence that increasing the width of keratinized tissue improves the long-term prognosis of the dental implant. However, inflammation and plaque accumulation are greater when the keratinized mucosa width is less than 2 mm. No correlation has been found between the peri-implant mucosa width and marginal bone loss. Surgical augmentation of keratinized mucosa should be limited to situations where it can be beneficial for individual plaque control.

Surgical procedure

Following conventional flap surgery, a slight buccal alveolar resorption may occur due to bone exposure. The flapless approach has been proposed to reduce postoperative bone resorption and to preserve soft tissue contours (Fig. 14.3). Furthermore, this procedure may reduce patient discomfort and surgical time. Favorable short-term implant survival rates have been reported (Hammerle *et al.*, 2009). Because this is a blind approach, the technique is limited to experienced surgeons.

Key points

- Primary stability is a key factor for implant survival.
- Poor bone quality and inadequate interproximal space are true risk factors.
- Limited evidence indicates that site infection is a risk factor.
- There is no evidence that soft tissue condition is a risk factor for implant survival.
- Flapless procedures are limited to experienced surgeons.

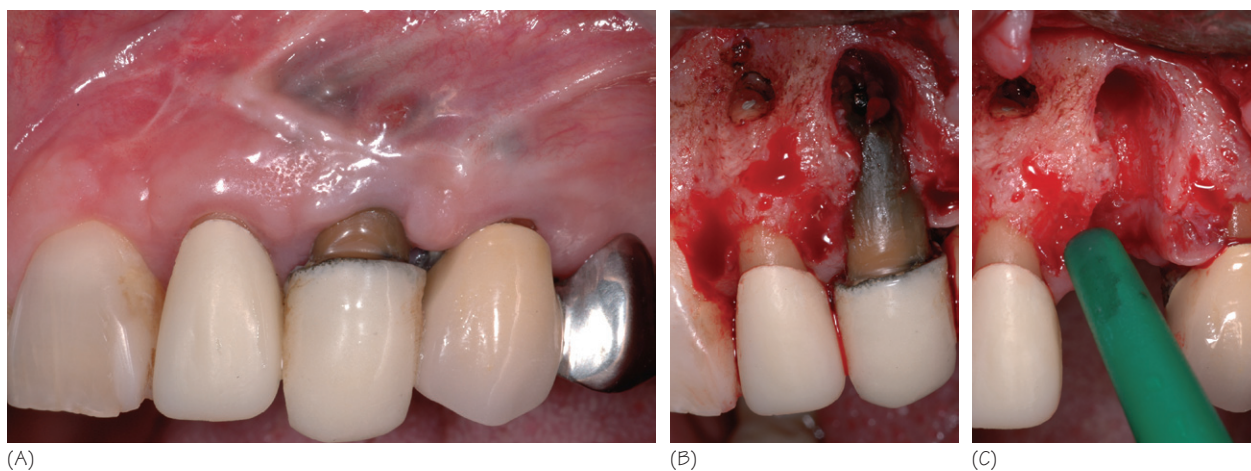


Figure 15.1 Extraction of the left cuspid after successive endodontic surgeries. (A) Successive surgeries have failed to treat the endodontic lesion. (B) Clinical view of multiple bone defects when extracting the canine. (C) The canine has been extracted and endodontic surgery has been performed on the lateral. Note the complete destruction of the buccal cortical plate at the canine site.

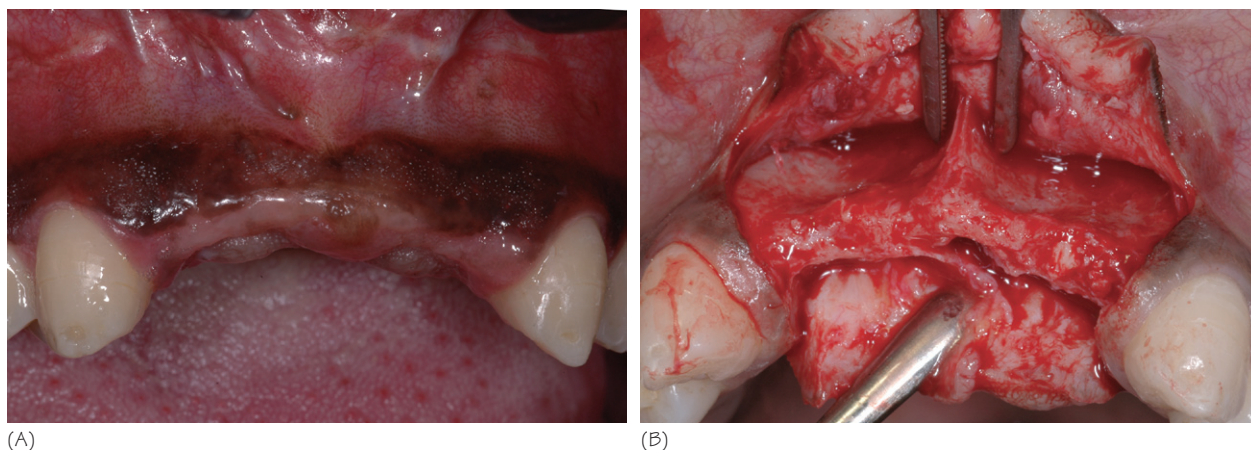


Figure 15.2 Traumatic injury of the anterior teeth. (A) The maxillary incisors have been knocked out following a trauma. Clinical view of the alveolar ridge 1 year after the trauma. The horizontal bone resorption beneath the soft tissue is clinically visible. (B) The thin alveolar ridge is confirmed during surgery.



Figure 15.3 Bone and soft tissue collapse following extraction of teeth 21 and 22 for periodontal reasons (severe periodontitis).



Figure 15.4 Posterior vertical bone resorption due to a removable denture worn for 20 years.

Not all patients are good candidates for dental implants, even if the clinical situation seems to be a good indication. Evaluation of dental history allows the clinician to establish a comprehensive treatment plan and to prevent the risk of failure or complication. Information is provided by the patient during initial interviews.

Compliance

Before surgery, during wound healing and after prosthesis delivery, a minimum of patient cooperation is essential to prevent complications. Some patients refuse to participate actively in their treatment, and their excessive “passivity” may be a barrier to the development of an implant treatment plan. Early detection of these “unmotivated” patients avoids unnecessary inconvenience for the clinician and the patient.

Oral hygiene

Effective dental plaque control is a prerequisite for successful implant therapy. A detailed description of patient brushing techniques and the type of professional support therapy must be reviewed, to be corrected if necessary. This point is particularly important for edentulous patients who no longer maintain effective plaque control habits.

Inadequate plaque control has a significant impact on:

- early implant failure in partially edentulous patients (bacterial contamination during surgery) (van Steenberghe *et al.*, 1990)
- excessive bone loss around osseointegrated implants, even in edentulous patients
- peri-implantitis (see Chapter 50).

Bruxism

Although this is a controversial issue, the trend is that excessive occlusal loading increases the risk of mechanical complications (pre-fabricated component), technical complications (laboratory fabricated) and failures (Salvi & Bragger, 2009). Despite this, bruxism (except in extreme cases) is not a contraindication for dental implants, but precautions are recommended for the selection of implants and elaboration of the restoration design.

History of tooth loss

Origin of tooth loss must be stated as it can compromise implant success or complicate dental implant placement.

Endodontic infection/endodontic surgery failure: in cases of incomplete debridement of the lesion, a latent inflammatory/infectious process may remain in the bone even after several years. This lesion is not always observable on radiographs, if not previously suspected, and can interfere with the osseointegration process. Moreover, successive endodontic surgeries are often associated with large postextraction bone defects (Fig. 15.1).

Root fracture may be related to excessive occlusal forces (bruxism) or occlusal disorders. Substantial alveolar bone loss occurs after extraction of a root with a vertical fracture.

Traumatic tooth loss and traumatic surgery will result in large alveolar ridge defects and gingival scars. Bone and soft tissue reconstruction should be considered (Fig. 15.2).

Terminal periodontitis: after tooth extraction, periodontal bone loss and soft tissue migration limit the amount of available bone and jeopardize the esthetic outcome (Fig. 15.3).

Extensive caries: caries risk does not directly influence implant success rates.

Age of edentulism negatively influences residual *bone volume*. For edentulous patients, removable dentures accelerate bone resorption (Fig. 15.4).

Multidirectional *tooth migrations* must be anticipated for partially edentulous patients with old non-compensated tooth loss. An orthodontic space management could be required.

Dental inflammatory or infectious process

Implant site (immediate implant)

Although implant placement in an infected site (if correctly debrided) does not affect osseointegration outcome, delayed implantation is recommended to the extent possible.

Adjacent teeth

Infections/inflammatory processes within the jawbone in the vicinity of an integrating implant (apical lesions, root remnants, endodontic material) can interfere with osseointegration. They must be treated separately, before implant placement.

Periodontal history (see Chapter 16)

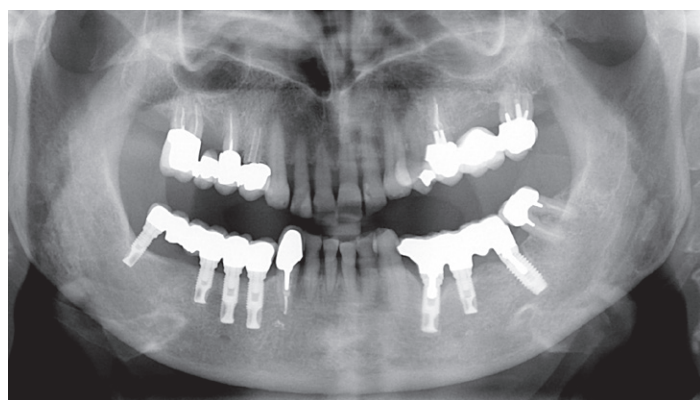
Untreated periodontitis is a contraindication to implant therapy. Periodontal infection must be controlled before implant placement.

History of treated periodontitis increases the risk of implant failure and peri-implant bone loss (Heitz-Mayfield & Huynh-Ba, 2009). Individual periodontal supportive therapy is essential.

Key points

- Dental history is mandatory before implant placement.
- The aim of dental history is to identify potential risk factors/indicators for implant failure.
- Knowledge of the history of tooth loss provides information on bone loss and infection risk.

Patient evaluation: dental implants in periodontally compromised patients



(A)



(B)

Figure 16.1 Dental implant therapy in a well maintained periodontitis patient. (A) Panoramic radiography, 7 years after implant placement. (B) Clinical view at the time of the radiography.



Figure 16.2 Full arch fixed restoration in a periodontitis patient. Note that, without bone augmentation procedures, the esthetic outcome is compromised by the restoration, which cannot compensate for bone resorption. In addition, plaque control may be difficult due to the reduction of the vestibule (see tooth 21).

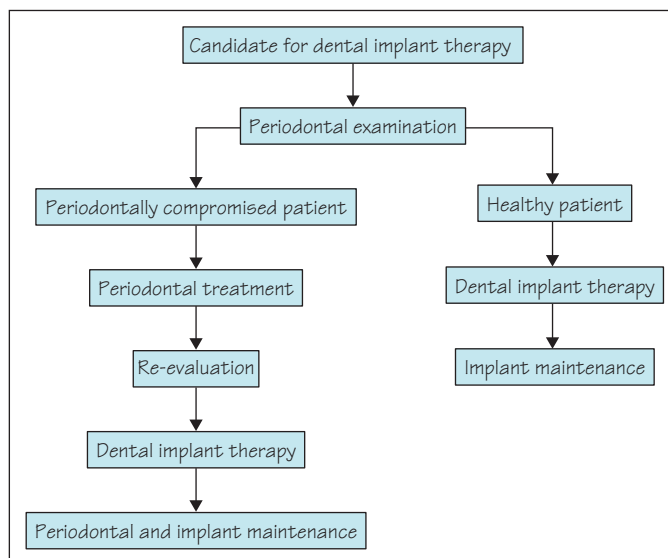


Figure 16.3 Treatment plan for dental implant therapy according to the periodontal status of the patient.

Treated periodontitis subjects

Implant outcomes

Patients with a history of periodontitis demonstrate a greater risk for peri-implantitis (OR 3.1–4.7) and a lower implant survival rate (ISR) than non-periodontal patients (Ong *et al.*, 2008; Cochran *et al.*, 2009). Nevertheless, over a period of 3–16 years, the ISR remains high, i.e. greater than 90%, when the patients are periodontally well maintained (Heitz-Mayfield & Huynh-Ba, 2009).

Thus, a history of treated periodontitis does not contraindicate implant therapy (Fig. 16.1). However, the patient must be informed of an increasing risk of implant failure and peri-implantitis (see Appendix E). The completed prosthesis and its supporting components (teeth and implants) must be carefully monitored with a maintenance program that includes systematic and continuous monitoring of the periodontal and peri-implant tissue conditions.

Risk factors

Smoking is a risk factor for periodontitis and peri-implantitis. Patients who combine cigarette smoking and a history of periodontitis should be considered at risk for implant failure, even if further research is required to properly assess the combination of these factors. Implant placement procedures do not affect the ISR (one-stage versus two-stage). The ISR does not change when immediate implant insertion and immediate loading procedures are applied. The characteristics of the implant surface seem to influence the ISR. Lower ISRs are observed for very rough surfaces.

Dental implant therapy

In cases of severe periodontitis, subsequent alveolar bone resorption poses a significant challenge to achieving esthetic and functional restorations. Implant placement in periodontitis patients often results in long, unesthetic teeth (Fig. 16.2).

Care must be taken in bone and soft tissue preservation during periodontal therapy. The ridge resorption which results from removal of the involved teeth should be anticipated (see Chapter 32). During periodontal surgical treatment, attention should also be paid to regeneration of the periodontal tissues.

Vertical and/or horizontal bone augmentations are often required in order to reduce the crown/implant ratio, and to allow adequate three-dimensional implant positioning.

The soft tissue biotype significantly affects the esthetic outcome. The thin-scalloped type (long and triangular teeth) often results in recession of the peri-implant soft tissues, exposing the gingival crown margins. Therefore, in esthetic areas, soft tissue augmentation is also often required. Consequently, dental implant therapy in periodontitis patients is often more complex than in patients with no history of treated periodontitis, and necessitates an extended team (see Chapter 10).

Untreated periodontitis subjects

In light of the data on treated periodontitis subjects, one can understand that the placement of dental implants in the context of untreated periodontitis is questionable in terms of long-term success, and may

dramatically jeopardize ISR. The possible translocation of microorganisms, the recurrence of disease, poor oral hygiene and systemic disorders may contribute to colonization of the peri-implant sulcus, and lead to peri-implantitis. Any patient who is a candidate for dental implant therapy must have a periodontal examination.

Decision making for teeth extraction

In dental implant therapy, the main difference between periodontally compromised patients and healthy patients is the prognosis of the remaining teeth after periodontal treatment. Dental implant prognosis should be viewed on a long-term basis. Consequently, the long-term prognosis of the periodontally compromised teeth must be carefully evaluated.

Aggressive or chronic periodontitis can be successfully treated. This is well documented in the literature. The decision to extract or maintain a periodontally questionable tooth may be critical in the context of dental implant therapy, and often requires a specialist approach (Popelut *et al.*, 2010). As a general rule, the projected survival rate of the residual teeth after periodontal treatment should not be less than 10 years, when implant-supported FPDs are planned for dental rehabilitations in partially dentate patients.

Treatment plan

The treatment may vary according to the periodontal condition of the individual patient. The following workflow may be used in periodontitis patients (Fig. 16.3):

- Comprehensive clinical and radiographic examination to adequately diagnose the periodontal disease
- Initial therapy to reduce the bacterial load (including extraction of hopeless teeth and the conservative control of dental caries)
- Orthodontic treatment to improve tooth position
- Periodontal surgical treatments to improve the results of the initial therapy (including the surgical regenerative procedures)
- Bone augmentation procedures to allow or improve implant placement
- Fabrication of a surgical template to guide implant placement
- Implant placement
- Interim maintenance to facilitate healing
- Re-evaluation to evaluate the stability of the remaining periodontally compromised teeth
- Prosthetic treatment.

Key points

- Dental implant therapy is a viable option in periodontally compromised patients.
- Periodontal examination is a prerequisite to dental implant therapy.
- Systematic and continuous monitoring of periodontal and peri-implant tissue conditions is critical for the survival of dental implants in patients with a history of periodontitis.



Figure 17.1 Patient with a high lip line ("gummy" smile).

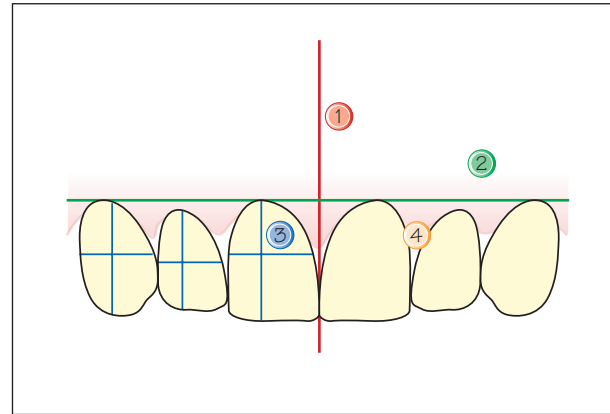


Figure 17.2 The determinants of esthetics. 1. Symmetry. 2. Gingival line. 3. Crown shape and proportions. 4. Interproximal papilla.



Figure 17.3 Thin scalloped biotype: high esthetic risk.

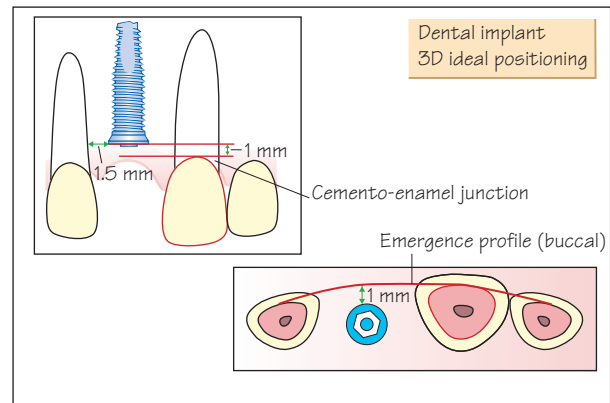


Figure 17.4 Three-dimensional ideal positioning of implant in the esthetic zone.

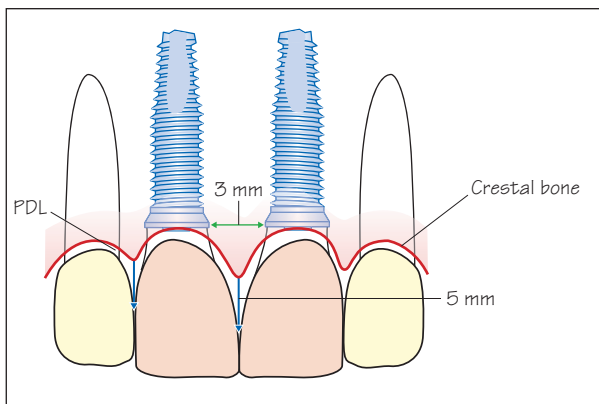


Figure 17.5 Parameters to be considered to obtain a papilla filling after implant placement.



Figure 17.6 Adjacent implants 21-22. Red circles indicate the implant-supported prosthesis.

The increasing demand for dental implants in the esthetic zone (anterior maxilla) is a challenge for the clinician who is seeking not only implant success but also esthetic predictability. With this in mind, the appearance and stability of the soft tissues are important factors to consider.

Acceptable esthetic results in the anterior area necessitate more complex treatments than in non-esthetic standard situations. However, the patient's request should be carefully evaluated to avoid overtreatments. Esthetic evaluation comprises both an objective and a subjective aspect. A full photographic documentation is essential.

Compliance and the patient's demand

Patient compliance is a key factor. The patient must be informed of the complexity and limitations of the treatment (see Chapter 22). If the esthetic demand of the patient is beyond the technical possibilities that can be offered by implant therapy, non-implant strategies should be considered.

Smile line

The smile line defines the lip position and its relationship to teeth during a "natural" smile. Most patients show part of the interproximal papilla but not the gingival margins.

Patients with a high lip line ("gummy" smile) are challenging, as they will show all the tissues surrounding the future implant restoration (Fig. 17.1).

Dental and periodontal full examination will highlight the following elements: teeth positions, teeth dimensions, gingival contour, and midline position (Fig. 17.2).

Biotype and soft tissue thickness

Biotype describes the periodontal morphology and it can be of two main types (Olsson & Lindhe, 1991): a thin-scalloped type (with long triangular teeth) and a thick flat type (with short square teeth).

Patients with a thin scalloped biotype are considered at "high esthetic risk" (Fig. 17.3). Bone modifications after tooth extraction will be more pronounced for these patients, and in cases of impaired healing, the esthetic consequences will be more evident than for patients with a thick flat biotype.

Soft tissue integration of the prosthetic restoration is easier and more stable with thick tissues. As a result, soft tissue augmentation is often recommended for high esthetic risk situations.

Tissue modification after tooth extraction

Extraction of a tooth leads to a succession of healing events in the socket, resulting in a loss of alveolar bone on the labial side. This bone loss is variable (2–3 mm vertically), and is the consequence of the bone remodeling (bundle bone) (Araujo & Lindhe, 2005).

For a single tooth extraction, proximal periodontium (bone and soft tissue) is supported by adjacent teeth. However, extraction of two or more adjacent teeth will result in proximal bone resorption and papilla collapse (tissue flattening).

Buccal and proximal tissue modifications must be prevented or corrected for an optimal esthetic result. Socket preservation, soft tissue augmentation, and bone augmentation procedures should always be considered in the esthetic area.

Immediate implant

Although implant placement into a fresh socket is supposed to preserve bone and soft tissue, it is a very controversial subject. The timing

of the implant placement has less influence on long-term esthetic outcome than other parameters.

Three-dimensional positioning of implant (Fig. 17.4)

Clinical recommendations are proposed to achieve a good and stable esthetic result. The crucial point is the precise 3D positioning of the implant, which must respect some minimal distances (Buser *et al.*, 2004) (implant–tooth, implant–implant) and prosthetic guidelines (emergence point and general axis). As a general rule, palatal positioning has fewer negative consequences than buccal positioning.

Bone height and soft tissue position

If one agrees with the postulate that soft tissue position depends on supporting bone, i.e. on the height of proximal and buccal bone surrounding implants, it is obvious that the stability of this bone is essential for long-term esthetic success.

Proximal bone (Fig. 17.5)

For an implant adjacent to a natural tooth, the crestal bone height depends only on the natural tooth. For adjacent implants, the stability of the proximal bone depends on interimplant distance (Tarnow *et al.*, 2000): a distance of 3 mm or more helps maintain a stable bone position.

After prosthetic restoration, the amount of filling of interproximal papilla depends on the vertical distance between the top of the crestal bone and the prosthetic contact area (Choquet *et al.*, 2001). A distance of 5 mm or less is required for a full filling.

Buccal bone

There is no evidence that a minimum bone width is required to ensure buccal bone stability, but 2 mm is usually recommended.

Esthetic limitations in implant therapy

Adjacent implants: because of proximal bone loss, the esthetic result is unpredictable for multiple edentulous ridges. Reducing the number of implants can sometimes facilitate esthetic predictability. The restoration of two adjacent teeth in a reduced prosthetic space is the most difficult situation (Fig. 17.6).

Vertical bone augmentation is a very challenging procedure. A limited esthetic outcome must be anticipated.

In cases of *advanced periodontitis*, the amount of bone and soft tissue loss is significant. This could result in longer clinical crowns and interdental black holes (incomplete papilla filling) after implant treatment. Preventive and reconstructive surgical procedures should be undertaken for these patients, if the esthetic demand is high. Compensations with prosthetic devices may also be considered.

Key points

- Dental implant therapy in esthetic areas is complex.
- Patient demand is central and must be thoroughly evaluated.
- Patients with a thin scalloped biotype must be considered at high esthetic risk.
- Bone remodeling after tooth extraction is predictable.
- A minimum of 3 mm is required between two implants.
- In esthetic areas, adjacent implants should be avoided.

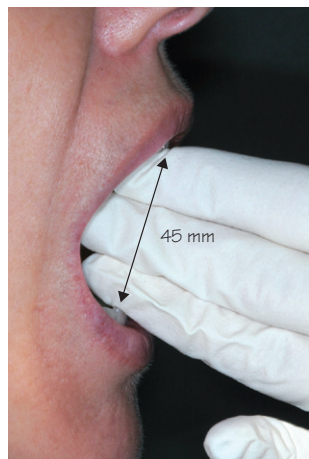


Figure 18.1 A minimum of 40–45 mm of mouth opening is required for surgical and prosthetic accessibility.



Figure 18.2 A drill extension may be necessary to avoid contact between the handpiece and the adjacent teeth, without altering the drilling direction.

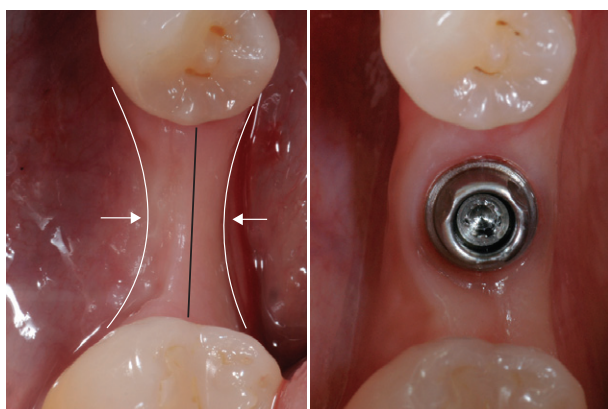
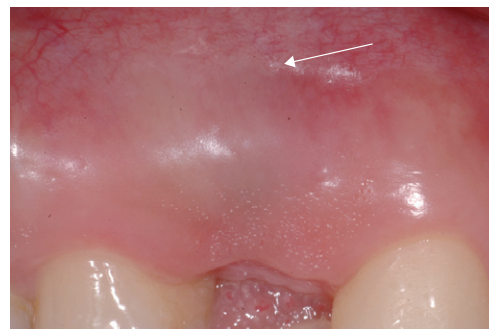
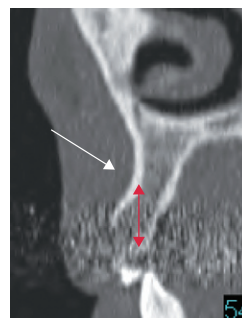


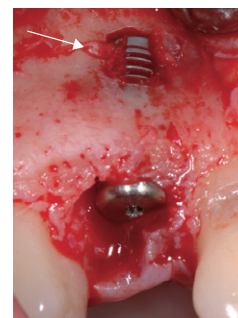
Figure 18.4 Management of the keratinized mucosa. The keratinized mucosa is located between the mucogingival junctions (white lines). The incision (black line) preserves a sufficient amount of keratinized tissue around the implant to allow a favorable environment after healing.



(A)



(B)



(C)

Figure 18.3 Buccal bone concavity. (A) A meticulous palpation of the alveolar process identifies a buccal bone concavity (white arrow). (B) The CT scan corroborates the clinical examination. In order to respect the prosthetic axis (red arrow), a short implant (8.5 mm) is selected. (C) The apical fenestration will require a guided bone regeneration (GBR) procedure.

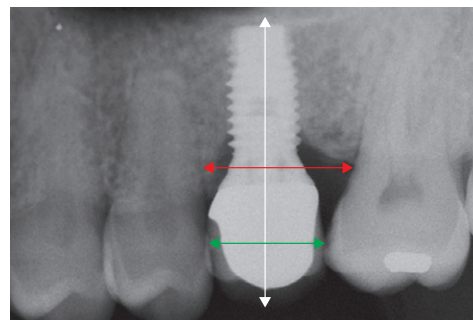


Figure 18.5 Prosthetic management of a reduced interdental space due to a mesial migration of 27. The implant is not placed in the middle of the original interdental space (red arrow), but slightly more mesial, in the middle of the residual interdental space (green arrow). The size of the crown is reduced (premolar design).

Before surgery, a clinical examination must be carefully conducted and cannot be replaced solely by a radiographic examination. A comprehensive patient examination is mandatory to anticipate surgical complications.

Surgical accessibility

Mouth opening: a minimum of 40–45 mm (about three fingers' width) is required to allow access to the posterior area of the mouth for drills and implants, while respecting prosthetic guidelines (Fig. 18.1). A limited mouth opening will compel the surgeon and prosthodontist to use short instruments, short implants or tilted implants. In extreme situations, implant therapy can be contraindicated.

Teeth adjacent to the implant site can interfere with correct positioning of drills (bumping of the handpiece). The use of a drill extension may be required, but is not always possible in the posterior area (Fig. 18.2).

Surgical access should be tested before confirming the surgery appointment.

Esthetic complexity (see Chapter 17)

Soft tissue manipulation during implant surgery of the anterior area can have detrimental consequences for patients with thin biotype or multiple planned surgeries. Evaluation of the esthetic surgical complexity is essential. Complex situations require the most predictable therapeutic options (Table 18.1).

Alveolar mucosa

The presence of keratinized tissue on the surgical site is evaluated. The incision will be located, if possible, within keratinized mucosa to facilitate tissue manipulation and to allow for a more favorable environment after healing (Fig. 18.4).

Probing of keratinized tissue thickness under local anesthesia provides a good evaluation of the transmucosal part of the future restoration for prosthetic anticipation and bone volume evaluation.

Hypertrophic mucosa on an edentulous ridge, particularly if it is mobile, can require a surgical reduction.

Alveolar process dimensions

A first estimate of bone width and height is performed with meticulous palpation of the alveolar ridge. This allows the clinician to identify

some anatomical limits and to anticipate specific surgical troubles (Table 18.2). Tomographic examination will confirm this first evaluation.

Diagnostic casts are sometimes needed to estimate the bone dimensions, after subtracting the thickness of the mucosa measured at several points.

Bone dimensions are compared to the prosthetic project to confirm the treatment decision.

Dimensions of the edentulous area

A minimum of 7 mm horizontal interdental distance is required to place a standard implant, 14 mm for two implants, 21 mm for three implants, and so on. In cases of tooth migration, a reduction of the tooth gap is observed. Even if bone dimension is not altered, reduced interdental distance can prevent correct orientation of the drills or implant insertion. Position, orientation and even implant number must be modified (Fig. 18.5). Orthodontic space management is an alternative.

Adjacent teeth

Periodontal support (bone and soft tissue): surgical access for implant placement can have detrimental effects on the adjacent periodontal tissues, in cases of thin biotype or reduced periodontal support. In order to prevent periodontal recessions, modified flap design or preventive soft tissue augmentation could be indicated.

It is crucial to estimate the direction of the roots of adjacent teeth, since they can converge with the implant axis and cause surgical interference. Modification of the implant direction (if compatible with the prosthetic project) or reduction of the implant length can avoid this drawback.

Table 18.2 Surgical complexity associated with anatomical deformities

Anatomical deformities	Surgical complexity
Bone concavities	Overdrilling risk
Horizontal resorption, narrow crest	Narrow implant or GBR indication
Vertical resorption	Anatomical risk Short implant indication
Shallow vestibule	Tension during healing Plaque control difficulty

Table 18.1 Surgical options according to the risk factors

Complexity parameter	Associated risk	Therapeutic option
Thin biotype	Recession	Soft tissue thickening
Proximal bone collapse	Papilla lost	Papilla preservation
Prominent natural roots	Large bone dehiscences	GBR
Incisors palatal version	Oblique bone orientation	Shorter implant in an adequate orientation
Buccal bone concavity (Fig. 18.3)	Bone fenestration	Shorter implant, tapered implant, GBR

Key points

- Before surgery, a clinical examination must be carefully conducted and cannot be replaced by a radiographic examination alone.
- A minimum of three finger widths mouth opening is needed for surgical access.
- Soft tissue manipulation is evaluated before surgery.
- The amount of keratinized mucosa must be evaluated for the design of the incisions, and for preservation.



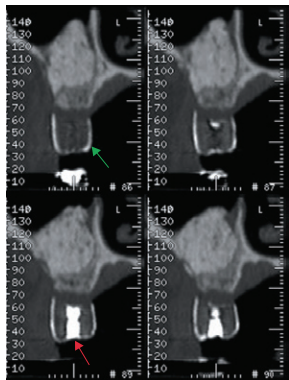
Figure 19.1 Radiographic template: titanium guide sleeves allow visualization of implant direction and indicate surgical placement.



Figure 19.2 Surgical template with a denture design. Note the exact positioning of implants.



(A)



(B)



(C)

Figure 19.3 Radiographic/surgical template. (A) Artificial teeth are covered with barium sulfate. The drilling holes are filled with a radiopaque cement for radiographic examination. The cement is removed before the surgical procedure (white arrows). (B) CT scan (cross-sectional images): visualization of tooth shape (green arrow), and identification of future implant position and direction (red arrow). (C) Drilling with surgical guide.



(A)



(B)

Figure 19.4 Dental-borne surgical guide. (A) Surgical template stabilized on the proximal incisal edges. (B) A wide hole allows modification of drilling only in the palatal direction.

The surgical template is a device that prefigures both (1) the prosthetic project to enable its visualization on X-rays (radiographic template), and (2) to optimize the implant positioning during surgery (surgical guide). Placement of several contiguous implants often requires a surgical template.

Characteristics

Precision is essential particularly in the esthetic area where even limited inaccuracy can have detrimental consequences. As a result, technical procedures are similar to temporary removable dentures.

Stability avoids any displacement of the template during radiographic examination and surgery. Stability is provided by non-mobile teeth if possible (teeth-borne template; Fig. 19.1) or by the edentulous ridge (soft tissue-borne template; Fig. 19.2).

The template must be *easy to use*, essentially because patients will wear them during radiographic examination. During surgery, positioning and retrieving the device must be simple and reproducible, without alterations.

Radiopacity offers the possibility to visualize tooth shape and ideal implant direction on the radiographs. Radiographic markers should not cause any radiographic diffraction. Barium sulfate can be incorporated in the whole template body during fabrication (Fig. 19.3). Radiopaque materials include:

- cavit
- gutta percha
- titanium
- steel
- barium sulfate.

Resistance to heat is critical for decontamination and sterilization of the template in order to use it during surgery.

The main information incorporated in the surgical template includes the following: teeth shape (Fig. 19.4), emergence crestal point, implant direction.

For esthetic areas, the surgical template can include soft tissue profile to adapt the implant position to the future gingival margin after

flap elevation, and if necessary to perform a soft tissue augmentation procedure.

Technical procedures

The surgical template is made from a simulation of the future restoration. Special radiopaque devices are included in the template, in the optimal position and axis of the future implants, i.e. compatible with the prosthetic project.

When residual teeth are present, they are used to stabilize the template. The existing partial or complete denture can also be modified (drill perforations in the implant positions) to be used as a template.

For partially edentulous patients, common manufacturing steps are:

- diagnostic casts
- wax-up or set-up
- duplicate casts
- vacuum-formed template
- ideal implant(s) location (position and axis)
- insertion of radiographic markers
- radiographic examination
- modification (opening) for irrigation and drills
- decontamination
- surgery.

Key points

- In all cases, a surgical template is mandatory to allow optimal implant placement, except for single tooth placement in non-esthetic areas.
- The surgical template mimics the future restoration.
- The surgical template must be stable, especially when it is supported by the mucosa.
- The placement and removal of the surgical template should be easy during surgery.

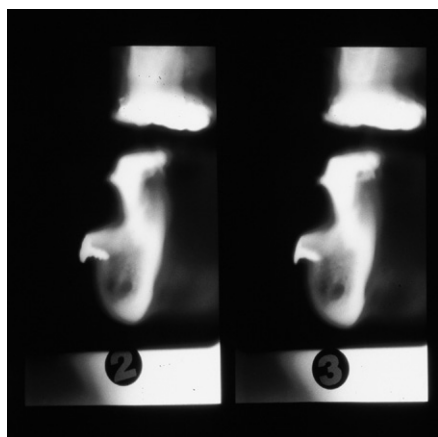


Figure 20.1 Conventional tomography image.

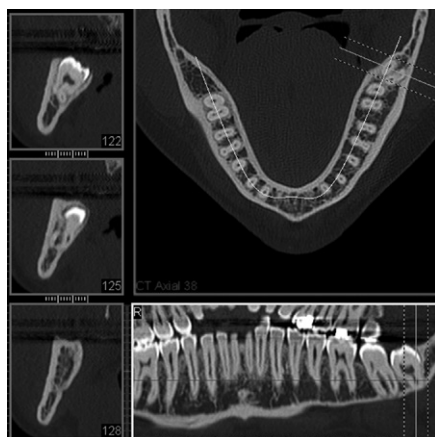


Figure 20.2 CT scan image.

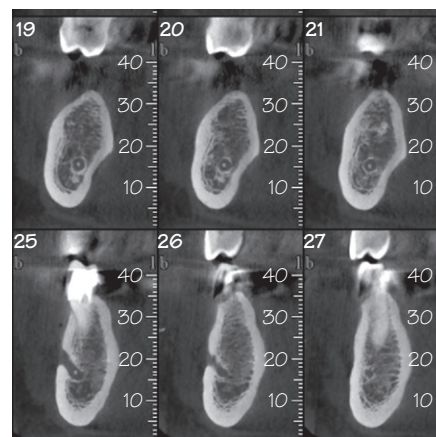


Figure 20.3 CBCT image.

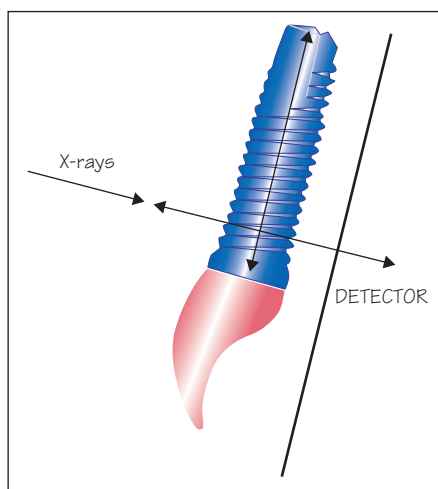


Figure 20.4 The periapical parallel technique: the detector (film, X-ray sensor) is positioned parallel to the long axes of the implants, and the central X-ray is directed perpendicular to both the film and the implant.

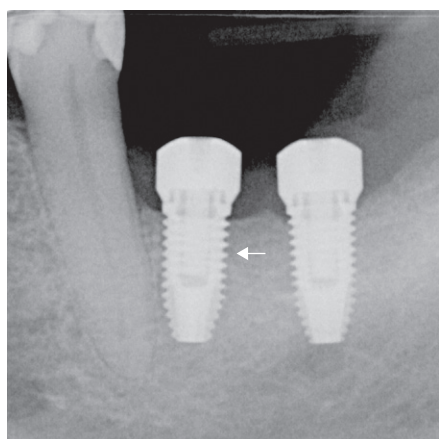


Figure 20.5 Proper parallel technique: good position of the film and correct orientation of the X-ray. Note the accurate appearance of the threads of the implant.

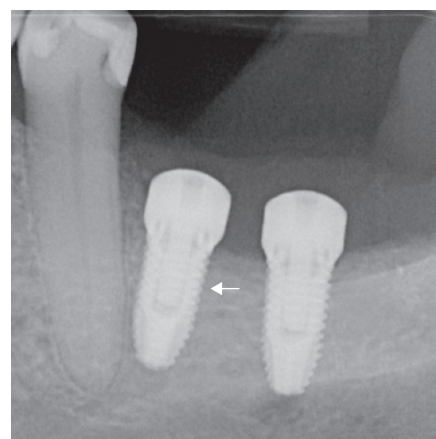


Figure 20.6 Incorrect technique: wrong position of the film and/or non-perpendicular orientation of the X-ray.

Table 20.1 Characteristics of different imaging techniques

	Two-dimensional			Three-dimensional		
	Intraoral	Panoramic	Cephalometric	Conventional tomography	CT scan	CBCT
Radiation dose	L	L	L	M	H	H
Accuracy	M	L	M	M	H	H
Distortion	L	H	L	No	No	No
Reproducibility	M	L	H	H	H	H
Magnification	L	H	L	No	No	No
Cost	L	L	L	M	H	M
Patient position	S	ST	ST	ST	SU	ST

CBCT, cone beam computed tomography; CT, computed tomography; H, high; L, low; M, moderate; S, seated; ST, standing; SU, supine.

With the development of implant therapy, many imaging devices have been suggested. The objective of the clinician is to select the most appropriate technique to obtain optimal information with the minimal radiation dose and the best financial cost.

ALARA principle: as low as reasonably achievable. The risk-benefit ratio must be evaluated to minimize the radiation dose, while obtaining the most reliable information.

Imaging techniques (Table 20.1)

Radiography

Panoramic radiography is a good, quite systematic screening examination in implant therapy. It allows global visualization of many anatomical structures. Its drawbacks include major distortion and variable magnification, making it inappropriate for accurate measurements.

Intraoral (periapical) radiography, performed with the parallel technique, provides a good deal of information with a minimum radiation dose. It is the examination of choice for dental/periodontal preoperative evaluation and for implant monitoring. If intraoral positioning of the detector is not possible, panoramic radiography can be an alternative.

Cephalometric lateral radiography is indicated to evaluate the sagittal interjaw relationship, the soft tissue profile, and the anterior bone width.

Tomography

Tomography is the only way to precisely evaluate bone dimensions. Images perpendicular to the dental arch (cross-sectional images) allow measurement of bone width. The absence of deformation and a constant magnification allow direct measurements.

The presence of artifacts with metallic elements affects the quality of images and makes this technique unsuitable for the control of osseointegration.

Conventional tomography (Fig. 20.1) can be used for examination of a limited zone, with relatively low radiation dose and cost. It provides thick cross-sectional images, which imply superposition of adjacent structures. Interpretation is not easy without proper training.

Computed tomography scan (CT scan) (Fig. 20.2) consists of acquisition of successive axial images (perpendicular to the body long axis), which are reformatted by computer software to obtain cross-sectional views.

The CT scan is the gold standard of tomographic implant bone evaluation. In a very short time (thus limiting patient movement), it provides an accurate examination of the whole mandible and/or maxilla. To limit radiation dose, current scanners use a “low-dose protocol” sufficient for bone evaluation.

Cone beam computed tomography (CBCT) (Fig. 20.3) consists of volumetric acquisition of a predefined volume, a computer reconstruction, and the possibility of obtaining images in any plane. Compared to CT scan, the reduction of examined bone volume allows reduction of the radiation dose. The resolution and image quality are quite similar, the cost is lower (small units) but the acquisition time is longer.

Preoperative examination

The following structures must be located.

- *Dental environment:* endodontic and periodontal radiographic examination of adjacent and other remaining teeth.
- *Extraction site:* evaluation of bone surrounding hopeless teeth (particularly for immediate implant protocols).
- *Bone morphology:*
 - height and width of alveolar bone to select the optimum implant size
 - precise location of cortical plates (buccal, lingual, sinus floor, nasal floor) to obtain cortical anchorage if necessary

– three-dimensional bone orientation, to compare with the prosthetic orientation (radiographic guide).

- *Location of anatomical structures:* is essential to avoid damaging them (e.g. inferior alveolar nerve) and to allow adaptation of the surgical approach (e.g. maxillary sinus).
- *Bone quality:* this determines the surgical technique (drilling) and the healing delay. Bone quality evaluation is difficult with imaging techniques. Appreciation during surgical drilling gives a more accurate evaluation.

Specific imaging techniques are recommended, according to the area to explore. (Table 20.2).

Radiographic monitoring of implants

Osseointegration is a prerequisite for implant success. It is always associated with a characteristic absence of radiolucency around the implant body on intraoral radiography.

Marginal bone level is measured on periapical radiography, to ensure that no excessive marginal bone loss occurs after implant insertion and prosthetic connection. Implant success requires a maximum of 0.1 mm marginal bone loss per year after the first year of prosthetic loading.

Adjustment of prosthetic components may need to be confirmed by intraoral radiography, to check the absence of any gap between the different components (implant, abutment, prosthesis).

Recommendations for radiographic monitoring of implants

Intraoral radiography with parallel technique is the examination of choice for implant monitoring. The irradiation geometry is crucial to avoid misinterpretation (Figs 20.4, 20.5, 20.6).

Table 20.2 Recommendations for radiographic preoperative examination

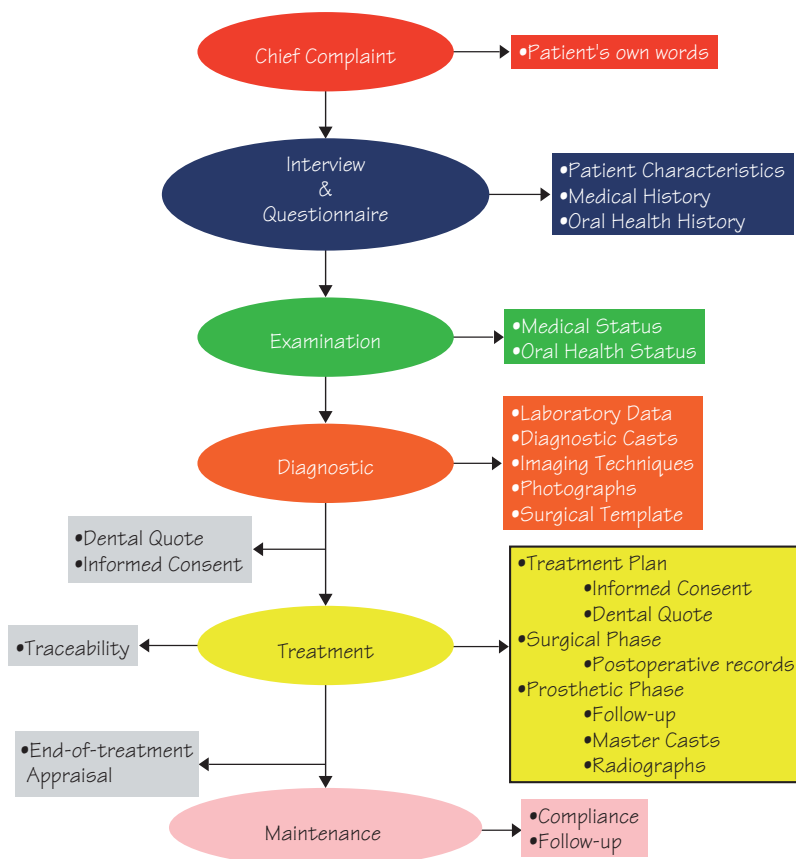
	Standard radiography	Tomography indication	Tomography technique
MAXILLA Partially edentulous	Panoramic Intraoral Intraoral status (1)	Incisive canal proximity Limited volume/ maxillary sinus Ridge alteration	Conventional (2) CBCT/CT scan (3)
MAXILLA Totally edentulous	Panoramic		CT scan
MANDIBLE Partially edentulous	Panoramic Intraoral Intraoral status (1)	Mandibular canal proximity Mandibular foramen proximity	Conventional (2) CBCT/CT scan (3)
MANDIBLE Totally edentulous	Panoramic Cephalometric	Ridge alteration	CT scan

CBCT, cone beam computed tomography; CT, computed tomography; (1) periodontitis patients; (2) small areas; (3) multiple areas.

Key points

- An intraoral radiograph with a parallel technique is mandatory before implant placement.
- Radiographic examination must be performed with a minimal radiation dose.
- CBCT is the basic 3D imaging technique.
- CT scan may be used for specific indications.

21 Patient records



Box 21.1 Preoperative checklist of the patient record

The medical record: is it complete?
 The general dentist/prosthodontist is identified?
 The surgical template: is it in the operating room?
 The panoramic X-ray: is it in the operating room?
 The CT scan (if any): is it in the operating room?
 The consent form: is it signed by the patient?
 The estimate (cost) of the surgery: is it signed by the patient?
 The estimate (cost) of the prosthesis: is it signed by the patient?

Figure 21.1 Patient records.

SURGICAL PLANNING						General Dentist/Prosthodontist ID					
Patient ID						Surgeon ID				Date	
Implant Brand			One Stage			Two Stage			Immediate Implantation	Immediate Loading	Temporary Implants
Bone Graft		Bone Substitute	Membrane			Fixation Screw			Sinus Grafting		
Tooth#	CT Scan		Dental Implants								
	Guide#	Slice#	Type	Length	Diameter	Angle	Head	Neck	Reference	Specific Comments	

Figure 21.2 Surgical planning form.

Implant Dentistry at a Glance, First Edition. Jacques Malet, Francis Mora, Philippe Bouchard.
 © 2012 John Wiley & Sons, Ltd. Published 2012 by John Wiley & Sons, Ltd.

The patient record includes the informed consent, the dental quote, and the medical records.

Figure 21.1 summarizes the documents that should be kept at various stages of treatment. Care must be taken with patients having complex care. Patients are considered to have complex care needs if they need ongoing care from a multidisciplinary team (see Chapter 10). These patients should have separate records from each practitioner involved in the treatment. Each practitioner should be able to provide a copy or summary of the patient's treatment plan to the referring general practitioner before beginning the course of treatment (i.e. following an examination and assessment of the patient).

Informed consent

The surgeon has a legal obligation to provide the patient with information on the planned procedure so that he/she has a clear appreciation and understanding of the surgery, implications, and future consequences. Therefore, all patients receiving dental implants and other oral surgeries are asked to sign a consent form. The content of the consent form mainly depends on the country's law. Basically, it is patient centered and based on the standard of care in that country. Ideally, an individual consent form should be created for each patient according to his/her specific condition. However, templates may be used for standard situations (see Appendix E).

Dental quote

The patient must understand the cost of dental implant treatment. Dental practitioners are required to provide a written quote or cost estimate to the patient prior to commencing a course of treatment. The written quote should be signed by both the patient and the practitioner(s). The cost estimate should include the comprehensive range of care related to dental implant therapy, including dental assessments, restorative care such as fillings, crowns and bridges, extractions and other oral surgery, orthodontic treatments, and dentures.

Traceability

Dental implants are medical devices. Thus, one must be able to verify the history, location, or application of dental implants by means of documented recorded identification. The traceability of dental implants and prosthetic devices such as abutments is mandatory. Stickers and/or labels on the packaging must be included in the patient records.

Medical record

The medical record is a systematic documentation of current and past medical history and care. It can be used as a legal document. The practitioner may use computerized patient record systems or paper-based ones.

The patient's chief complaint, i.e. the initial demand of the patient, is the cornerstone of the treatment plan. Dental implant therapy may take place over a long time. Further, in complex cases, more than three specialists can be involved in the treatment. There is a risk over time that the patient's demand will be overlooked, due to the complexity of the procedures. Consequently, the patient record should include the patient's own words corresponding to his/her demand, and not the interpretation of practitioner.

The medical chart should include the following:

Demographics and patient characteristics

- Patient's chief complaint
- Patient expectation of therapy outcome
- Patient motivation/ability to provide home care

Practitioner characterization

Health conditions/problems

Health history

- Medical history
- Oral/dental history

Examinations

- Medical status
- Oral health status

Diagnostic observations

- Laboratory data
- Diagnostic casts
- Imaging techniques
- Surgical template
- Photographs

Treatment plan

Surgical phase

Preoperative checklist. The surgeon should have the following on the day of the operation:

- preoperative checklist of the patient record (Box 21.1)
- surgical planning form that has been approved, if applicable, by the professional in charge of the prosthetic phase (Fig. 21.2).

Postoperative records

The postoperative record depends on national laws. It can be a written narrative of the surgical procedure or a postoperative form that is completed at the end of the surgical procedure. The electronic postoperative patient records and follow-up we use are provided in Appendices F and G. They can be modified according to the surgeon's opinion.

Prosthetic phase

- Patient follow-up
- Master cast
- Radiographs

End-of-treatment appraisal

The surgical procedure and the reconstruction may not be performed by the same professional. Surgeon and prosthodontist are both responsible for the treatment. Thus, after completion of the prosthetic phase, the patient, before being placed in a maintenance program, should be re-examined by the surgeon to confirm the dental implant reconstruction.

Key points

- Informed consent is a legal obligation.
- An overall cost estimate must be given to the patient before treatment.
- Traceability is mandatory.
- The medical record can be used as a legal document.
- The surgical planning form must be approved by the professional in charge of the reconstruction.

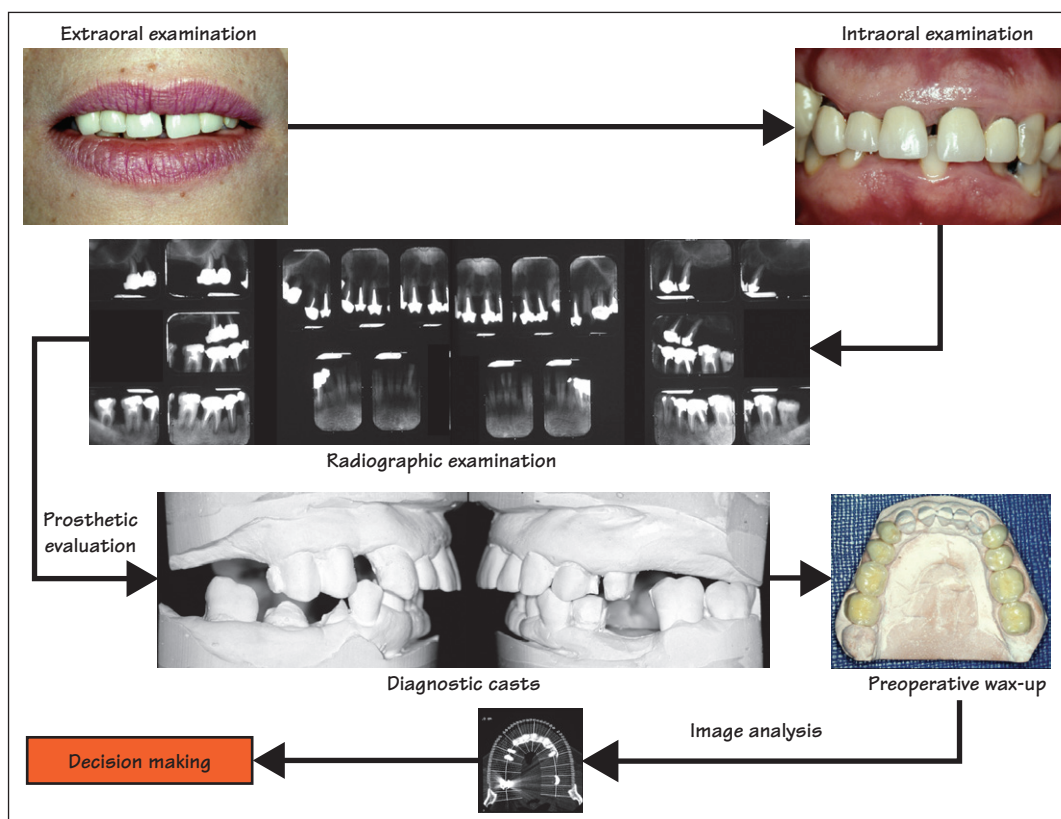


Figure 22.1 Decision-making process in dental implant therapy.

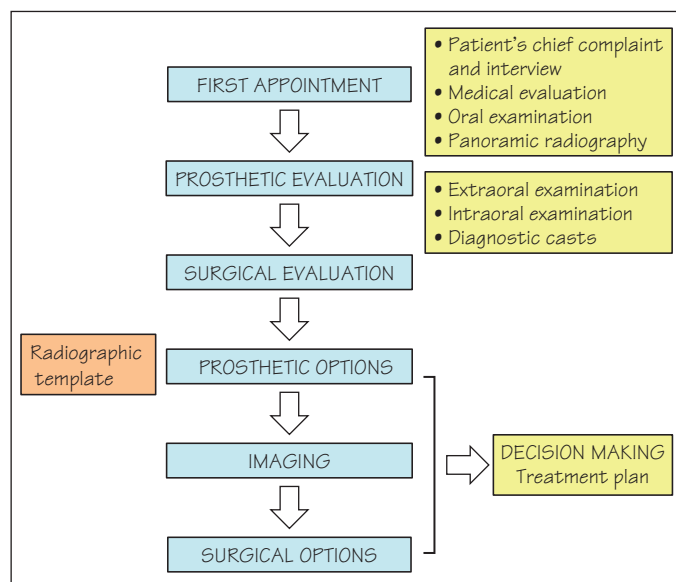


Figure 22.2 The pretreatment phase.

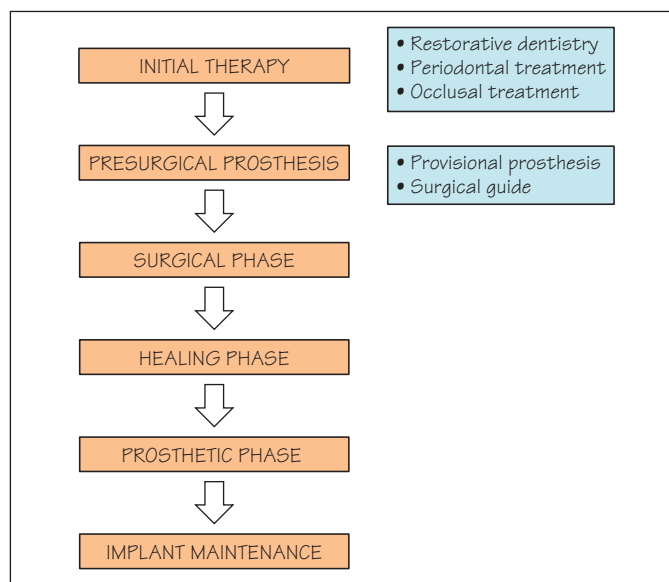


Figure 22.3 The treatment plan.

The first appointment

The patient's chief complaint determines the main objective of the treatment and is the cornerstone of the prosthetic plan. An in-depth interview is required to identify the patient's profile. The functional and esthetic demands are carefully documented. Patients with unrealistic demands should be excluded from implant therapy. In addition, because some implant procedures are irreversible, time-consuming, and expensive, patient compliance is required during and after implant therapy (see Appendix E).

Information is provided to the patient regarding the limitations of dental implant therapy. This information is personalized according to the patient's medical and dental conditions. At this stage, the patient should be made aware of the overall cost of the therapy, including the surgical procedure(s), imaging, and restoration fees. The patient should also be verbally informed of the overall length of the treatment.

Panoramic radiography should be sufficient for this preliminary approach. Dental impressions are made in order to obtain diagnostic casts.

The prosthetic evaluation

The prosthetic evaluation should precede the surgical evaluation.

Extraoral examination

The temporomandibular joint status is carefully evaluated. Information is gathered on facial musculature and facial harmony. Attention should be paid to the masticatory muscles (hypertrophy, masticatory forces, bruxism, and parafunctions), the loss of occlusal vertical dimension, and the lip support in the frontal and sagittal planes. Esthetic evaluation of the lip-teeth relationship present in the smile, during speech and at rest is mandatory.

Intraoral examination

The clinical examination in dental implant therapy does not differ from the basic preprosthetic examination (Belser *et al.*, 2008a,b). Special attention should be paid to the signs and symptoms of bruxism (tooth wear, indentation of the tongue, etc.).

A thorough clinical examination at the implant site evaluates the following features:

- shape of the residual ridge, including the degree of horizontal and vertical alveolar ridge resorption
- thickness of the soft tissues and presence of gingiva
- position/migration of the adjacent teeth
- migration/egression of the antagonist teeth
- width of the edentulous area
- characteristics of the antagonist arch.

During the examination, care must be taken when the arch includes implant-supported FPD and any type of fixed restoration, especially when the cosmetic reconstruction is made of porcelain. Removable dentures at the opposite arch are at the lowest risk of occlusal stress.

The diagnostic casts

Even if an implant can be surgically placed, this does not mean that the prosthetic envelope is sufficiently large for the implant-supported

prosthetic restoration. In implant dentistry, the dimensions of the commercially available prosthetic components require a minimum horizontal and vertical space. The diagnostic casts mounted in an articulator are critical to the evaluation of the following parameters.

- The interarch relationship. The interarch distance and the discrepancy between the upper and the lower arches are assessed (Renouard & Rangert, 1999).
- The existing static and dynamic occlusion.
- The interocclusal space. A minimum of 6 mm is required for a fixed restoration. For a removable denture, a minimum of 12 mm is often required.
- The interdental space. For a single implant, a minimum of 7 mm (6 mm for narrow implants) is required. For two implants the minimum is 14 mm.

The surgical evaluation

The surgical decision-making process is complex and requires a medical approach, an intraoral evaluation, and imaging. These points are developed elsewhere in this book (see Chapters 11, 18, and 20).

At the end of the surgical evaluation, a prosthetic option is determined, which enables the fabrication of the radiographic template which prefigures the future reconstruction. The final surgical evaluation takes into account the imaging diagnostic, and may confirm or modify the prosthetic option.

The decision-making process

Decision making in dental implant therapy requires a team approach (see Chapter 10). Good decision making integrates the best research evidence with clinical expertise and patient values. Therefore, the final decision leading to the treatment plan combines technical feasibility with the patient's demand. Technical feasibility takes into consideration both the surgical and the prosthetic options (Figs 22.1, 22.2).

The treatment plan (Fig. 22.3)

Normally, the treatment plan should not be modified because it is the result of the decision-making process. However, a realistic approach allows for changes according to the patient's compliance and complications.

The initial therapy aims to control the bacterial load, the occlusal load, and the vertical dimension. After the initial therapy, the provisional restoration is prepared and delivered at this stage. The surgical guide is then created from the radiographic template. The dental implants are placed. After the healing phase, a clinical and radiographical evaluation of the integration of the implants to the bone is performed. The prosthetic phase can then begin. At the end of treatment, the patient is enrolled in a maintenance program.

Key points

- The patient's chief complaint determines the main objective of the treatment.
- A treatment plan is mandatory, even in simple situations.
- The decision-making process requires a team approach.
- The maintenance program is part of the treatment plan.

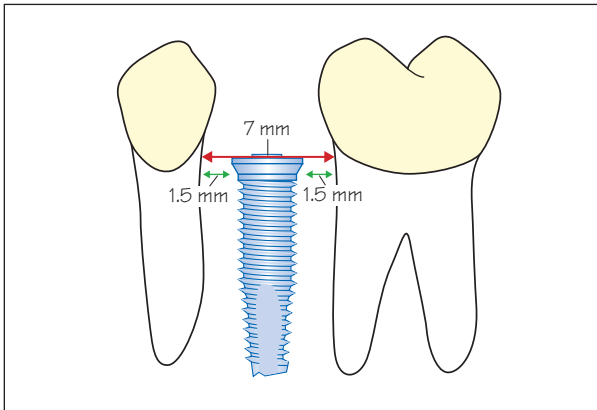


Figure 23.1 Minimal interdental space to place a standard-diameter dental implant.

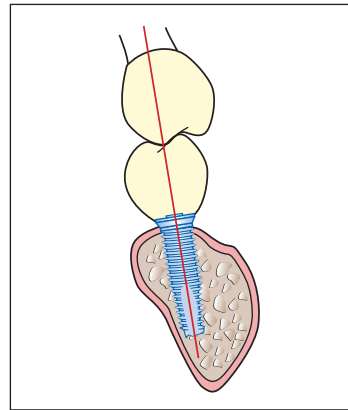


Figure 23.3 Optimal orientation of the implant: the implant axis should emerge in the central fossa and in the direction of the opposing supporting cusps.

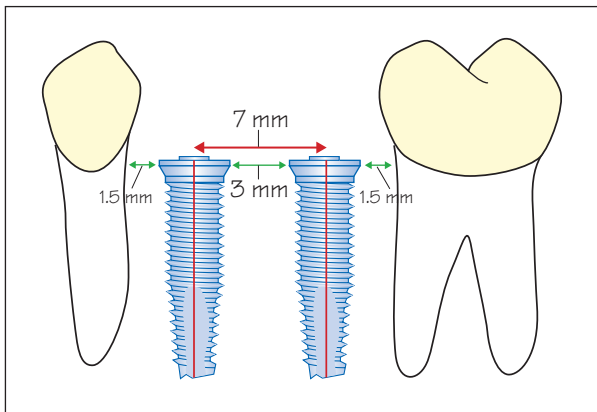


Figure 23.2 Minimal distance between the centers of two standard-diameter dental implants.

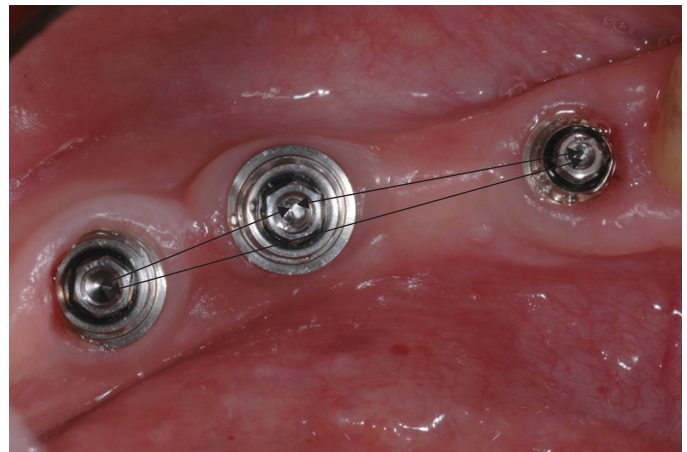
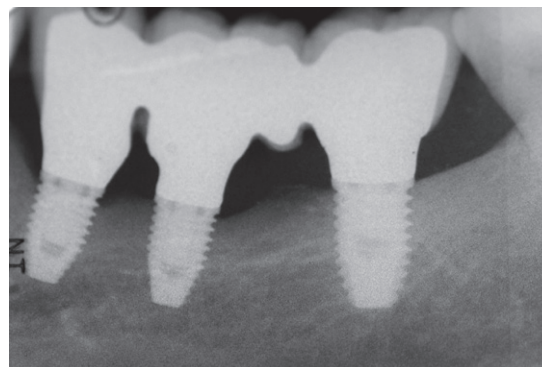


Figure 23.4 Three implants placed in a tripod alignment to minimize stress and torque distribution.



(A)



(B)

Figure 23.5 Fixed partial denture supported by two short implants (7 mm length, 4 mm diameter) in positions 35 and 36 and one wide implant (8.5 mm length, 5 mm diameter) in position 37. (A) Clinical view. (B) Radiographic control.

Implant selection is performed after prosthetic planning, in order to match implant characteristics with the prosthesis requirements: this is the concept of *prosthetic-driven implant dentistry*.

Guidelines for implant selection are based on several parameters (Box 23.1), and involve clinical examination, radiographic examination, and ultimately surgical evaluation.

Implant characteristics include the following: length, diameter, shape, roughness, number, and position. In addition, esthetics may affect the choice of implant (see Chapter 17).

Dimensions of the edentulous area

Ideally, the diameter of the implant platform should be identical to the cervical dimension of the replaced tooth.

Interdental distance: single tooth replacement

A 7 mm interdental distance is considered as a routine case, i.e. a standard implant can be placed without particular risk (Fig. 23.1). For the smallest spaces (5–6 mm), one should consider the use of small diameter implants to avoid excessive proximal bone loss. For larger spaces, a wide implant may be used if a sufficient thickness of bone is available. For edentulous areas exceeding 14 mm, two implants are required, to avoid horizontal cantilever.

Interdental distance: multiple teeth replacement

The number and positions of implants are defined according to the prosthetic planning (see Chapter 22), and with respect to interimplant distances. A minimum of 7 mm is required between the centers of two standard implants (Fig. 23.2).

Interocclusal distance

It is important to ensure sufficient space for the prosthetic components of the implant system. Most implant systems require a minimum vertical distance of 6 mm to allow fabrication of the restoration.

Adjacent teeth

For the preservation of alveolar bone and to allow hygiene access, a minimum of 1.5 mm must separate the implant from the adjacent tooth.

Apical root convergence

The mesiodistal bone volume must be measured over the entire height of the implant site. In cases of apical root convergence, a shorter implant or a conical implant avoids root interference.

Biomechanics

In the posterior area, implant position and implant axis are determined by occlusal force distribution (although it is difficult to prove a correlation between excessive occlusal forces and marginal bone loss or implant failure).

The bone/implant interface is well adapted to axial compressive forces. Shear forces should be avoided. Consequently, for optimal loading, the implant should be placed in the direction of the axial forces (Fig. 23.3).

In strong occlusal forces, the use of wide-diameter implants increases the BIC and improves mechanical strength of the implant body (Ivanoff *et al.*, 1999).

Small-diameter implants are contraindicated with high occlusal loading.

Box 23.1 Checklist of parameters to be evaluated for implant selection

Dimensions of the edentulous area
Adjacent teeth
Biomechanics
Bone volume
Bone quality (loading protocol)
Anatomical structures

For three or more splinted implants, it has been advocated that a tripod configuration improves force distribution (Fig. 23.4).

Bone volume

Ideally, the implant should occupy the maximum bone volume and be surrounded by a sufficient bone thickness (1 mm, and 2 mm buccal in esthetic areas) (Table 23.1), while respecting the position (emergence point and axis) guided by the prosthesis (surgical template).

Long implants (>10 mm) may be indicated to achieve primary stability in the following situations: immediate implants, bone defect, tilted implants, poor bone quality.

Short implants (<10 mm)

Limited data are available in the literature. Most failures have been described with machined surface implants when used in soft bone. The following parameters must be controlled (Renouard & Nisand, 2006; Telleman *et al.*, 2011).

1. *Primary stability*: underdrilling is recommended in soft bone.
2. *Learning curve*: the surgical procedure is demanding.
3. *Implant surface*: the use of a rough surface gives an improved success rate.

Short implants are indicated in limited bone volumes (Fig. 23.5). With good case selection and controlled surgery, results are comparable to longer implants after augmented bone procedure (vertical bone graft, sinus lift) with less morbidity.

Bone quality

Sufficient primary stability is a prerequisite for success for immediate or early loading of implants, while there is no evidence for delayed loading. Nevertheless, primary stability is required if possible.

To improve primary stability in type 3 and 4 bone, the surgeon may adapt the implant dimensions and select a specific design (see Chapter 6) as well as a rough/bioactive surface (see Chapter 8).

For type 1 and 2 bone, standard implant designs are preferred to limit bone compression and facilitate insertion. Rough surfaces are not useful either in this indication except for immediate loading. However, most implant companies offer only relatively rough surfaces.

Table 23.1 Minimal buccolingual bone volume

Implant diameter	Non-esthetic areas	Esthetic areas
3 mm	5 mm	6 mm
4 mm	6 mm	7 mm
5 mm	7 mm	8 mm
6 mm	8 mm	–

Key points

- The design of the restoration is a key factor in implant selection.
- A standard implant requires 7 mm mesiodistal distance, 10 mm bone height, and 6 mm bone width.
- Wide implants are preferred for molars, and when high occlusal loading is expected.
- Long implants (>10 mm) are indicated when poor primary stability is expected with standard implants.
- Limited data are available on the use of short implants as an alternative to bone augmentation surgical procedures.
- Specific implant types are available for type 3 and 4 bone or for immediate loading.



Figure 24.1 Single tooth replacement: removable denture. (A) Extraction of tooth 11. (B) Temporization with a removable denture. (C) Buccal view after insertion of the provisional denture. Note the lack of artificial gingiva to avoid any buccal compression.

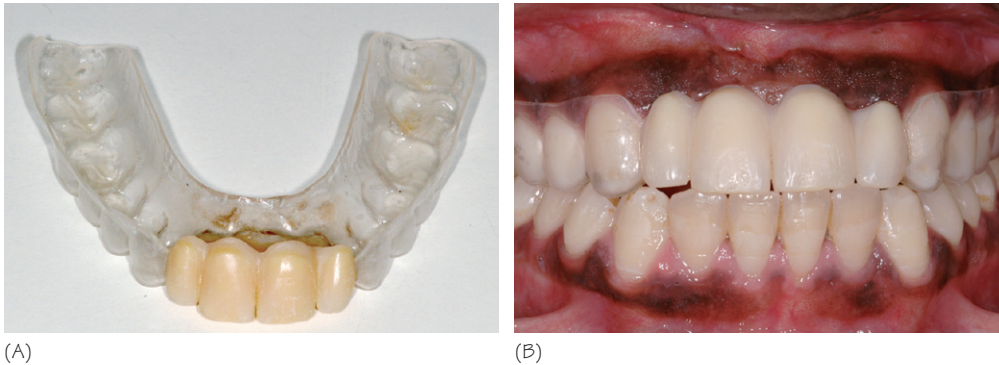


Figure 24.2 Multiple teeth replacement: removable denture. (A) Modified vacuum-formed clear resin tray (flexible, 0.5 mm thick) replacing the four maxillary incisors during the osseointegration phase. (B) The buccal portion is removed for esthetics and commercially available artificial teeth are attached to the tray.

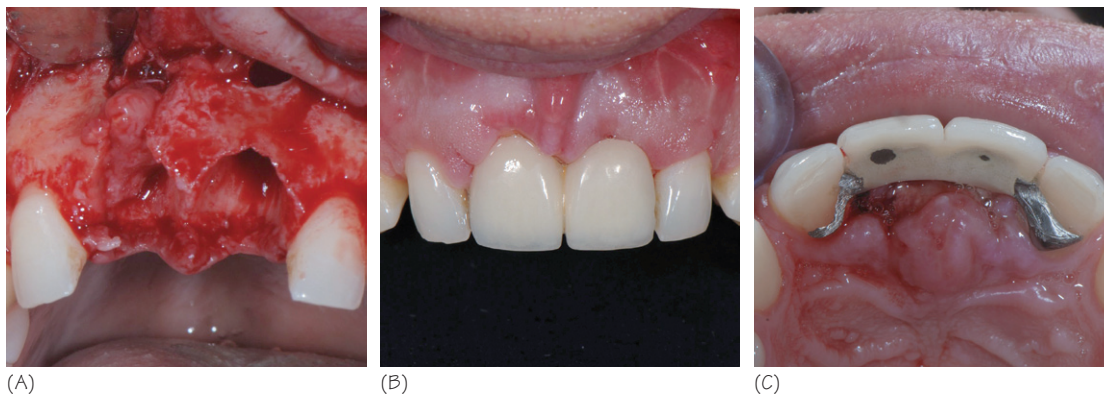


Figure 24.3 Multiple teeth replacement: fixed provisional restoration. (A) Extraction of teeth 11 and 21. (B) Temporization with a resin-bonded cast metal bridge cemented to the abutment teeth without any tooth preparation (buccal view). (C) Palatal view. Courtesy of Dr Alexandre Sueur, Bruxelles, Belgium.

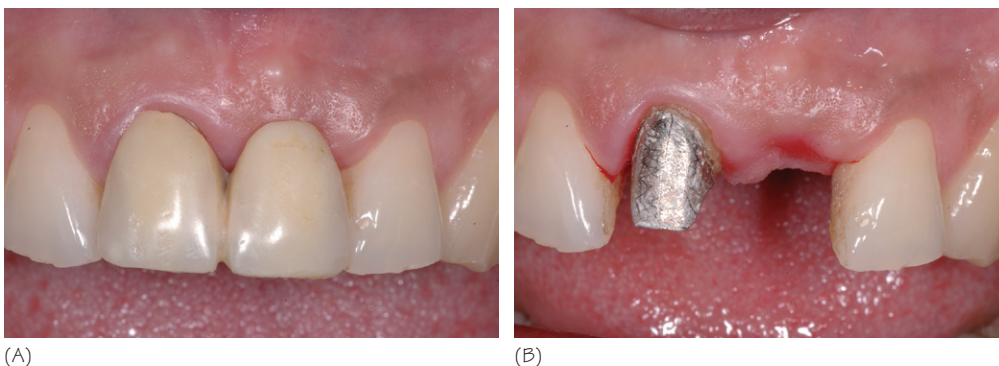


Figure 24.4 Single tooth replacement: fixed provisional restoration. (A) Tooth-supported provisional bridge on tooth 11, replacing 21 (cantilever). (B) Clinical view without the provisional restoration.

One critical challenge of implant therapy is the provisional phase. Most patients want a temporary replacement of missing teeth during the period between implant placement and final prosthetic restoration, in particular in esthetic areas. Temporary solutions may be of three types: removable, tooth supported or implant supported. Their role is to preserve esthetics and function, and to prevent tooth migration. In non-esthetic areas and for particularly risky procedures (bone grafts, barrier membranes), clinicians may decide not to place any provisional restoration.

Timing

The decision to use a temporary replacement and the choice of restoration type should be determined during treatment planning. The restoration can be elaborated chairside or in the laboratory. The provisional prosthesis can be elaborated at different steps of the treatment: prior to extraction, before implant placement, after implant placement or after implant osseointegration.

The role of the temporary prosthetic restoration

As in conventional dentistry, the temporary prosthetic restoration in implant dentistry plays a major role during the entire treatment. It maintains esthetics and provides stabilization and function.

In the esthetic area the provisional restoration is used to maintain soft tissue morphology after tooth extraction and to guide soft tissue healing for the final restoration (see Chapter 26, Fig. 26.3). It is a preview of the future restoration on which all modifications can be tested with the patient and the laboratory.

General specifications of temporary prosthetic restorations

- Not traumatic to adjacent teeth and soft tissues
- No negative interference with osseointegration
- Easy to modify if necessary
- Acceptable esthetics
- Comfortable
- Easy to clean
- Strong and durable for the duration of the treatment
- Low financial cost

Removable solutions

A *temporary partial denture* is an inexpensive, simple to elaborate, easy to remove and easily revisable solution. However, a denture may be unstable and compressive on the mucosa, causing indirect loading, marginal bone loss and even loss of osseointegration. This drawback can be particularly obvious with grafted sites.

The denture should be modified for the first weeks, to avoid any contact with the wound, and regular checks and relining are necessary afterwards to avoid hampering the healing process.

In the esthetic area, the gingival portion of the denture should be reduced or removed to avoid contact with the soft tissue (Fig. 24.1).

A *modified clear resin tray* (Fig. 24.2) is an alternative to a temporary partial denture, when the clinical situation requires a total lack of compression during the first weeks (bone graft, poor primary stability) or in the case of limited interocclusal space.

Tooth-supported solutions

A *resin-bonded cast metal bridge* is a very reliable, comfortable, and stable solution. However, it may not be easy to remove and to reline if necessary. During prosthetic steps, debonding and rebonding procedures can be time-consuming and degrade the bonding strength. In addition, it has a higher financial cost. It is indicated for long-term temporary placement, particularly in young patients (Fig. 24.3).

Temporary bridge: this is an inexpensive, simple to elaborate, easy to remove, and easily revisable solution. *Temporary cantilevers* (with low occlusal contact) are possible but not recommended (Fig. 24.4).

However, few clinical situations of this type are encountered, since at least one adjacent tooth must be prepared for a prosthetic reconstruction.

Staged approach: for extended or complete restorations, it may be possible to elaborate a first temporary bridge on some remaining hopeless teeth. After implant insertion and osseointegration, teeth are extracted, an implant-supported temporary bridge is placed, and other implants are inserted if necessary.

Transitional implants

Small screws inserted in some strategic positions and immediately loaded serve to support a provisional fixed restoration or to stabilize a removable denture. Bone volume and cortical anchorage are essential for these devices.

Implant-supported solutions (immediate function)

Modified implant surfaces, evolution of surgical techniques, and better understanding of healing processes have led to protocols for immediate placement of temporary implant prostheses, with acceptable success rates. These *immediate function* devices can be subjected to full occlusal loading (*immediate loading*) or not affected by the occlusal forces (*immediate restoration*) (see Chapter 25).

It is a very comfortable and stable solution for the patient, with the added advantage of allowing soft tissue maturation. However, indications are restricted to particular clinical conditions and include, among other parameters sufficient primary stability of implants (see Chapter 25).

Key points

- A provisional restoration should replace the missing teeth during the healing phase.
- The design of the provisional restoration must not be detrimental to the osseointegration process.
- In esthetic areas the provisional restoration should have a design aiming to guide soft tissue healing.

Treatment planning: immediate, early, and delayed loading

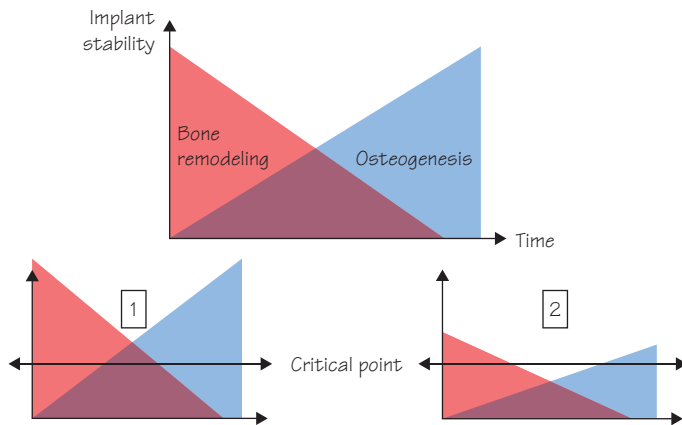


Figure 25.1 Evolution of dental implant stability in time, after surgical placement. 1. Favorable conditions for immediate loading: good primary stability and rapid osteogenesis. 2. Unfavorable conditions for immediate loading: insufficient primary stability and slow osteogenesis.

Table 25.1 Different loading protocols: level of scientific evidence (edentulous patient)

		Mandible	Maxilla
Removable prosthesis	Conventional loading	H	M
	Immediate loading	H	L
	Early loading	M	M
Fixed prosthesis	Conventional loading	H	H
	Immediate loading	H	H
	Early loading	M	M
Immediate implants	Immediate loading (fixed prosthesis)	L	M

H, high; M, medium; L, low.

Adapted from: Gallucci GO, Morton D, Weber HP. Loading protocols for dental implants in edentulous patients. *Int J Oral Maxillofac Implants* 2009;24 Suppl:132–46.

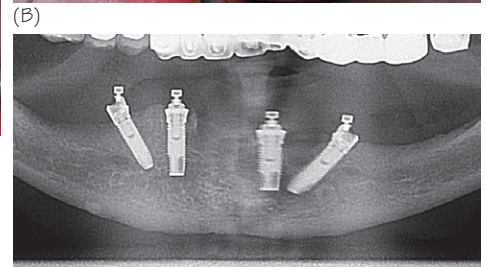
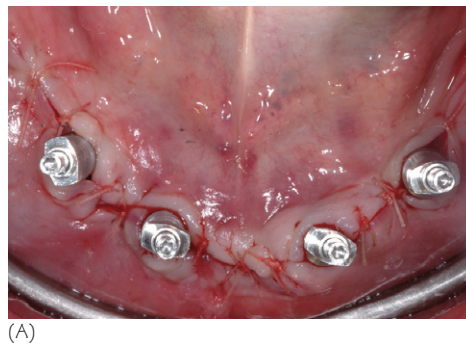


Figure 25.2 Immediate loading (edentulous mandible). (A) Four implants are inserted between the mental foramina. An impression is taken at the end of surgery. (B) The fixed restoration (10 teeth and no cantilevers) is delivered within 24 h. (C) Radiographic control on the day of prosthesis insertion.

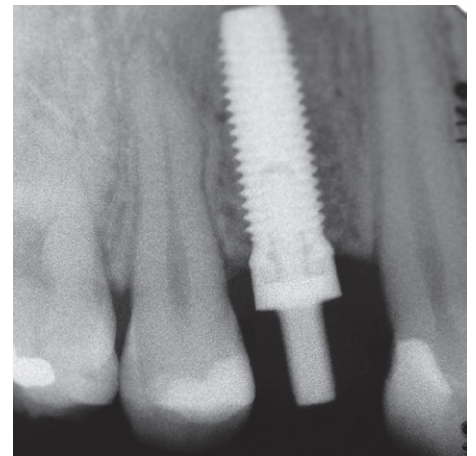
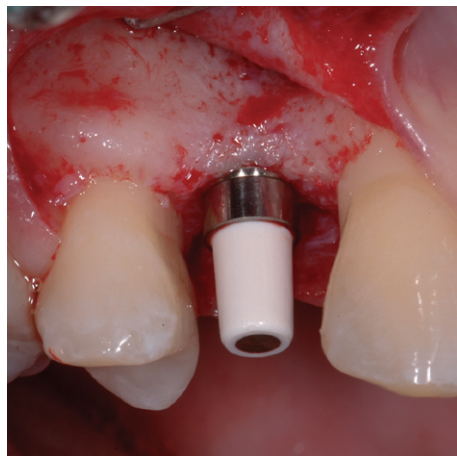


Figure 25.3 Immediate restoration (tooth 14). (A) After insertion of the implant, a temporary prosthetic abutment is placed. (B) A temporary crown is elaborated chairside and cemented without occlusal contact. (C) Radiographic control.

The conventional protocol in dental implant therapy includes a healing period of 2–6 months during which dental implants are unloaded. Nowadays, this period may be shortened or eliminated.

Rationale

After implant insertion, primary initial stability decreases during the first weeks (*bone remodeling*), while secondary stability (*osteogenesis*) increases during the same period (Fig. 25.1). The role of forces transmitted to the implant during this period is not clear: implant *micromotion*, if excessive, can affect osteogenesis and impair osseointegration, but it seems that limited loading may not be detrimental and may even be beneficial. If micromotion is kept under a threshold of about 150 µm during the entire healing process, osseointegration will occur normally. During this period, the control of factors influencing bone remodeling, osteogenesis, and micromotion is the biological basis of immediate loading.

Definitions

Immediate loading	Early loading	Conventional loading	Immediate restoration
Same day to 1 week In function	1 week to 2 months In function	After 2–3 months In function	Within 1 week Not in occlusion

Loading is defined as full occlusal contact at least in centric occlusion. Immediate restoration (syn: non-occlusal loading) means that despite no occlusal contact, some forces are transmitted to the implants by muscles (tongue, lips, cheeks) and food.

Background

Until a few years ago, predictable results with immediate and early loading protocols were only described in the anterior mandible area. Today, more data are available for edentulous maxilla, fixed partial dentures, and single-tooth implants.

Although immediate and early loading protocols are viable treatment options, the evidence level is low, and very often clinical studies are characterized by high patient selection and trained operators, both minimizing the risk. From a scientific point of view, the more predictable option is still the conventional approach, followed by immediate loading, and finally, the early loading approach (Esposito *et al.*, 2009).

Clinical situations

Edentulous patients (Table 25.1)

Conventional loading of implants for edentulous patients often requires to wear a complete removable denture that can compromise implant success. Consequently, the possibility of an immediate loading protocol must be considered. This is the case for the following well-documented situations:

- Mandibular overdenture supported by four splinted, immediately loading implants in the interforamina area
- Mandibular fixed restoration supported by four, five or six immediately loading implants (Fig. 25.2).
- Maxillary fixed restoration supported by 6–8 immediately loading implants

The relatively important number of implants and the possibility of achieving a cross-arch stabilization explain the good results obtained in these situations. For other situations that are less well documented, a conventional loading protocol is still indicated.

Partially edentulous patients

Although the level of evidence is low, it seems possible to load implants with a FPD immediately or early, even in the posterior maxilla (Roccuzzo *et al.*, 2009). Implant distribution, bone quality, opposite dentition, and occlusal schemes are critical parameters for implant success. Furthermore, the possibility not to have the restoration in occlusal contact with the opposite jaw extends the indications of immediate placement of the restoration (Fig. 25.3).

Recommendations

Primary stability of implants is essential for immediate loading. It can be measured by the insertion torque value during implant placement. Although non-consensual, 30 Ncm is considered as the minimum insertion torque value. Modified drilling protocol (underdrilling) can be necessary to improve primary stability.

Prosthesis insertion as soon as possible (within 1 week) is recommended.

It must be pointed out that not all clinicians will achieve optimal results, as immediate loading requires sufficient training.

Indications for immediate/early loading of implants

Patient benefit

Since conventional loading is still the gold standard, a modified protocol should provide real patient benefit: shortened treatment time, safer provisional restoration, and financial cost.

Patient selection

Medically compromised patients, bruxism patients, and heavy smokers should be excluded.

Site selection

Sufficient amount of good-quality bone allowing placement of implants in optimal conditions is required.

Surgical decision

The decision for immediate loading is validated during surgery, only if sufficient primary stability of implants is achievable.

Box 25.1 Parameters involved in immediate loading success

Patient	Implant	Surgery	Prosthesis
Non-bruxing Non-smoker	Osseointegrative surface Special design Number/ distribution	Bone quality Bone volume Drilling protocols	Lateral load control Rigid splinting of implants

Key points

- Immediate/early loading is a technically demanding procedure for experienced clinicians.
- Good primary stability of implants is essential for immediate/early loading.
- Rough implant surfaces play a major role in the success of immediate/early loading.
- The risk/benefit of immediate loading procedures should be considered in the decision-making process.



Figure 26.1 Anterior single-tooth replacement. Preoperative clinical view.



Figure 26.2 Postoperative clinical view (1 year).



Figure 26.3 Emergence profile on the provisional restoration is gradually modified. Note the shape of the peri-implant mucosa at the end of this process. The provisional restoration is positioned on the initial cast and the emergence profile is transferred to the laboratory.

The decision-making process for single-tooth replacement should include all therapeutic options, including tooth-supported FPDs and resin-bonded bridges. There is limited evidence that implant-supported single crowns perform better than tooth-supported FPDs on a long-term basis. However, taking into account the favorable cost/benefit ratio and the high ISR, dental implant therapy is the first-line strategy for single-tooth replacement.

Advantages/disadvantages of tooth-supported FPDs

From a biological point of view, preservation of the integrity of the teeth adjacent to the edentulous area is the main advantage. From an economic point of view, it has been shown that dental implant therapy is less costly and more efficient over time than tooth-supported FPDs for the replacement of one missing tooth (Bouchard *et al.*, 2009).

The major disadvantage of dental implant therapy is the need for a surgical procedure. Tissue abnormalities at the implant site may require additional complex surgical procedures. The morbidity of these procedures must be considered in the decision-making process. The risk/benefit ratio with a single implant should be carefully evaluated, and alternative treatment options should be considered.

Indications

Anterior single-tooth replacement

In sites without tissue deficiencies, predictable treatment outcomes, including esthetics, can be achieved because support is provided by the neighboring teeth (Belser *et al.*, 2008). However, esthetics in dental implant therapy remains a challenge. Depending on the status of adjacent teeth, tooth-supported FPDs should sometimes be preferred to achieve better esthetics.

Posterior single-tooth replacement

Esthetic considerations are less important here than in the anterior area. Therefore, dental implant therapy is the first-line strategy when it is compared to the bridge strategy in the case of intact bordering teeth.

Contraindications

- Interdental space less than 6mm and/or apical root convergence. This may lead to proximal attachment loss and/or root injury.
- Unpredictable esthetic achievement in sites with tissue deficiency in anterior areas.

Single-tooth implant in the anterior area

An optimal esthetic result depends on appropriate patient and implant selection, the correct three-dimensional implant positioning, and soft tissue stability. Dental implant therapy in the anterior area is a complex procedure, which is based on a comprehensive preoperative evaluation.

Surgical risk

Evaluation of the implant site should highlight the following high-risk situations:

- buccal bone deficiencies
- soft tissue deficiencies
- distance between the proximal bone and the cemento-enamel junction (CEJ) of the adjacent teeth >2mm
- buccal cortical bone plate <1mm.

Optimal implant placement

See Chapter 23.

Provisional fixed restoration and soft tissue modeling

(Figs 26.1–26.3)

Papilla preservation/reconstruction is a critical challenge. The provisional restoration plays a major role in esthetic outcome. After implant loading, successive modifications of the emergence profile of the provisional restoration are performed, in order to modify the position of the soft tissues and to allow papillae growth within the “black triangles.” Once an optimal result is obtained, the emergence profile is recorded and transferred to the dental laboratory.

Single-tooth implant in the posterior area

In the premolar area, standard-diameter implants are usually used.

In the molar area, large-diameter implants are preferred to standard-diameter implants, in order to increase the BIC and to improve the mechanical strength of the implant body. A wide platform, which improves the emergence profile, is also recommended in the molar area for better proximal plaque control. The replacement of a second molar can be a challenging situation.

Masticatory function and patient comfort must be evaluated before deciding to replace a second molar, especially if it requires complex surgical procedures. A passive option (no tooth replacement) may be a simple and viable solution.

Prosthetic considerations

The characteristics of the clinical situation are transferred by a master model to the laboratory technician. The master model is obtained after impression, and contains an analog of the implant and/or the replica of the abutment. Then the technician folds the crown of the homologous teeth in wax, integrating the same emergence from the labial and interproximal soft tissue margin.

At this stage, selection of the abutment depends on the following factors:

- implant shoulder position in relation to peri-implant gingival margin, with respect to the emergence profile of the suprastructure
- the longitudinal implant axis (Belser *et al.*, 2008).

Cemented restorations are normally used due to the simplicity of the technique. However, screw-retained restorations show better marginal precision. In addition, the implant shoulder is often located deep under the mucosa in esthetic areas. Cement removal may be difficult. Therefore, a screw-retained abutment/restoration interface is advisable, when feasible, for the anterior single-tooth replacement.

Key points

- In non-esthetic areas, dental implant therapy is the first-line strategy.
- In esthetic areas, the decision-making process depends on the predictability of esthetic outcome.
- Cemented restorations are generally preferred to screw-retained restorations.
- In terms of success, there is limited evidence that implant-supported single crowns perform better than tooth-supported FPDs on a long-term basis.

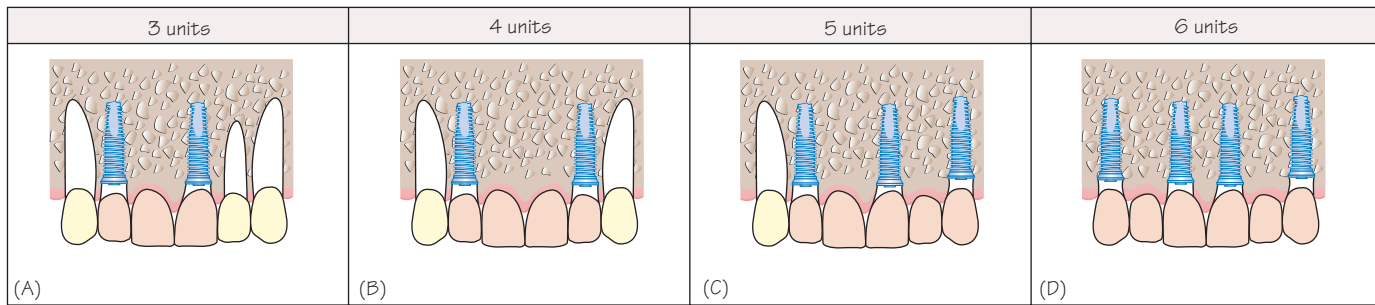


Figure 27.1 (A–D) Anterior area recommendations. The number of implants is reduced, to avoid adjacent implants and optimize esthetics.

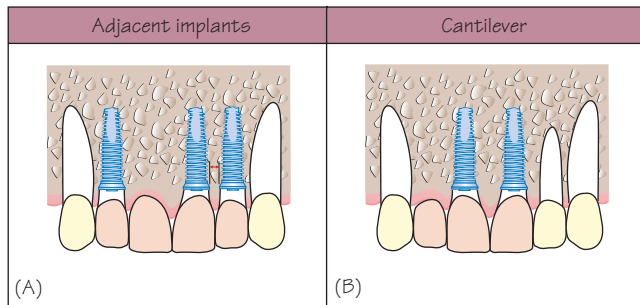


Figure 27.2 Anterior area alternatives. (A) More implants are necessary when the occlusal load is high and/or when the bone volume is reduced. The distance between adjacent implants (red arrow) should be more than 3 mm. (B) Cantilever replacement of a lateral incisor is an alternative to avoid bone augmentation procedures. Excursive tooth contact must be avoided on the cantilever.

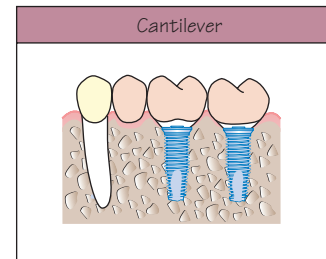


Figure 27.4 Posterior area alternative. Mesial cantilever can avoid bone augmentation procedures. A minimum of two adjacent implants is required.

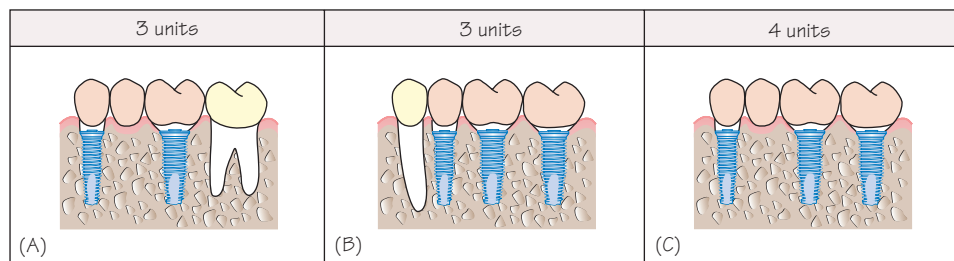


Figure 27.3 Posterior area recommendations. The number of implants depends on biomechanical parameters. (A,C) Short span bridges are preferred for better financial cost and to avoid implants that are too close. (B) Each molar is replaced by an implant.

Rationale

Dental implants have become the first treatment option for most edentulous patients and in particular for partial restorations. This is due to the favorable long-term results and the opportunity to deliver a prosthetic restoration with minimal risk, compared to a conventional approach.

Nevertheless, some controversies remain concerning the overall prosthetic decision: distribution of implants, cantilevers, implant/natural tooth connection, and screw-retained or cemented restorations.

The general prosthetic goal is to create an overall *reliable* structure consistent with a comfortable *function* (biomechanics), acceptable *esthetics*, and with minimum morbidity and cost.

Opinions based on conventional prosthetic treatments experience are not always reliable, as implant-supported denture concepts follow specific rules, mainly related to the osseointegration process.

Advantages

Compared to most conventional restorations, implant-supported FPD represents a less invasive prosthetic treatment with a reduction of the overall risk (Pjetursson and Lang, 2008) (Table 27.1). This is partially due to the possibility of increasing the number of abutments.

Disadvantages

Financial costs and anatomical limits can represent barriers which are not easy to overcome, and conventional restorations can then be considered.

Indications

Implant-supported FPD, when possible, is the treatment of choice for partially edentulous patients in the following situations:

- healthy adjacent teeth
- intact adjacent tooth restoration
- posterior reduced arch
- extended edentulous segments.

Implant distribution (Figs 27.1–27.4)

The number of implants depends on the number of units to be replaced. Other parameters are taken into account, including bone volume, occlusal parameters (antagonist teeth, hyperfunction), dimensions of the edentulous area, and adjacent teeth. Implant diameter is selected to best match the replaced tooth.

An optimal number of implants is selected to limit financial cost and improve esthetics. A prosthetic bridge design with one or two pontics is a reliable option in most cases. However, some clinicians recommend one implant per lost unit in the high-load zone.

Missing second molars are not systematically replaced (shortened arch); this has no consequences, depending on functional parameters.

Splinting of implants

In cases of restoration of each lost unit with an implant, there is no scientific evidence to recommend splinting of the implants. While splinting could be justified from a mechanical point of view (better force distribution, fewer technical complications), single units allow a better prosthetic passive fit and easier plaque control.

Indications for splinting of implants include:

- narrow-diameter implants in the posterior area
- short implants
- bruxism
- poor bone quality.

Cantilevers

Although real, the risk associated with cantilevers (abutment fracture, loss of retention) is much lower than with tooth-supported fixed dentures. The option of cantilevers can sometimes avoid bone reconstruction, and thus simplify the overall treatment. Mesial cantilevers are considered to be less hazardous than distal ones.

For edentulous patients, cantilevers of limited length are viable for long span bridges.

Implant/natural tooth connection

Although no data support the hypothesis of a particular risk when connecting implants and natural teeth in a FPD, totally implant-

Table 27.2 Advantages and disadvantages of screw-retained and cemented FPD

	Advantages	Disadvantages
Screw-retained FPD	<ul style="list-style-type: none"> – retrievable – reduced height – margin precision 	<ul style="list-style-type: none"> – bacterial colonization – more screw loosening – cost – esthetics (occlusal holes)
Cemented FPD	<ul style="list-style-type: none"> – simplicity – cost – passive fit – esthetics 	<ul style="list-style-type: none"> – less precise margin – cement removal – difficult to retrieve

FPD, fixed partial denture.

supported FPD are preferred whenever possible, rather than implant/natural tooth-supported FPD.

If the only solution is to splint teeth and implants, a rigid connection is preferred, as intrusion of natural abutments has been described in this situation.

Screw-retained or cemented restoration

There is an overall trend to promote cemented restorations over screw-retained FPD. This is due to the “similarity” with conventional treatments, and the relative expected simplicity. However, better precision is demonstrated with screw-retained FPD, although it is more difficult to achieve. Both treatment options show good prognosis, with no statistical difference (Table 27.2).

Indications for screw-retained FPD include:

- reduced interarch distance (<5 mm)
- expected frequent prosthetic modifications in the future
- non-visible areas (maxilla).

Complications

Despite the high survival rates, 38.7% of patients with implant-supported FPD have some complications during the 5-year observation period, as compared to 15.7% for conventional FPD and 20.6% for cantilever FPD respectively.

Compared with tooth-supported FPD, the incidence of technical complications was significantly higher for implant-supported reconstructions. The most frequent technical complications were fractures of the veneer material (ceramic fractures or chipping), abutment or screw loosening, and retention loss.

Table 27.1 Survival rate of prosthetic fixed partial dentures (Pjetursson and Lang, 2008)

	5 years (%)	10 years (%)
Conventional tooth-supported FPD	93.8	89.2
Cantilever FPD	91.4	80.3
Implant-supported FPD	95.2	86.7
Combined tooth-implant FPD	95.5	77.8
Implant-supported single crown	94.5	89.4
Resin-bonded bridge	87.7	65

FPD, fixed partial denture.

Key points

- Implant-supported FPD is the dominant strategy for partially edentulous patients.
- There is no evidence to support the concept of one tooth, one implant.
- Combined tooth/implant FPDs should be avoided as much as possible.
- There is no evidence that a screw-retained restoration performs better than a cemented restoration.
- Technical complications are frequent with implant-supported FPDs.

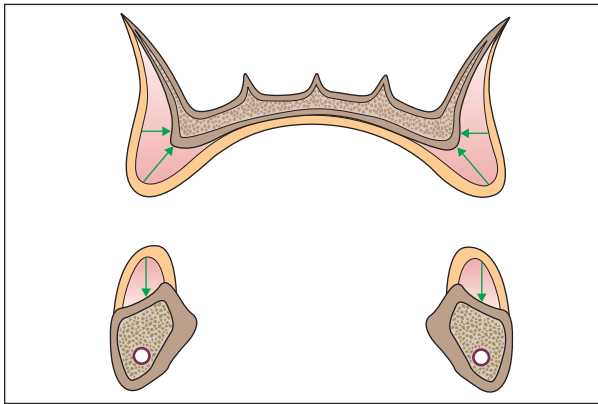


Figure 28.1 Modification of jawbone dimensions in the fully edentulous patient.

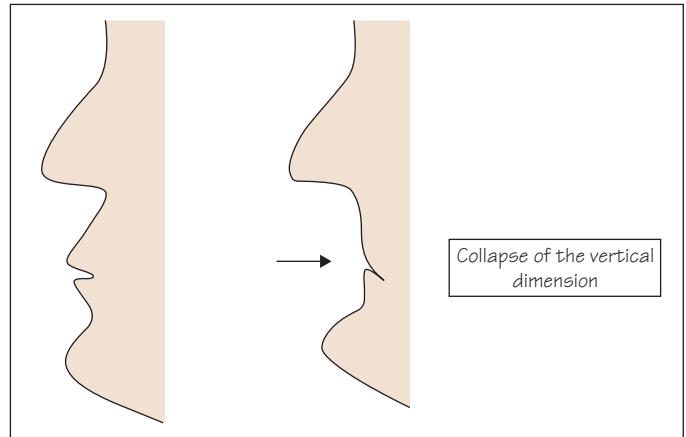


Figure 28.2 Modification of the orofacial support in the fully edentulous patient.

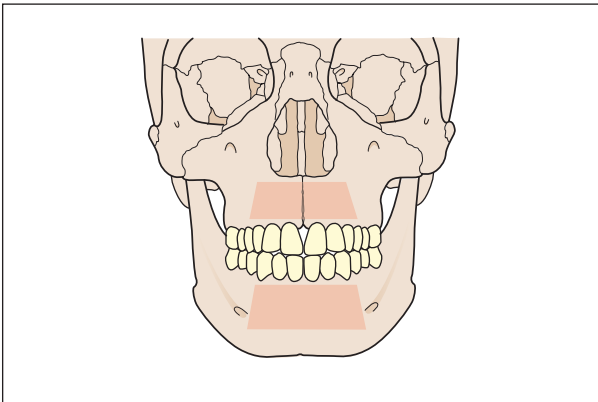


Figure 28.3 Anatomical areas at the maxilla and at the mandible where dental implants can normally be placed in the native bone (shaded areas).

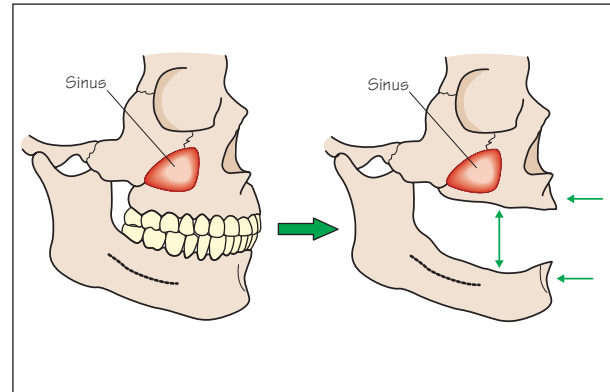


Figure 28.4 Bone resorption in edentulous patients.

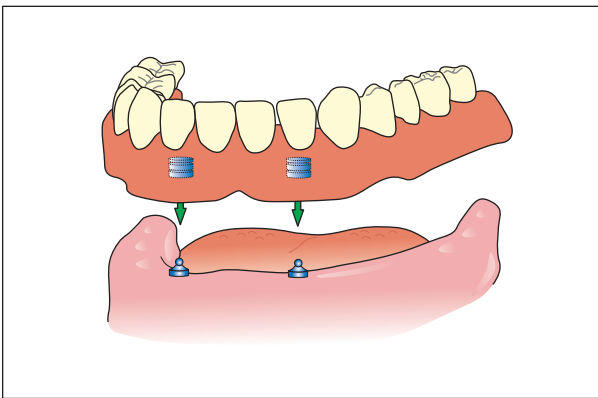


Figure 28.5 The simplest option: overdenture supported by two dental implants.

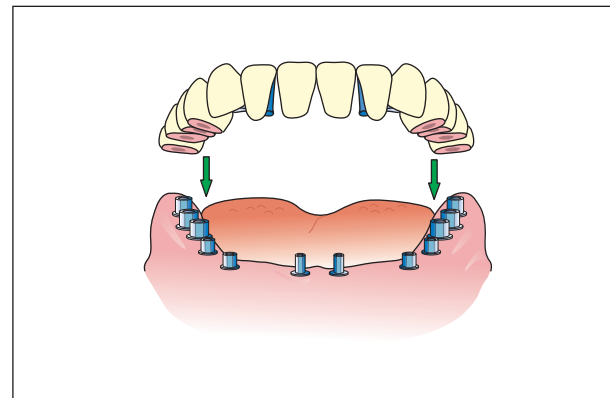


Figure 28.6 A sophisticated option: implant-supported FPD replacing the entire arch.

Bone resorption is the major problem in completely edentulous patients (Fig. 28.1). The edentulism leads to the loss of orofacial support, facial esthetics, phonetics, and the collapse of vertical dimension (Fig. 28.2). Treatment at the maxilla is more complex than at the mandible, and overdentures and fixed restorations show better success at the mandible than at the maxilla.

Surgical specificities

The anatomical areas where dental implants can be placed in the native bone are often limited (Fig. 28.3). Bone resorption increases the need for surgical bone compensation (Fig. 28.4). Situations where more than six dental implants can be placed in the native bone, either at the mandible or at the maxilla, are rare. Nevertheless, dental implant placement does not differ *per se* from the standard surgical procedure, except for the fixed prosthesis supported by four implants.

A surgical guide is mandatory because of the lack of benchmarks.

One-stage or two-stage approaches can be used. A two-stage approach may be indicated when it is expected that prostheses could transmit excessive forces on the dental implants (Esposito *et al.*, 2009).

Number and position of dental implants

There is no evidence to suggest that a minimum number of implants should be placed to achieve a standard clinical level. It cannot be concluded that patient satisfaction, denture function or implant survival improve by increasing the number of implants (Gotfredsen *et al.*, 2008). Restorations can replace the entire arch according to the number of implants that can be placed (see Appendix I, Tables I.1 and I.2).

From a biomechanical point of view, the position of the implants should be symmetrical about the midline. Thus, the number of placed implants should be even. An odd number of implants has been proposed, including the placement of a single implant in the midline. Routine use of these approaches cannot be recommended, except for the five-implant option at the mandible, and specific clinical situations that cannot be detailed in this book.

Prosthetic specificities

The treatment may vary from simple to highly complex (Figs 28.5, 28.6). The prosthesis may be constructed to be removable by the patient (overdenture) or non-removable if cemented or fixed with screws to the implants (bridge or denture design).

These two main options present both advantages and disadvantages (see Appendix I, Table I.3). Bridge design restorations often necessitate surgical augmentation procedures to achieve good esthetics and function. Enhancement of esthetic appearance and facial morphology may be easier with a denture design, possibly with decreased costs and less surgical intervention. Overdentures or denture design fixed restorations may compensate for defects in the alveolar ridge as well as lip support. In addition, dental implants can be placed according to

the bony availability because there is no need to place the implant at the emergence of a tooth. However, the volume of the acrylic support may vary from a mucosa-borne complete denture to an implant-borne reduced denture, limited to the premolar area that poorly compensates for bone resorption.

Removable options

Overdentures are implant- and mucosa-borne dentures. The denture base is attached to the dental implants by various commercially available attachment systems. One part of the attachment is connected to the dental implants and the other incorporated within the undersurface of the overdenture.

Attachment systems are adjustable and/or replaceable. They include bar, ball, stud, magnetic, and telescopic attachment systems (Preiskel, 1996). Patients prefer bar-clip or ball attachments over magnet attachments (Cune *et al.*, 2005, 2010). The bars can be soldered, cast with milled designs, made using spark erosion or even milled precision bars using non-precious alloys as part of an attachment system (Sadowsky, 2007). The bar can be extended by distal extensions.

It seems that restorations with distal bar extensions up to 12 mm have no influence on crestal bone loss around implants (Semper *et al.*, 2010). The bar may be round, ovoid, or parallel sided. The overdenture contains clips, spring pins, or other elements that fit onto the bar.

There is no difference in marginal bone loss around implants retaining/supporting mandibular overdentures relative to implant type or attachment design (Cehereli *et al.*, 2010).

Fixed options

According to the number and seating of the dental implants, the restoration may have a denture design (screw retained) or a bridge design (screw or cement retained). These two main options present both advantages and disadvantages (see Appendix I, Table I.4).

Denture design restorations can be implant and mucosa borne or solely implant borne according to the number and position of the implants. A metal framework retains and supports the acrylic resin denture base.

Fixed restorations may have distal extensions. The custom metal framework must seat with no tension on any implants (passive fit).

Key points

- There is no evidence for a single, universally superior treatment modality for the edentulous patient.
- The treatment at the maxilla is more complex than at the mandible.
- Overdentures and fixed restorations demonstrate better success at the mandible than at the maxilla.

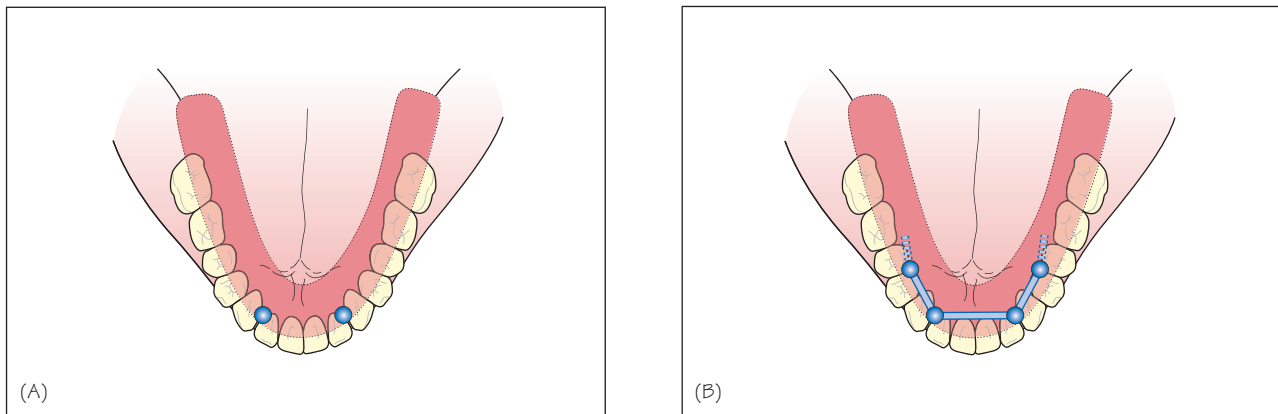


Figure 29.1 Removable options: overdentures with attachment systems. (A) Two dental implants. Ball attachment system. (B) Four dental implants. Bar attachment system. Distal bar extensions are possible.

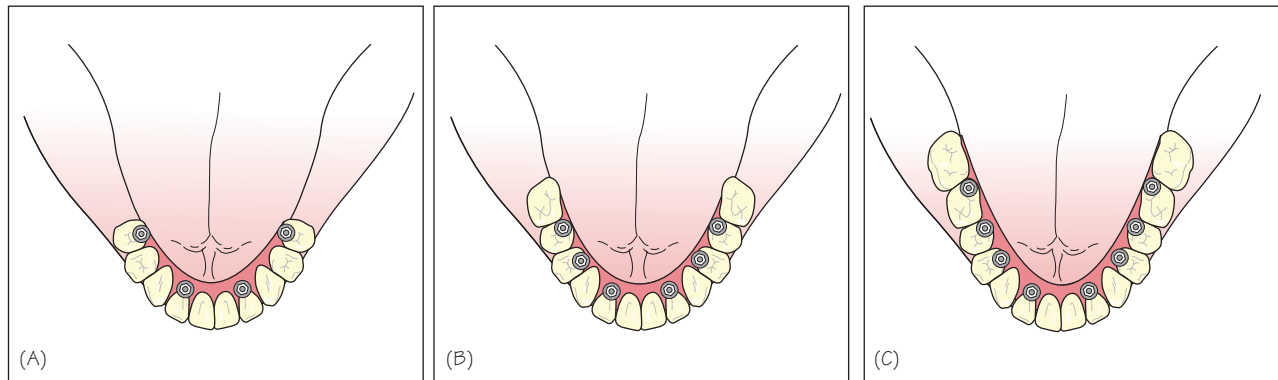


Figure 29.2 Fixed options: screw-retained denture designs. (A) Four dental implants. The two distal implants are tilted (see Appendix L). (B) Six dental implants. (C) Eight dental implants.

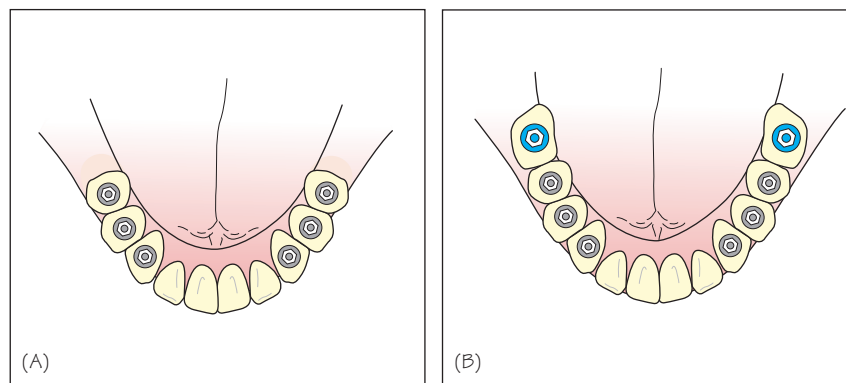


Figure 29.3 Fixed options: screw-retained or cemented bridge designs. (A) Six dental implants. The second premolar may have a molar shape. (B) Eight dental implants.

Removable options

Overdenture supported by two implants: ball attachment systems (Fig. 29.1A)

This is the least expensive, shortest, and simplest option. Normally, this option is possible in any case, except for severely resorbed mandibles. A bar can also be used. One international consensus has proposed mandibular two-implant overdentures as the minimum standard of care for edentulous patients (Feine, 2002).

Treatment plan specificities

Two implants are placed in the anterior mandible between the mental foramina (see Appendix J). Placing the implant in the canine-lateral region is recommended. A minimum of 7 mm of interocclusal distance is necessary. The implants must be parallel with a 10° tolerance. One-stage or two-stage procedures can be used. After the osseointegration process, ball abutments are placed. The existing denture can be used (see Appendix K). If this is not possible for functional or esthetic reasons, a new denture must be prepared according to the standard principles of complete dentures.

Overdenture supported by four implants: bar attachment systems (Fig. 29.1B)

Fixed options

Fixed prosthesis supported by four implants: screw-retained prosthesis (see Appendix L)

This technique is indicated with a minimum bone width of 5 mm and a minimum bone height of 8 mm between the mental foramina. The posterior implants are tilted to a maximum of 45°. Immediate loading with a provisional restoration is part of the initial description of the technique (Malo *et al.*, 2003). The restoration has a denture design (see below).

The major advantage of this technique, which is technically demanding, is that it may avoid bone transplantation. The restoration is limited to premolars. Molar sites are not replaced.

Fixed prosthesis supported by more than four implants

Denture design restoration: screw-retained prosthesis (Fig. 29.2)
A minimum of four implants is required.

Bridge design restoration: screw- or cement-retained prosthesis (Fig. 29.3)

A minimum of six implants is required.

Success/survival rates

Overall implant survival ranges from 86% to 100% at 5 years for fixed prostheses and from 83% to 100% for overdentures (Bryant *et al.*, 2007). Overdentures supported by two implants demonstrate a survival rate of 95.5% after 20 years of loading (Vercruyssen *et al.*, 2010).

Nowadays, immediately and early loaded implants are commonly used in mandibles with good bone quality (Brånemark, 1999). Short-term outcomes (24 months) of early or immediate loading protocols for mandibular implant overdentures achieved comparable success to conventional loading ones (Kawai and Taylor, 2007; Alsabeeha *et al.*, 2010). Micro-roughened implants should be preferred to machined implants in this indication.

Key points

- An overdenture supported by two unsplinted implants is an efficient, cheap, and simple option. It functions as effectively as four splinted implants.
- Overdentures and denture design fixed restorations can compensate for alveolar bone resorption.
- Bridge design restorations require at least six symmetrical dental implants.
- Eight symmetrical dental implants are necessary to replace all the teeth.

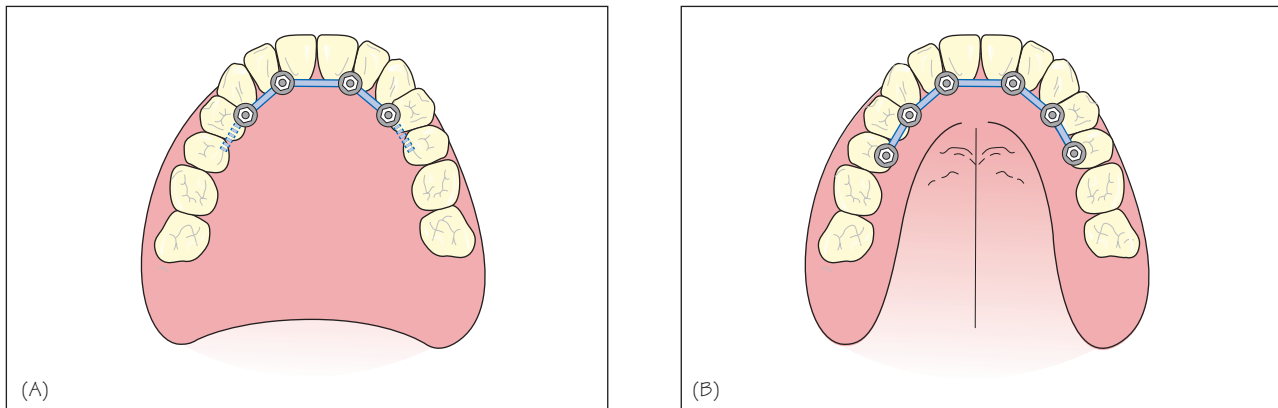


Figure 30.1 Removable options: overdentures with bar attachment systems. (A) Four parallel dental implants. The denture base has full palatal coverage. Distal bar extensions are possible. (B) Six parallel dental implants. The palatal area of the denture is relieved.

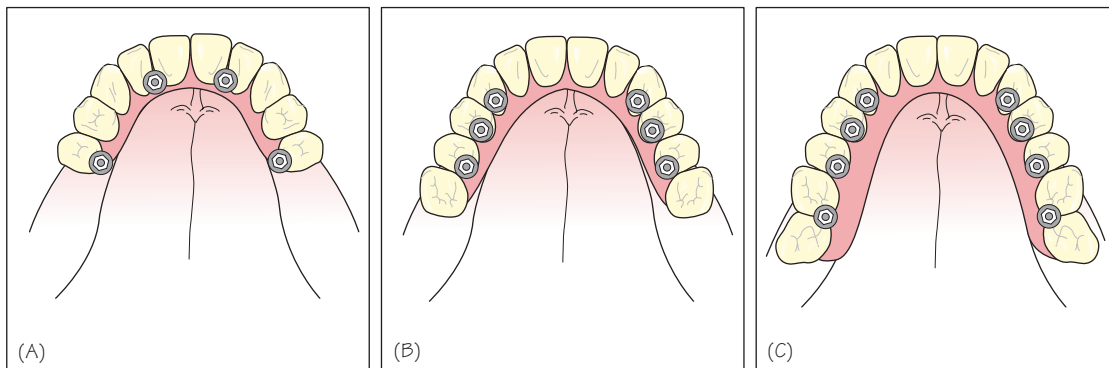


Figure 30.2 Fixed options: screw-retained denture designs. (A) Four dental implants. The two distal implants are tilted (see Appendix M). (B) Six dental implants. (C) Eight dental implants.

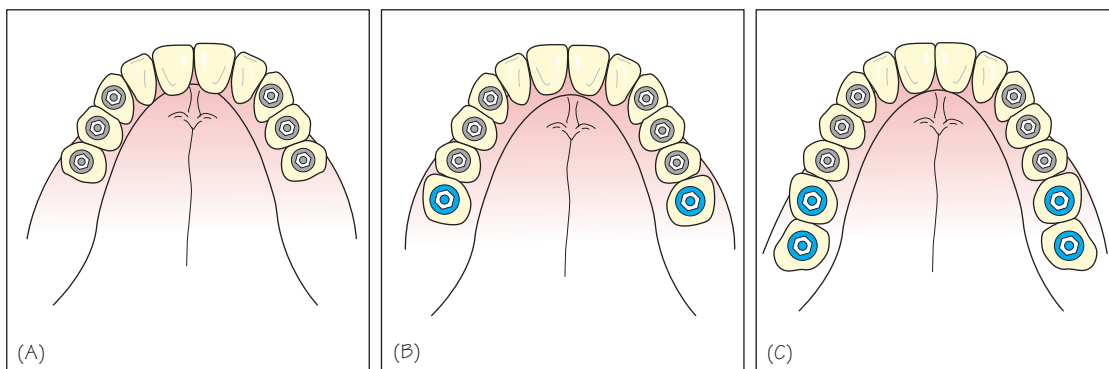


Figure 30.3 Fixed options: screw-retained or cemented bridge designs. (A) Six dental implants. The second premolar may have a molar shape. (B) Eight dental implants. (C) Ten dental implants.

Bone resorption in the anterior area may jeopardize esthetic results; and sinus volume following alveolar bone resorption may preclude implant placement in the posterior areas. Consequently, patients who are edentulous at the maxilla are often good candidates for hard and soft tissue augmentation procedures. In addition, the maxillary bone quality is often worse than that of the mandible, making the prognosis for dental implants in the edentulous maxilla less secure than in the mandible.

Thus, the decision-making process depends not only on the surgically available bone volume, but also on the patient's wishes in terms of esthetics. In other words, treatment choice at the maxilla cannot be reduced to a choice between removable or fixed options, but should be considered in terms of surgical and esthetic feasibility.

Removable options

Overdenture supported by four implants: bar attachment systems (Fig. 30.1A)

The recommended treatment option as the standard of care is at least four splinted implants using a bar attachment system (Mericske-Stern, 2003). The decision to place the implants in the anterior area is mainly due to reduced volume of bone beneath the sinus floor in the posterior area.

In addition to the improvement of denture stability, the dental implants may also allow for the reduction of prosthesis volume by relieving the palatal area of the overdenture. This advantage is important for patients with gag reflex problems. However, this decision must take into account the number and length of dental implants; removal of the palatal support produces a greater effect and more concentrated stress difference for maxillary overdentures than do differences between the attachment designs (Bueno-Samper *et al.*, 2010).

Care must be taken to evaluate the volume of the bar attachment that is incorporated into the overdenture. Excessive volume of the bar in conjunction with a low-to-moderate bone volume resorption in the anterior area may lead to an overexaggeration of the lip support.

Overdenture supported by six implants: bar attachment systems (Fig. 30.1B)

From a clinical point of view, it seems that the optimal number of implants to support a bar at the maxilla is six. The stress due to removal of the palatal support seems to be better distributed with six implants than with four.

Fixed options

Fixed prosthesis supported by four implants: screw-retained prosthesis (Fig. 30.2A; see Appendix M)

The technique is recommended with a minimum bone width of 5 mm and a minimum bone height of 10 mm from canine to canine. The posterior implants are tilted to a maximum of 45°. Immediate loading with a provisional restoration is part of the initial description of the technique (Malo *et al.*, 2003). The restoration has a denture design.

The major advantage of this technique, which is technically demanding, is that it may avoid bone transplantation. The restoration is limited to premolars. Molar sites are not replaced.

Fixed prosthesis supported by at least six implants

A minimum of six implants is required when the implants are parallel.

Denture design restoration: screw-retained prosthesis (Fig. 30.2B,C)

The implants should be placed as distally as possible in the canine-premolar region. From an esthetics standpoint, it is preferable to avoid seating the implants in the incisor area in order to facilitate placement of the prosthetic teeth. Sinus lift procedures are often required to place implants in the molar area (Fig. 30.2C).

Bridge design restoration: screw- or cement-retained prosthesis (Fig. 30.3)

Surgical augmentation procedures are often needed to compensate for bone loss. They aim not only to increase the vertical dimension of the bone to allow for implant placement, but also to increase the horizontal dimension so as to improve esthetics and function. Thus, complex surgeries are often planned.

Success/survival rates

For removable restorations, implant survival rates (1–10 years) range from 95% to 98%. Prosthodontic survival rate is around 91%. For fixed restorations, implant and prosthodontic survival rates (3–10 years) range from 95.5% to 98%, and from 96% to 100%, respectively.

Overdentures and fixed restorations demonstrate less success at the maxilla than at the mandible. Implant number and distribution along the maxilla seem to influence the prosthodontic survival rate (Lambert *et al.*, 2009).

There is no evidence to support early or immediate loading protocols with removable restorations (Gallucci *et al.*, 2009). There is some evidence to support immediate loading of roughened dental implants with fixed restorations (Weber *et al.*, 2009).

Key points

- The decision-making process depends on the patient demand in terms of esthetics.
- Esthetics achievements are technically demanding.
- Surgical augmentation procedures are often mandatory.
- A comprehensive view of skeletal maturation, occlusion, facial and dental esthetics is a key factor in the decision-making process.



Figure 31.1 A dental practice setting is not adapted for dental implant surgery.



Figure 31.2 Key equipment for the operating room:

An operating table or a dental chair.

A dental cart.

A surgical aspirator.

An over the patient stainless steel rolling table adjustable in height to set up instruments.

A stainless steel rolling dressing cart to set up surgical motors. An X-ray viewer.

A stainless steel bucket on castors. Two stools (if the surgeon works seated). Containers for disposables.



(A)



(B)



(C)



(D)

Figure 31.3 Key aspects of the operating suite. (A) Preparation room for the patient. (B) Nurses' room, in the storage room of the operating suite. (C) Dental X-ray generator. (D) Recovery room. Note the monitoring devices, and the window where the nurse can provide attention to the patient.

Dental implants can be placed in an operating room (OR) or in a dental practice. It is imperative that practitioners consider all surgical procedures as potentially infectious. In addition, it has been shown that it is especially important to avoid perioperative infection of the wound during surgery, when foreign bodies are implanted (Haanaes, 1990).

In the oral cavity, several sources of infection during surgery have been identified: instruments, the hands of surgeon and assistants, the air of the OR, patients' nostrils and saliva, and the perioral skin (van Steenberghe *et al.*, 1997).

Thus, the concepts of asepsis and sterility must be adhered to in dental implant surgery, and an OR is by far the most appropriate setting for dental implant surgeries (Fig. 31.1). Leaving aside the requirements for an aseptic environment, from an economic point of view, the transformation of a dental setting to an acceptable "operating room" requires such efforts that the profitability of the surgery is questionable. Consequently, we strongly recommend an aseptic OR being part of the dental setting if the practitioner aims to place implants on a regular basis.

The surgical team

- The surgeon
- The operating room nurse, who assists the surgeon during surgery
- The circulating nurse, who connects the people in the sterile field with the non-sterile area

The operating room

Outside the OR is a dedicated scrub area used by surgeons and nurses prior to surgery. There is storage space for common surgical supplies.

The OR is a controlled temperature and humidity environment, spacious, easy to clean and without windows. Operating fields should be cleaned before and after each surgical procedure and at the end of each day.

During surgery, the goal is to keep the operating field totally sterile for patient safety. This involves the following points.

- The door of the OR is closed during the operation.
- Traffic flow and conversation are reduced to a minimum.
- If an instrument or hand touches something outside the sterile field, the instrument or glove should be replaced immediately.

In an operating room, there are two areas: the sterile operating field and the non-sterile area. The circulating nurse connects the people in the sterile field with the non-sterile area (opens the implant packaging, resupplies the surgical table with disposable material, etc.).

Figure 31.2 indicates the key equipment of the OR. Operating tables are more convenient if the surgeon works standing; whereas dental chairs are preferable if the surgeon works seated. We prefer dental chairs because they are more comfortable for the patient and because the head of the patient can be easily immobilized.

The operating suite

In large facilities, several operating rooms may be part of the operating suite that forms a distinct section within a healthcare facility. The operating suite is climate and air controlled and separated from the remainder so that only authorized personnel have access. It contains rooms for personnel to change, wash, and rest, preparation and recovery

rooms, storage and cleaning facilities, offices, and dental X-ray generators (Fig. 31.3).

Preparation of the patient

Before surgery, the patient is dressed in a cap, shoe covers, and a light gown. Make-up should be removed. The patient's skin is scrubbed with povidone-iodine or chlorhexidine. Scrubbing starts at the lips and moves to the outside in a linear or circular manner.

A sterile fenestrated surgical drape is used to isolate the disinfected area from surrounding areas (eyes covered is preferable).

Preparation of the surgical team (see Appendix C)

The surgeon's hands and arms are scrubbed for 3 minutes with povidone-iodine or chlorhexidine, rinsed with water and dried prior to gloving.

Hand rubbing with aqueous alcoholic solution, preceded by a 1-minute non-antiseptic hand wash before each surgical procedure, is as effective as traditional hand scrubbing with antiseptic soap in preventing surgical site infections (Parienti *et al.*, 2002).

Each member of the surgical team wears:

- a cap
- a facemask
- shoe covers
- a sterile gown
- safety glasses or loupes.

Preparation of the surgical table

The surgical table is draped and the instruments are arranged. Various arrangements may be suggested and vary according to the type of the surgery. Appendix B indicates the basic arrangement for dental implant placement. The implant motor and the handpieces are placed on a rolling cart.

Basic instrumentarium (see Appendix B)

This is virtually identical to that used for periodontal flap surgery.

Different surgical trays and instruments are commercially available according to the implant brand. Basically, they include a depth gauge, screwdrivers, a wrench, a ratchet wrench with extensions, implant holders, an implant drill extender, and direction indicators.

Disposable single patient-use drill kits are preferred to reusable drills.

According to the requirements of the surgical procedure, other instruments can be set on the table (mallet, fixation screw kit, set of trephines, bone crunchers, sinus lift kit, tissue punches, etc.).

Key points

- The concepts of asepsis and sterility must be adhered to in dental implant surgery.
- An aseptic operating room is recommended in the dental setting.
- When available, disposable instruments should be preferred to reusable instruments.

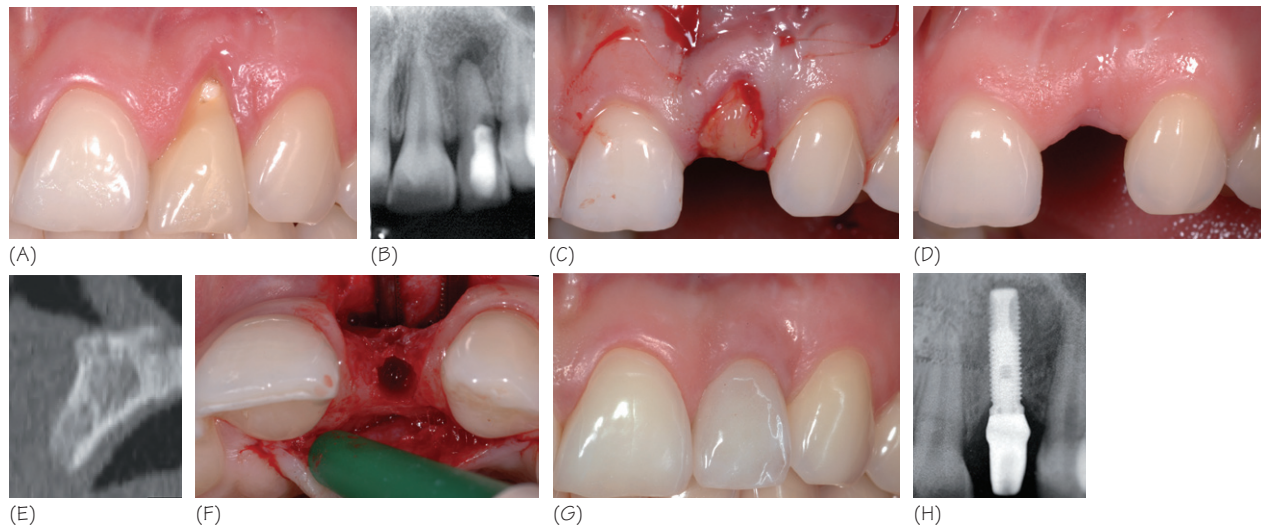


Figure 32.1 The Bio-Col socket preservation technique. (A) Soft tissue recession on 22 (hopeless tooth). (B) Intraoral radiography showing an endodontic lesion and root perforation. (C) Stabilization of a connective tissue graft with mattress sutures. (D) Three months healing, before implant surgery. (E) Three months CT scan showing bone preservation. (F) Implant bed preparation. (G) Five-year clinical result. (H) Intraoral radiography (5 years).

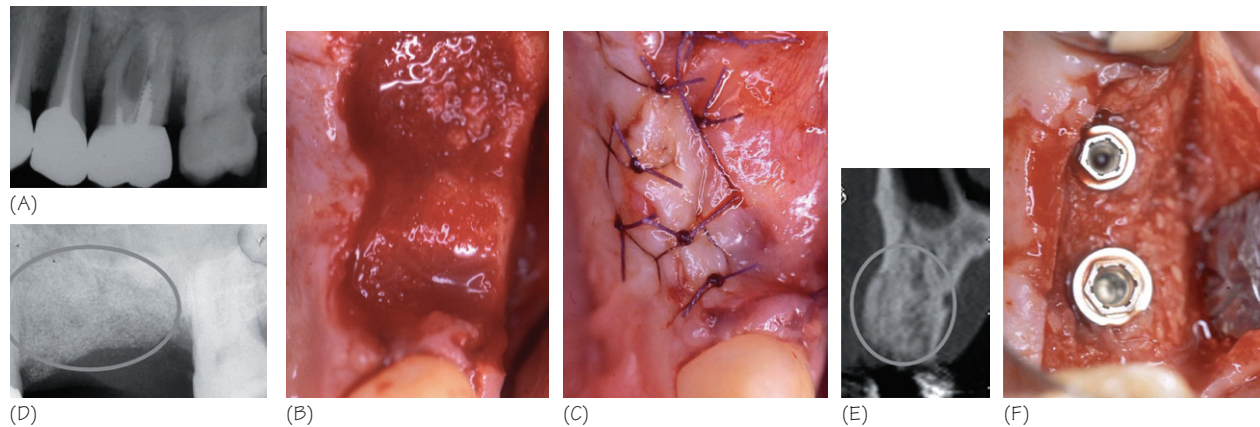


Figure 32.2 Combined surgical protocol (flap elevation). (A) Intraoral radiography showing the complex periodontal lesions in the upper lateral jaw. (B) A flap elevation is combined with teeth extraction. An autologous particulated bone graft associated with xenograft (Bio-Oss® material) filled the fresh alveolar socket extraction. (C) The vestibular mucoperiosteal flap is raised to cover the extraction area. (D) Eight months later, radiography to evaluate the gain of osseous volume. (E) CT scan control at 8 months; note the bone gain. (F) The dental implants are placed in the regenerated edentulous area. The bone maturation is partial, and Bio-Oss® granules are visible at the top of the alveolar crest (second-stage procedure).

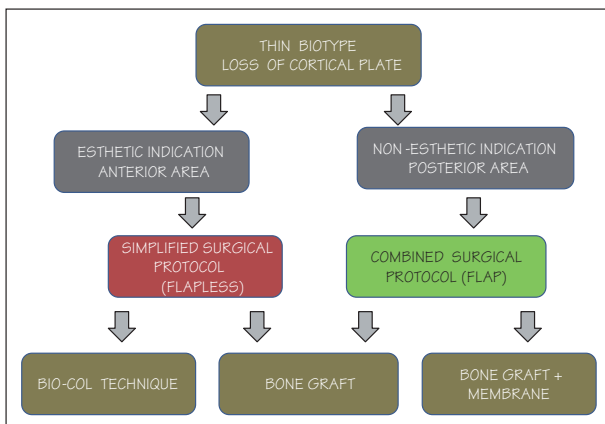


Figure 32.3 Decision making in socket preservation procedures.

Based on healing events in postextraction sites, socket preservation following tooth extraction seems to be important to prevent ridge resorption, to reduce the need for further augmentation/surgical procedures, and to simplify implant placement at a later time (Darby *et al.*, 2009).

Rationale

The healing of an extraction socket results in negative changes in the alveolar bone dimensions. The bundle bone disappears and the height of the buccal wall of the socket is reduced. Tissue loss is more pronounced from the buccal aspect than from the lingual/palatal aspect (Araújo & Lindhe, 2005, 2009a).

Healing is characterized by internal changes (bone formation within the socket) and external changes (three-dimensional resorption of the bony walls). The imbalance between bone formation in the socket and bone resorption of the socket walls results in a net loss of hard tissues. After tooth removal, the extravascular blood cells form a blood clot that fills the socket. Within 2–3 days, primary granulation tissue infiltrates the clot, beginning at the base and periphery of the socket. After 7 days, woven bone, characterized by uncalcified bone spicules, appears and mineralization is initiated from the base to the coronal part of the socket. Epithelialization achieves the complete closure of the socket about 6 weeks after the extraction. Complete healing of the extraction socket is achieved after at least 3 months, depending on bone destruction following the tooth extraction.

Products and devices

Bone graft materials may be used to limit alveolar bone resorption. Autogenous graft, substitute materials, membrane barriers, collagen sponges, and PGA/PLA sponges can be employed. The true impact of substitute materials on healing periods and regenerative outcomes is unknown (Darby *et al.*, 2009). It is unclear to what extent residual particles of grafting material still present at the time of implant affect the ISR. Animal studies indicate that autograft material fails to prevent ridge resorption (Araújo & Lindhe, 2011). Instead, bone substitute (Bio-Oss®) counteracts ridge contraction (Araújo & Lindhe, 2009b). The use of membrane barriers in addition to the graft material can increase the amount of newly formed bone in preserved sockets, but membrane exposure can decrease regenerative benefits.

Technical procedures

Simplified surgical protocols (flapless)

The blood clot is stabilized with or without a collagen sponge. The extraction socket is either left as is or covered with a connective tissue graft immobilized with mattress sutures (Bio-Col socket preservation

technique, Fig. 32.1). A bone substitute can be placed within the socket which may prevent resorption of the facial cortical wall (Carmagnola *et al.*, 2003; Iasella *et al.*, 2003).

Combined surgical protocols (flap elevation)

Either coronally positioned flap techniques or palatal rotation flap techniques are used to fully or partially cover the extraction site (Fig. 32.2). A bone substitute is placed within the socket. A barrier membrane is used to protect the particulate bone graft and to prevent contact between the graft material and the inner portion of the flap.

There is no evidence to support the superiority of one technique over another (flapless or flap elevation).

Antibiotics are usually prescribed but no conclusions can be drawn regarding their influence on ISR (Esposito *et al.*, 2010).

Indications (Fig. 32.3)

The indication is to prevent the occurrence of three-dimensional alveolar bone resorption following tooth extraction, with special attention to the buccal portion of the alveolar crest. It has been shown that dental implants inserted in fresh alveolar extraction sockets have not prevented the resorption of the buccal aspect of the ridge (Araújo & Lindhe, 2006). Consequently, adjunctive augmentation procedures are often required *prior to* implant placement, especially in the anterior region of the maxilla with thin periodontal biotypes. In grafted sites, the mean ISR is high (94%) (Darby *et al.*, 2009).

Complications

There is no evidence in humans on the optimal healing time for implant placement, when graft materials have been placed in the sockets. Consequently, the implant can be inserted even if socket bone regeneration is not completely achieved. The poor quality of the immature new bone and/or the presence of non-integrated graft particles may compromise the primary stability of the implant and may lead to implant failure.

Infections have been described in the literature. They are mainly due to membrane exposure. No other adverse effects have been documented.

Key points

- Socket preservation procedures are effective in preventing alveolar bone resorption in postextraction sites.
- Long-term data on ridge stability and implant survival are limited.

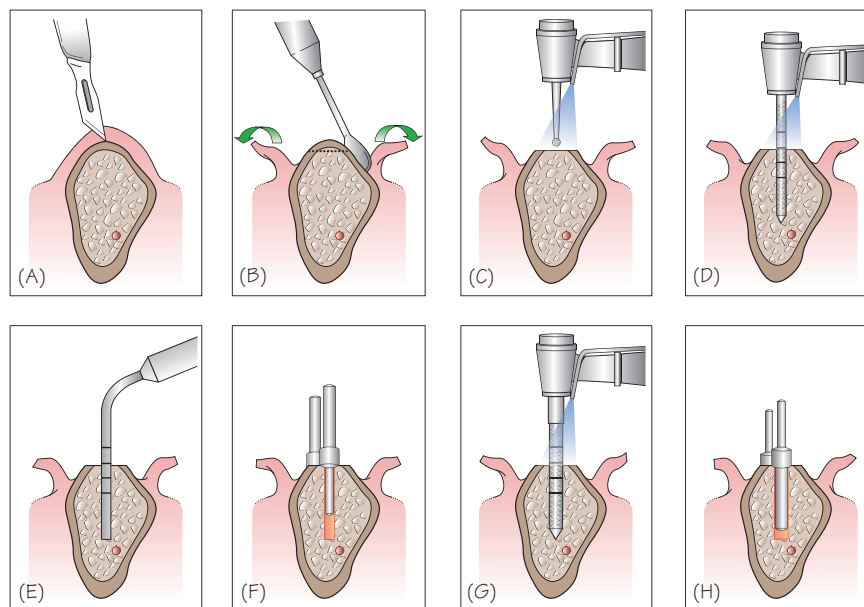


Figure 33.1 Standard protocol: surgical technique. (A) Mid-crestal incision in the keratinized tissue. (B) Mucoperiosteal flap elevation. (C) Alveolar ridge preparation to obtain a flat surface (if necessary) followed by perforation of the cortical bone at the exact implant location. (D) Drilling (Ø 2 mm) to the appropriate depth and direction. (E) The depth gauge is inserted in the implant bed to check the drilling depth. (F) The direction indicators are placed in the sites to verify the parallelism and direction of the implants. (G) Drilling is continued to the desired final diameter (pilot drills may be used). (H) Before implant placement, direction indicators confirm the final implant bed.

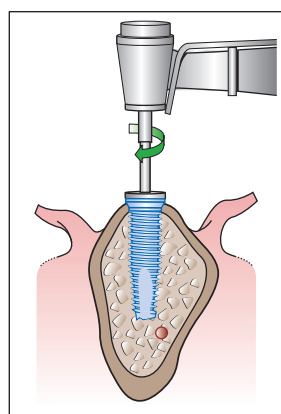


Figure 33.2 Dental implant installation (speed: 25 rpm; torque: 35 Ncm).

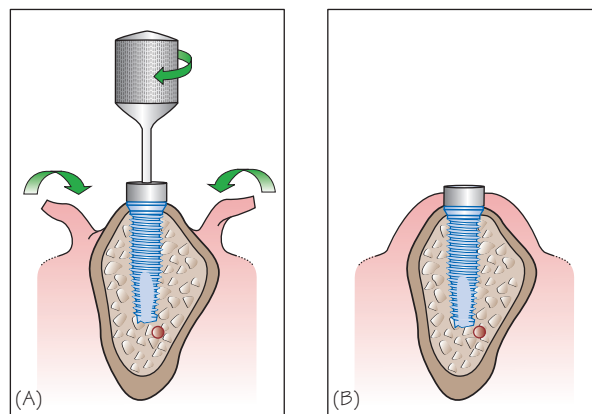


Figure 33.3 One-stage procedure. (A) The healing abutment is tightened with light finger force. (B) Flap adaptation around the healing abutment (mattress sutures).

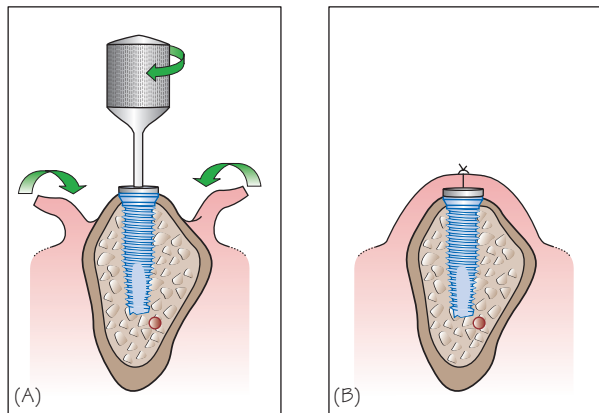


Figure 33.4 Two-stage procedure. (A) The cover screw is tightened with light finger force. (B) The flap is carefully closed over the cover screw (mattress sutures).

Rationale

The rationale for dental implant placement is based on the osseointegration process as defined in Chapter 1. Various dental implant systems are commercially available. Surgical techniques may vary according to the implant brand. However, some basic surgical guidelines can be set to define a standard protocol corresponding to a late implantation procedure.

Products and devices

An implant system should be selected according to the available scientific background, ease of use in surgical practice, cost benefit, and the ability of the company to insure follow-up of the products. Not all commercially available implant systems meet the basic selection criteria.

Generally, the dental implant tray includes the following:

- disposable drilling kit
- screw-taps
- screwdrivers
- drill extension
- handpiece connectors or implant drivers
- ratchet extension
- direction indicators
- depth gauge
- ratchet wrench.

In addition to the above implant instruments, the surgical equipment includes a basic surgical kit (see Appendix B) and a surgical drilling unit.

Technical procedure

Soft tissue elevation and preparation of the alveolar ridge

A mid-crestal incision is made in the keratinized tissue (Fig. 33.1A). A mucoperiosteal flap is elevated without releasing the incision (Fig. 33.1B). After opening the gingiva, the alveolar ridge is prepared with a large round burr or a bone chisel in order to obtain a flat bone surface (Fig. 33.1C). The surgical template is placed.

Preparation of the implant bed

All drilling should be performed under profuse saline irrigation at a speed around 1000rpm according to the instructions of the manufacturer, and considering the bone density (Quirynen & Lekholm, 2008).

The planned position of the implant bed is marked with a round bur through the surgical template (Fig. 33.1C). The first step consists of drilling with a 2 mm drill to the appropriate depth in the planned direction (Fig. 33.1D). The depth gauge enables checking of the drilling depth (Fig. 33.1E). The direction indicator is placed in the site (Fig. 33.1F). The patient is asked to bite. The tip of the direction indicator must be oriented to the occlusal surface of the antagonist tooth. When more than one implant is placed, the direction indicator is left in place to verify the parallelism of the other implants.

Once the direction and depth of the implant bed are validated, drilling is continued with drills of increasing diameter to the desired final diameter (Fig. 33.1G, H). Depending on the selection of the implant system, pilot drills may be used to facilitate the penetration of a subsequent drill.

High bone density (type 1): an extra wide drill may be used in conjunction with a screw-tap to prevent high compressive strengths.

Low bone density (type 4): the diameter of the final drill may be reduced to prevent the lack of primary stability.

Implant installation

The dental implant is removed from the sterile package, and connected to the implant driver. The implant is installed with a contra angle at low speed (25 rpm) and the torque is set (35 Ncm) (Fig. 33.2). When the bed is adequately prepared, the implant should work its way into the site without any pressure. If an overly high insertion torque is necessary, the implant should be retrieved for additional drilling.

The implant shoulder is positioned at the marginal bone level. An adequate primary stability should be obtained at this stage.

Wound closure

One-stage procedure

A healing abutment corresponding to the implant diameter and the soft tissue thickness is tightened with a manual screwdriver (light finger force) (Fig. 33.3A). The flap is adapted and tightly sealed around the healing abutment using mattress sutures (Fig. 33.3B).

Two-stage procedure

A cover screw is inserted into the implant (Fig. 33.4A). The flap is carefully closed over the cover screw using mattress sutures (Fig. 33.4B). The height of the cover screws may prevent complete adaptation of flap edges. Consequently, a periosteal fenestration of the buccal flap may be performed to facilitate the wound closure, and to avoid excessive tensions during the contraction phase of wound healing.

After an adequate healing phase, the cover screws are removed. In the standard protocol, when soft tissue management is not required, a minimally invasive approach is recommended. When the keratinized tissue is sufficient, a gingivectomy is performed above the cover screw using a tissue punch. Otherwise, a mini-flap is recommended to maintain a band of keratinized tissue around the healing abutment.

Healing duration

The mean healing time is 3–4 months in the maxilla and 2–3 months in the mandible.

Indications

The standard protocol is indicated when the vertical and horizontal bone volume is sufficient, and when the amount of soft tissue allows adequate oral hygiene procedures and esthetics.

Contraindications

Implant site requiring soft and/or hard tissue augmentation.

Complications

Leaving aside the classic complications of any surgical procedure, the major complication of the standard protocol is the lack of primary stability of the implant. This complication can be prevented by thorough patient examination and treatment planning.

Key points

- Implant placement is a demanding procedure.
- However, implant placement is not difficult in standard situations if the surgeon adheres to a strict protocol.
- Surgical training is mandatory to achieve the success rates indicated in the literature.

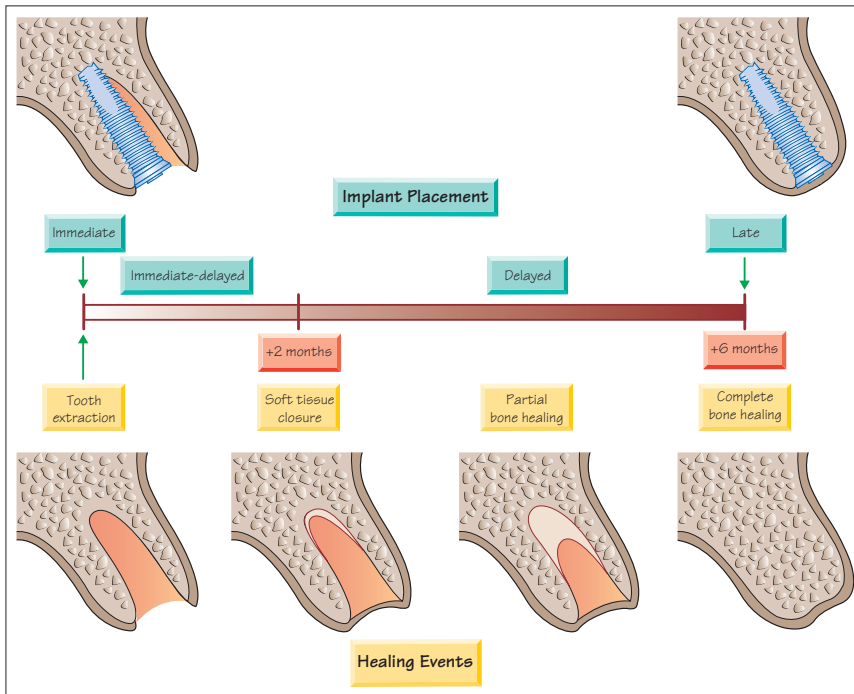


Figure 34.1 Relationship between healing events and the time of implant placement.

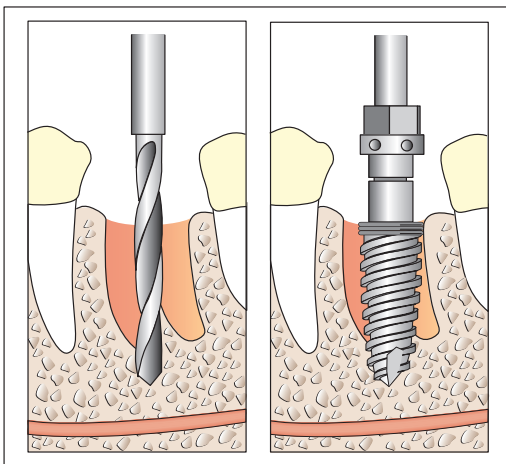


Figure 34.2 Immediate implant placement in molar site at the mandible. The inter-radicular septum is used to drill the implant bed, and to insure primary stability.

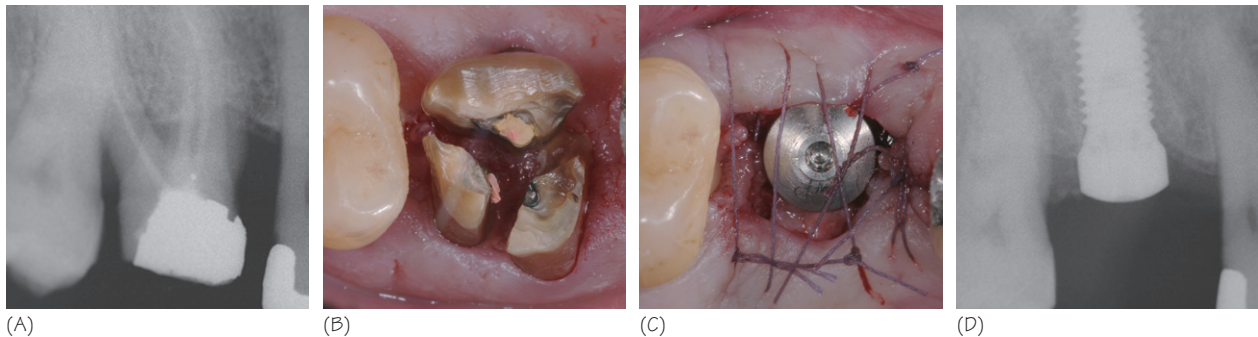


Figure 34.3 Immediate implant placement in molar site at the maxilla (one-stage procedure). (A) Preoperative X-ray of a hopeless first molar (pulp floor perforation). (B) Perioperative view of the extraction: root separation to preserve the inter-radicular septum. (C) Clinical view of the healing abutment after completion of the surgical procedure. (D) Postoperative X-ray 4 months after surgery.

The standard dental implant protocol corresponds to a late implantation, i.e. implant placement after complete bone healing of the extraction site. This means that the postextractional phase is no less than 24 weeks in standard clinical situations. Surgical alternatives have been explored to reduce the length of the treatment, leading to immediate, immediate-delayed and delayed implantation procedures, whose background is now documented (Chen & Buser, 2008). All the postextraction procedures shorten the treatment time. In addition, the immediate implantation procedure improves patient comfort because only one surgical procedure is required for both tooth extraction and implant placement.

Definitions

(Figure 34.1 indicates the time of implant placement (Esposito *et al.*, 2010))

Immediate implantation: implant placement within the extraction socket at the time of the extraction.

Immediate-delayed implantation: any implant placed in an extraction socket within 8 weeks after tooth extraction, i.e. after soft tissue closure of the extraction site.

Delayed implantation: implant placement at least 2 months after tooth extraction, i.e. after soft tissue closure and partial bone healing.

Outcomes

It has been shown that the ISRs with postextraction procedures are comparable to those of the standard procedure (Chen & Buser, 2009). Immediate and immediate-delayed implants may be at higher risk for implant failures and complications than delayed implants (Esposito *et al.*, 2010).

Rationale

From a biological point of view, the fresh extraction socket does not preclude the osseointegration process. However, following implant installation in fresh extraction sockets, the resorption process of the buccal and lingual bony walls still continues to a level similar to that of an edentulous site (Botticelli *et al.*, 2004; Araujo *et al.*, 2006; Sanz *et al.*, 2010).

Products and devices

Periotomes and piezoelectric devices should be used for the extraction procedure.

Bone regeneration is recommended to compensate for bone modeling and to optimize esthetic results. It should combine the use of bone substitute and barrier membrane. However, there is no reliable evidence that supports the need for augmentation procedures or the superiority of one augmentation technique over another.

Specific dental implants may be used. They have various truncated shapes and different diameters, and are designed to be used as immediate implants in sockets of varying dimensions. They aim to reduce the gap between the socket walls and the dental implant.

Technical procedures

Postextractional procedures are time-saving approaches. It is therefore not surprising that the one-stage implantation procedure is preferred. The necessity of raising a flap for covering the implant, if a two-stage procedure is performed, calls into question the advantages of the postextraction protocol.

Meticulous tooth extraction is essential to the success of the technique. Socket wall preservation is critical. Atraumatic maneuvers

should be implemented by using periotomes, root-section technique, and ultrasonic devices. The operator should pay particular attention to weak osseous walls in order to avoid fractures.

After removal of the granulation tissue, the socket is carefully evaluated. If the primary stability of the implant seems doubtful, implant placement is postponed for delayed or late implantation. When soft tissue closure is mandatory (membrane barriers) or when esthetics is a priority, implant placement is postponed for immediate-delayed implantation.

The implant is then placed. In single-root sites, the drilling is palatal/lingual to the axis of the socket. In multi-rooted sites, the implant is placed in the inter-radicular septum, when possible (Figs 34.2, 34.3). The implant shoulder is positioned slightly beneath the coronal border of the socket (about 1–2 mm).

If the gap exceeds 2 mm, a regenerative material is placed between the implant and the native bone. This has been shown to improve the level of marginal BIC. Otherwise, there is no need to fill the gap because complete defect resolution is achieved with a gap of less than 2 mm with intact socket walls. Two- or three-wall defects are favorable for bone augmentation.

The soft tissues are closely tightened to the implant neck.

Indications

All healthy extraction sockets with completely or partially preserved bony walls allow primary stability.

Esthetics

It has been suggested that ridge dimensions can be preserved if implants are placed in the fresh extraction socket. Animal studies and clinical trials have demonstrated that implant placement in fresh extraction sockets fails to preserve the hard tissue dimension of the ridge following tooth extraction. Immediate implantation procedure in esthetic areas should be carefully planned. A thick periodontal biotype preventing osseous/gingival recessions is recommended. The amount of bone resorption and soft tissue recession following immediate implant placement is unpredictable.

Contraindications

- Presence of an acute infection.
- Periapical infections.
- High esthetic risk profile.
- High risk of lack of primary stability.

Complications

Postoperative complications, including infection at the socket site and soft tissue recession, are common with immediate implantation.

Key points

- The postextraction procedures shorten the treatment time.
- In cases without complications, the ISR is comparable to the standard procedure.
- Following immediate implant placement, the edentulous site undergoes substantial resorption, in particular at the buccal aspect.
- Immediate implantation procedures in esthetic areas should be carefully planned.
- Postoperative complications are common with immediate implantation.



Figure 35.1 Edentulous maxilla: computer-guided surgery and immediate loading protocol. Radiopaque markers (white spots) are inserted in the denture, which serves as a radiographic template.

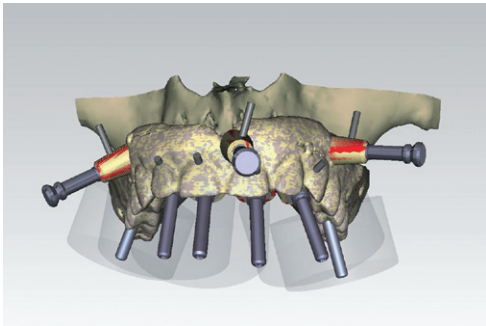


Figure 35.3 Implant positions and stabilizing pins are virtually planned. The data are transferred to the implant company that will fabricate the template.



Figure 35.5 Immediate provisional implant-supported FPD, fabricated from the surgical template.

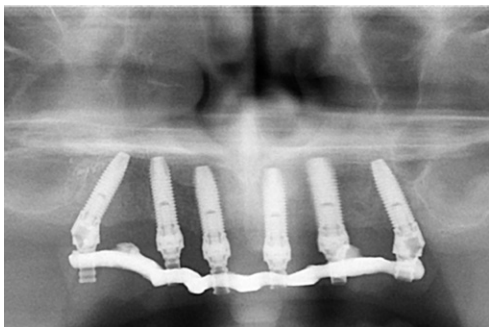


Figure 35.7 Radiographic control.



Figure 35.2 During radiographic examination, the template is stabilized with an occlusal index to avoid incorrect positioning.

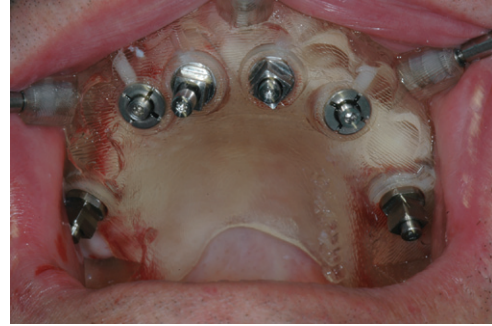


Figure 35.4 End of the surgery. Six implants are placed. Note that the surgical template is stabilized on the maxilla with three pins.



Figure 35.6 The provisional implant-supported FPD is screwed on the implants at the end of the surgery.

Rationale

The general principle is to create a virtual image of the jaws through a CT imaging technique (CT scan or CBCT), and a computer 3D reconstruction software. Radiopaque landmarks, included in the images through a radiographic template, allow the simulation of a prosthetic-driven virtual surgery.

A surgical tool (solid guide or live navigation images) is produced and used during actual surgery, so that the clinician is guided to comply with the virtual planning.

Definitions

The following definitions have been proposed (Hammerle *et al.*, 2009): *Computer-assisted surgery* consists of the use of 3D imaging software, to combine prosthetic planning with the anatomical structures.

Computer-guided surgery is the use of a static surgical template that reproduces the virtual implant position directly from computed tomographic data and does not allow for intraoperative modification of the implant position.

Computer-navigated surgery is the use of a surgical navigation system that reproduces the virtual implant position directly from computed tomographic data and allows for intraoperative changes in implant position. Also called real-time navigation.

Products and devices

Computer-guided surgery

The CT scan or CBCT data are processed with specific software, allowing the production of a precise 3D reconstruction of the jaw, including prosthetic information of the radiographic template. After virtual surgery, planned implant positions are transferred to a precise surgical template by a stereolithographic process. The template includes fixation devices and drill guides. It can be used by the laboratory before surgery to elaborate a provisional implant-supported FPD, that will be placed at the end of the surgery.

Computer-navigated surgery

Special devices are securely attached:

- to the patient (during CT radiographic examination and during surgery)
- to the handpiece of the clinician.

During implant surgery, the system records the position of the handpiece and the position of the patient (by infra-red camera, laser or tactile device) and reproduces a 3D real-time image of the situation in progress.

Accuracy

Accuracy is a critical factor which may limit the technique. Accuracy is evaluated by comparing the planned position of the implants with the result after actual implant placement (Table 35.1). Some deviation can occur between the two positions for the entry point, the apex, the axis, and the vertical position of the implant.

It seems that navigated surgery is, on average, more accurate than guided surgery (Jung *et al.*, 2009). Nevertheless, if the range of error (and not only the mean) is taken into account, the values are inconstant.

Technical procedures

- *Prosthetic planning*: as in conventional procedures, the future prosthetic teeth positions are planned via a wax-up or a set-up.
- *Radiographic template* (see Chapter 19): for edentulous patients, the denture (if sufficiently stable) can be used for the radiographic template. Insertion of specific markers on the template could be necessary before radiographic examination (Fig. 35.1).
- *Radiographic examination*: CT scan or CBCT, with the radiographic template. Stability of the template is mandatory to assure accuracy (Fig. 35.2). Some companies require an additional CT of the template alone.
- *Virtual surgery*: implants are placed according to the prosthetic planning. Optimal length and diameter are selected to respect anatomical structures (Fig. 35.3). Different implant libraries are available for each company.

- *Surgical template*: once achieved, the simulation is sent to the company that produces a customized surgical template (Fig. 35.4).
 - *Anticipation of the prosthesis (immediate loading)*: the laboratory can use the surgical template to prepare an immediate fixed prosthesis according to the planned positions of the implants (Fig. 35.5).
 - *Actual surgery*: the surgical template is precisely secured to the jawbone, with either tooth retention or bone-stabilizing pins. It contains metallic sleeves in which successive drill guides are inserted (to assure precise guidance of each drill diameter), and through which implants are installed in the planned 3D position. Then the surgical template is removed.
- For the immediate loading protocol, the prosthesis is inserted at the end of the surgery (Fig. 35.6). A radiographic control is mandatory (Fig. 35.7).

Computer-guided versus computer-navigated surgery

Computer-navigated surgery provides real-time observation and allows modifications of the implant position during surgery. The visibility is compatible with all surgical procedures. The financial cost is still high.

Computer-guided surgery does not permit any modification once the virtual surgery is validated. It allows for the preparation of an immediate prosthesis for immediate loading protocols. The financial cost is acceptable for complex cases.

Indications

- Adequate bone volume.
- Anatomical complexity.
- Less invasive surgery (flapless).
- Complex esthetic cases, to optimize implant placement.
- Anticipation of the prosthesis for immediate loading.

Limitations

Because the surgeon must anticipate all surgical events, and integrate the error range before actual surgery, computer-guided surgery is reserved for experienced clinicians, and is indicated for favorable bone and soft tissue cases.

Table 35.1 Deviation (error) between computer-assisted planning and actual surgery

	Entry point (mm)	Apex (mm)	Angulation (°)	Vertical (mm)
Computer-guided surgery	0.82–1.42	0.87–1.52	1 to 12°	No data
Computer-navigated surgery	0.58–0.90	0.55–0.80	1 to 20°	0 to 1.4

Key points

- A high level of clinical expertise is required for the use of computer-guided surgery.
- Deviation between virtual and actual surgery must be anticipated.
- Flapless procedures require ideal soft and hard tissues condition.
- Indications are still limited.

Bone augmentation: one-stage/simultaneous approach versus two-stage/staged approach

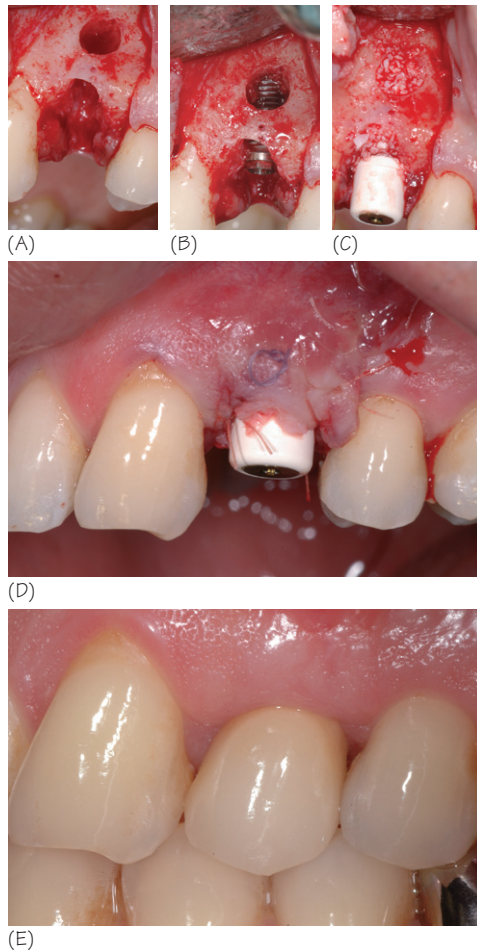


Figure 36.1 The simultaneous approach 2. (A) Tooth extraction. (B) Implant insertion. (C) Bone grafting (Bio-Oss ®). The final prosthetic abutment is screwed. (D) Clinical view after suturing. (E) Four-year outcome.

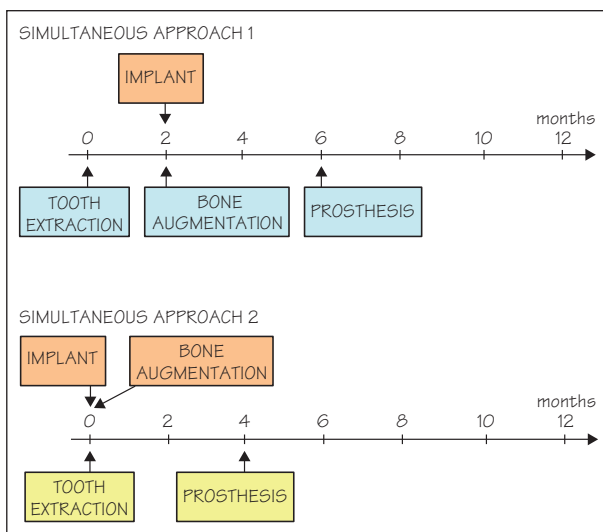


Figure 36.2 One-stage/simultaneous approach (maxilla).

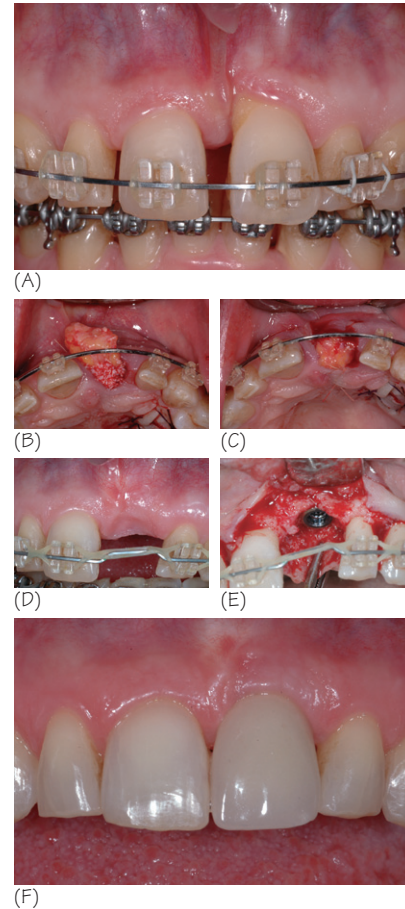


Figure 36.3 The staged approach 2. (A) Tooth 21 must be extracted for periodontal reasons. (B) Extraction and socket preservation (Bio-Oss ®). (C) The bone substitute is covered by a connective tissue graft. (D) Four-month clinical view. (E) Implant placement. (F) Two-year outcome.

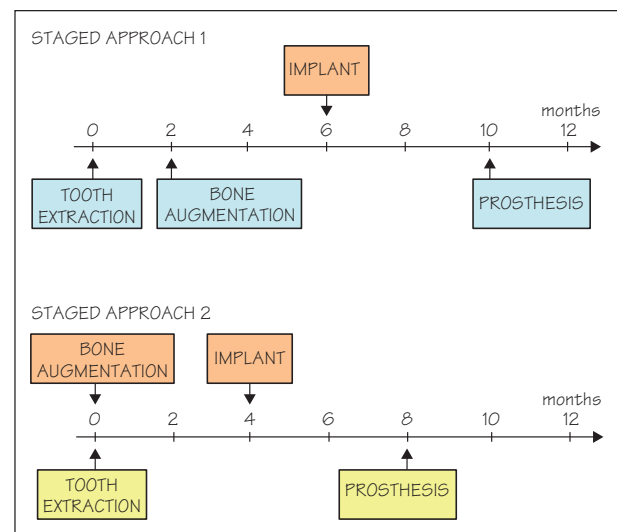


Figure 36.4 Two-stage/staged approach (maxilla).

All bone augmentation techniques, except alveolar distraction, can be performed in a one-stage approach (bone augmentation and implant placement simultaneously) or a two-stage approach (bone augmentation in a first stage and implant placement in a second stage, 4 to 6 months later).

The choice between simultaneous or staged approach depends upon the following clinical parameters: treatment duration, morbidity, risk:benefit ratio, and implant outcome.

Optimal timing for bone augmentation

Bone augmentation procedures (simultaneous or staged approach) can be performed at different times after tooth extraction. The later the procedure is performed, the more bone resorption occurs. Consequently, bone augmentation procedures must be performed as soon as possible.

For most bone augmentation procedures, a soft tissue primary closure is recommended to prevent material exposure. In these cases, a 6–8-week healing period after tooth extraction is considered as the optimal timing.

Optimal timing for implant placement

The decision to place the implant at the time of the augmentation procedure depends on the ability to obtain the primary stability of the implant and the ability to achieve the soft tissue closure. One must keep in mind that immediate implantation usually increases the risk of complication of the bone augmentation procedure (Table 36.1).

Risk of complication with bone augmentation procedures

Complications may result in inflammation, infection or reduction of new bone gain.

The *quality of the risk* depends on the procedure itself and on the soft tissue healing at the time of the surgery (Table 36.1). Soft tissue covering is mandatory for membranes and block bone grafts. Complications are frequent with non resorbable membranes.

One-stage/simultaneous approach

(Figs 36.1, 36.2)

Implant configuration

There must not be any material exposure during the healing period after bone augmentation procedures. This involves the use of a submerged implant configuration in order to achieve a complete soft tissue covering. For immediate implantation, flap advancement or soft tissue graft can be required.

An augmentation procedure concomitant with a transmucosal implant configuration is also possible (Hammerle and Lang, 2001). However, a high level of clinician experience is required.

Advantages

- The global healing time is reduced to the osseointegration period.
- Low morbidity.

Disadvantages

- In cases of partial bone augmentation, implant success may be compromised.
- In cases of failure, implant and augmentation material are lost.

Indications

- Low-risk procedures: two- and three-wall defects, split osteotomy, sinus floor elevation with residual bone ≥ 5 mm.
- Implant primary stability achieved with a correct implant position.
- Low healing risk: thick biotype, non-smoker.

Recommendations

- Block bone grafts are not recommended since the survival rate is lower with a simultaneous approach (Chiapasco *et al.*, 2009).
- Membrane barriers are not recommended for inexperienced clinicians.

Two-stage/staged approach (Figs 36.3, 36.4)

Advantages

- Primary stability of the implant easier to achieve.
- Optimal positioning of implant into the regenerated/grafted bone.
- In cases of complication or failure, the implant is not affected.

Disadvantages

- The global healing time before prosthetic procedures is higher.
- Higher morbidity.

Indications

- Medium- and high-risk procedures: zero- and one-wall defect, vertical augmentation, sinus floor elevation with residual bone < 5 mm, block bone grafts.
- No primary stability of the implant.
- High healing risk: thin biotype, heavy smokers.

Implant survival, marginal bone loss, and implant complications

When the augmentation procedure is uneventful, implant survival rate, marginal bone loss, and implant complications are similar with simultaneous and staged approaches. However, in cases of complication or failure of the augmentation procedure during a simultaneous approach, the implant can be compromised or even lost.

Key points

- The choice between a simultaneous and staged approach is first based on risk evaluation.
- With block bone grafts, implant survival is lower with the simultaneous approach compared to the staged approach.
- For other procedures, implant survival is similar when healing is uneventful.
- Implant primary stability is mandatory for a simultaneous approach.
- For low-risk situations, the simultaneous approach is preferred.
- For high-risk situations, the staged approach is preferred.

Table 36.1 Risk of complication with bone augmentation procedures

Time after extraction	Resorbable membrane	Non-resorbable membrane	Graft materials	Block bone grafts	Split osteotomy	Sinus floor elevation
Immediate	H		M	H	M	M
2 months		H				
>4 months	M		L	M	L	L

L, low risk; M, medium risk; H, high risk.

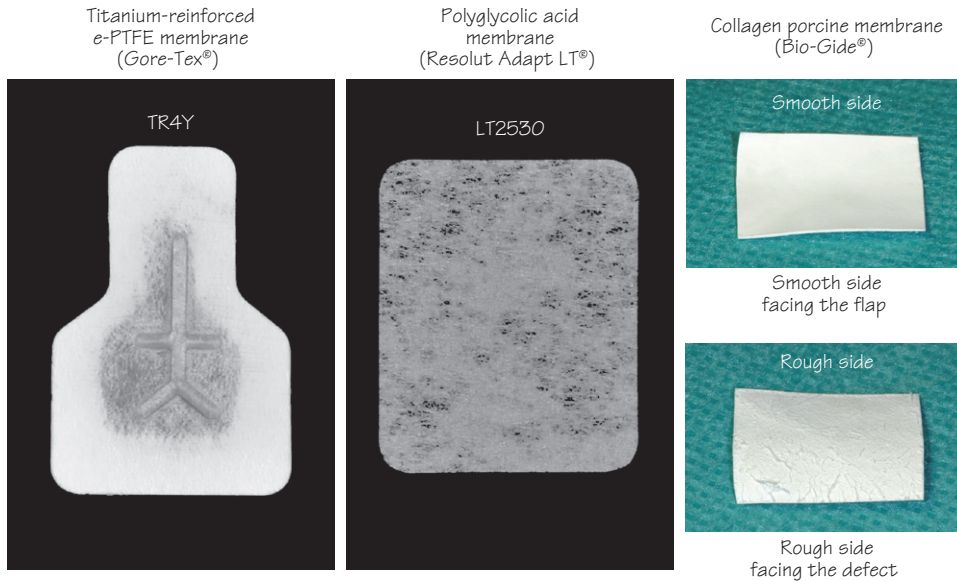


Figure 37.1 Configuration of the most often used commercially available membranes.

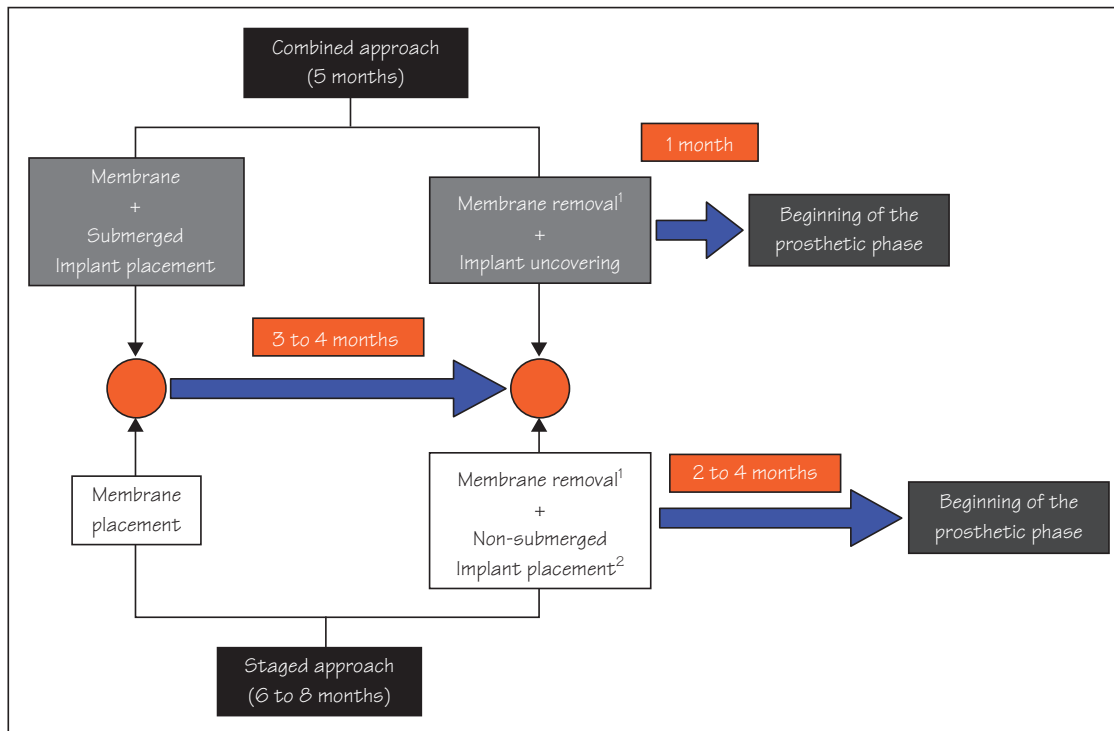


Figure 37.2 Time difference between the staged and the combined approach.

¹Only for non-resorbable membranes; ²a submerged implant requires an additional month.

Rationale

Membrane barriers are employed to create sufficient bone availability for dental implant placement. It has been shown that ingrowth of soft tissue may disturb or totally prevent osteogenesis in a defect or wound. Guided bone regeneration (GBR) procedures allow spaces maintained by barrier membranes to be filled with bone.

The procedure aims to:

- stabilize the blood clot
- prevent growth of soft tissue cells (connective tissue and epithelium) into the bone defect
- allow spaces maintained over the defect to be filled with bone progenitor cells that may develop bone uninhibited.

Products and devices

A wide range of non-resorbable and resorbable membrane materials has been used (Fig. 37.1). There is no evidence to support or refute the superiority of a specific membrane (Klinge & Flemmig, 2009). The membranes have different advantages and disadvantages depending on whether they are resorbable or not (see Appendix N, Table N.1).

Non-resorbable membranes

Titanium-reinforced e-PTFE membranes (Gore-Tex®) are the gold standard. They are space-maintaining membranes, i.e. they do not require the use of a supportive material.

Resorbable membranes (syn. bioresorbable or bio-absorbable membrane)

Xenogenic collagen membranes (Bio-Gide®) and polyglycolic acid membranes (Resolut®) have been used extensively. They are not space-maintaining membranes and cannot be used without a supportive material, except when the defect is space making by itself.

The majority of the membranes remain substantially intact for 8–24 weeks depending on the product. The membranes are available in different sizes.

Technical procedures

Guided bone regeneration procedures are difficult to perform. The skills and experience of the clinician are critical factors in the success of treatment. Various combined procedures have been proposed but it is unclear which are the most efficient. However, some clinical recommendations can be made (see Appendix N, Box N.1).

The treatment of a bone defect may be performed before (staged approach), at the time of (combined approach) or after implant placement (peri-implantitis therapy). Compared to the staged approach, the combined approach reduces by 1–3 months the lag between implant surgery and the beginning of the prosthetic phase (Fig. 37.2). However, in the combined approach, the consequence of a complication during the first surgery may not only impair the amount of bone regenerated, but can also lead to primary implant failures.

Any membrane should remain in place for at least 3 months.

Indications

Transmucosal implants

The evidence for the use of GBR techniques combined with transmucosal implants is limited (Chiapasco & Zaniboni, 2009). Thus, the membrane should not be employed in this specific indication without a high level of clinician experience.

Vertical and horizontal bone augmentation

Guided bone regeneration technique is a predictable procedure for lateral ridge augmentation (clinical case). The technique has also been

successfully performed for vertical augmentation, but the level of evidence is lower than for horizontal augmentation (Esposito *et al.*, 2009). A range of vertical bone gain of 2–8 mm has been reported for GBR procedures (Tonetti *et al.*, 2008).

Extensive alveolar ridge defects require a grafting material to support the membrane. These large bone defects are often augmented with autogenous block grafts and membranes (von Arx *et al.*, 2001). The use of e-PTFE membrane covering onlay bone grafts for lateral ridge augmentations seems to decrease resorption of the bone graft (Antoun *et al.*, 2001).

Immediate and delayed implantation

The lack of soft tissues for primary healing is a frequent problem when placing implants immediately into extraction sockets. The GBR technique may not be recommended for immediate implantation due to the high risk of membrane exposure.

The GBR technique may be recommended for delayed implantation since it can compensate for the small loss of bone volume that occurs before wound closure (6–8 weeks).

Dehiscence and fenestrations

Placement of oral implants into alveolar ridges with insufficient dimension may result in dehiscence or fenestration. These types of defects can be successfully treated with GBR using non-resorbable membranes alone or in combination with a graft (Klinge & Flemmig, 2009).

Peri-implantitis

It has been shown that the use of a bone substitute with a resorbable membrane may improve some clinical parameters but there is very little reliable evidence suggesting that the use of the GBR technique is beneficial in the surgical treatment of peri-implantitis (Esposito *et al.*, 2010).

Contraindications

- Lack of patient compliance.
- Lack of patient strict plaque control.
- Heavy smokers (more than 10 cigarettes per day).
- Untreated periodontal patients.
- Infection at the surgical site.

Complications

A frequent complication is membrane exposure and infection. Premature exposure of the membrane does not always preclude success if closely monitored (see Appendix N, Box N.2).

Regarding resorbable membranes, exposure may often be managed and monitored over time. However, when they must be removed (infection), care must be taken so that the process of hydrolysis/resorption is not too advanced.

Key points

- GBR is a difficult procedure to perform.
- GBR procedures may be successfully considered for horizontal bone augmentation, delayed implantation, dehiscence, and fenestrations. Further studies are needed for the other indications.
- Resorbable membranes require the use of a supportive material.
- Better bone formation is achieved with non-resorbable membranes than with resorbable membranes.
- There are more exposures with non-resorbable than with resorbable membranes.

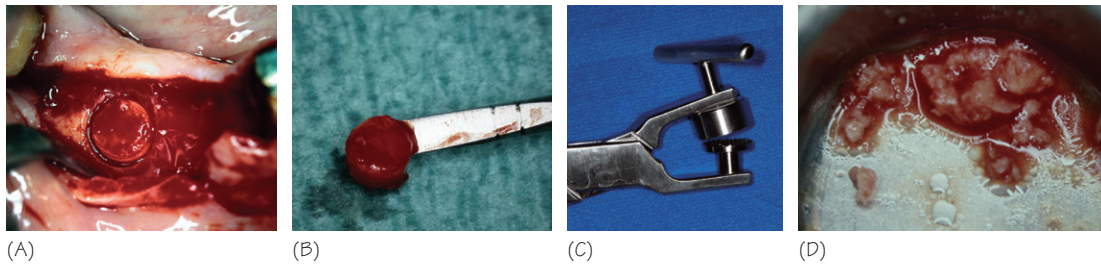


Figure 38.1 Autogenous bone (A,B) Bone is harvested at the donor site with a trephine. (C,D) Bone is ground in a bone mill.

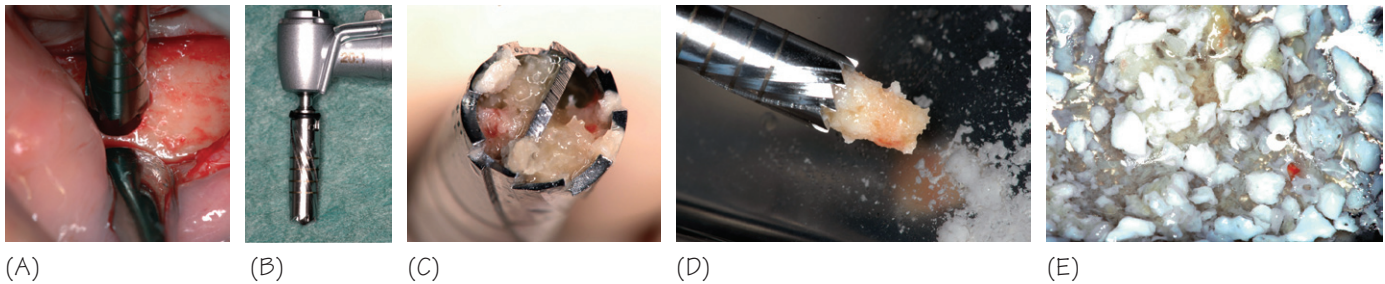


Figure 38.2 Autogenous bone plus xenograft (A–C) Bone is harvested with a trephine mill system. (D,E) The retrieved bone is collected, and may be blended with a bone substitute.

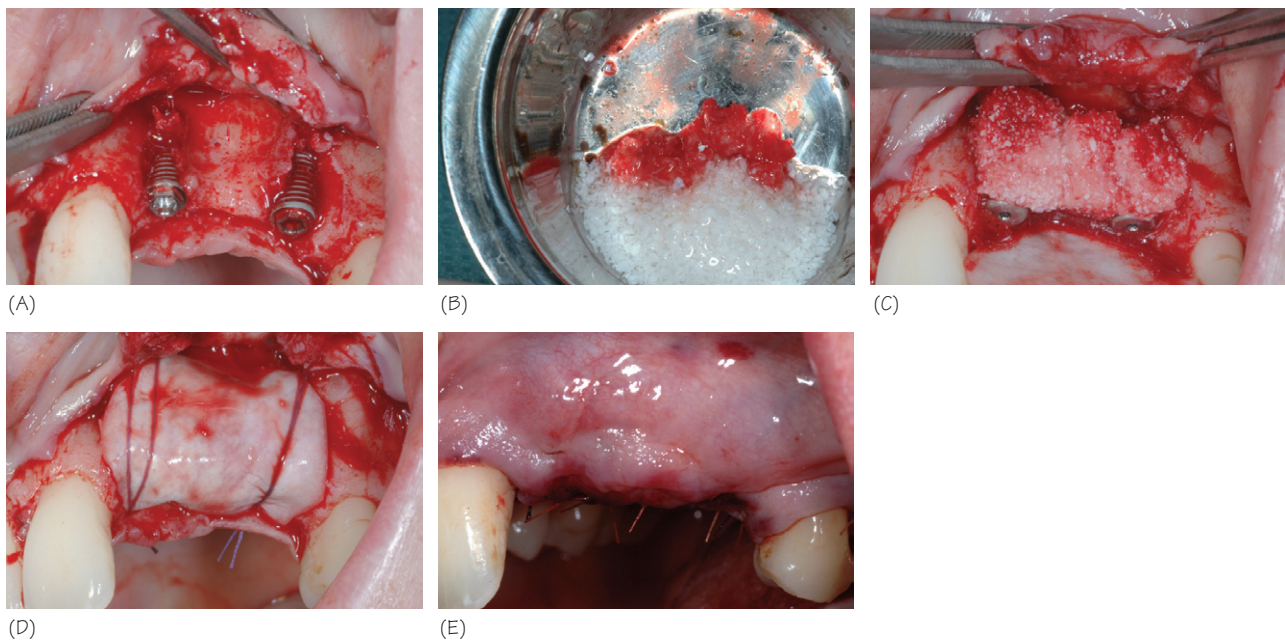


Figure 38.3 Xenograft (A) Implant placement with two important bone dehiscences requiring horizontal bone augmentation. (B) The bone substitute is soaked with blood. (C) The xenograft covers the defects. (D) A collagen barrier membrane is secured with mattress sutures over the bone material. (E) Periosteal fenestration is performed to achieve soft tissue closure.

The autogenous bone graft with its biological properties (osteogenicity, inductivity, conductivity) has long been considered the ideal grafting material in bone reconstructive surgery. Recent advances in biotechnology have provided the surgeon with access to a great variety of bone grafting materials, i.e. osteobiologics, in order to reduce the morbidity and unpredictable resorption of autogenous bone graft (Hallman & Thor, 2008). Trends suggest that the survival rate of dental implants in grafted zones may be slightly lower than the survival rate of implants placed in native bone (Tonetti & Hammerle, 2008; Esposito *et al.*, 2009).

Autogenous bone graft

The grafted bone can be regarded as a scaffold for new bone formation. The vascular supply of cortico-cancellous bone graft enables the survival of cells, the diffusion of nutrients, and revascularization (Davies & Hosseini, 2000). The healing events involve osteoconduction (new bone is gradually formed around the resorbed graft) and osteoinduction (release of proteins stimulating osteoblasts to form new bone).

Positive outcomes have been reported in sinus floor augmentation (Boyne & James, 1980). Rigid fixation of block bone graft is a prerequisite for stimulating the progenitor cells. Particulate or chip bone grafts with/without substitutes and non-resorbable membranes are alternatives (Fig. 38.1).

Autogenous bone grafts can be mixed with any of the materials listed below (Fig. 38.2).

Growth factors and platelet-rich plasma

These may be incorporated into any of the graft types.

The growth factors, which are present at low concentrations in bone matrix and plasma, induce bone formation, growth, migration, and differentiation of cells. They play a regulatory role in homeostasis as well as in tissue repair. Recombinant bone morphogenetic proteins (BMPs) are associated with carriers or scaffolds such as substitute materials. They are released on the repaired site to increase tissue reconstruction (Terheyden *et al.*, 1998).

Platelets are non-nucleated bone marrow fragments, abundant in blood. They act in hemostasis, wound healing, and inflammation and are activated by collagen, thrombin, thromboxane A₂, adenosine phosphate, and P-selectin. By using a common centrifugation technique, platelet-rich plasma (PRP) can be prepared in the operating room during surgery (Aniuta, 1999). Positive effects with or without allografts have been reported where PRP has been used before implant installation (Merckx *et al.*, 2004). However, these benefits are controversial. The PRP/ β -tricalcium phosphate association has not enhanced bone formation in sinus augmentation procedures in the absence of osteoblasts or osteocytes (Thor *et al.*, 2005; Wiltfang *et al.*, 2005).

Bone graft substitutes

Allografts

These are bone grafts harvested from cadavers and processed by methods such as freezing or demineralizing and freezing. Freeze-dried bone and demineralized freeze-dried bone allografts are reported to be less immunogenic than fresh-frozen bone allografts (risk of transfection).

These materials are frequently used in mixtures with autogenous bone or bone substitutes.

Xenografts

Xenografts consist of bone mineral from animals or bone-like minerals (calcium carbonate) derived from corals or algae. Deproteinized bovine bone (DBB) is widely used because of its similarity to human bone and its osteoconductive properties (Berglund & Lindhe, 1997). Proteins in DBB are extracted to avoid immunological rejection.

In human studies of maxillary sinus alveolar ridge augmentations (Carmagnola, 2000), DBB and autogenous bone have histologically been associated with active bone formation. Biopsies harvested after a 6–9-month healing period of sinuses grafted with DBB showed 30% newly formed bone, 30% DBB, and 40% bone marrow. Increased mineralization was detected after 14 months, and osteoclastic resorption of DBB particles was found after 4 years (Valentini *et al.*, 1998; Piatelli *et al.*, 1999). It has been shown that there is no benefit to adjunct autogenous bone in maxillary sinus procedures (Yildirim *et al.*, 2001).

Alloplastic bone substitutes

Alloplastic bone substitutes represent synthetic calcium-based biomaterials. Calcium phosphate, calcium sulfate, and bioactive glasses have been used in dental implant surgery for bone augmentation. Alloplasts provide a physical framework for bone ingrowth. Pore size greater than 300 μ m (similar to bone structure) shows enhanced formation of new capillaries and bone.

Calcium phosphates can be bound to collagen carriers, to form a network on which minerals can crystallize. Biphasic tricalcium phosphate, produced by sintering hydroxyapatite, has been shown to be effective in repairing skeletal defects (Daculsi, 1998). Calcium sulfate resorbs quickly and must be used carefully in esthetic areas because of the lack of control of the resorption process.

Bioglass is a commercially available family of bioactive glasses. In biological fluids, bioglass (particle size 300 μ m) releases calcium ions, which can stimulate stem cells to produce bone-building cells. Bioglass is slowly resorbed (12–16 months) before the graft is replaced by newly formed bone. Biopsies of a mixture of autogenous bone and bioactive glass particles (300–355 μ m in size) have shown new bone after 16 months. Biopsies harvested after 2 years have revealed similar bone-forming outcomes (Turunen *et al.*, 2003).

Key points

- Autogenous bone grafting and osteobiologics are predictable materials for the correction of edentulous ridge defects.
- Various bone graft substitutes can augment bone horizontally and vertically, but it is unclear which are the most efficient.
- Some bone substitutes could be a preferable alternative to autogenous bone since they are associated with less postoperative morbidity.

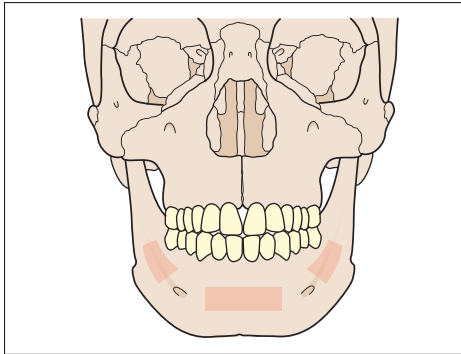


Figure 39.1 Intraoral autogenous bone block grafts: anatomical areas at the mandible where cortical bone can be harvested (shaded areas).

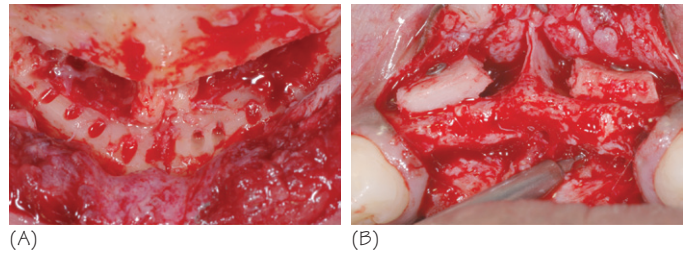


Figure 39.2 Bone block graft harvested from the chin. (A) Donor site after harvesting. (B) Adaptation and fixation of the blocks in the anterior area of the maxilla.

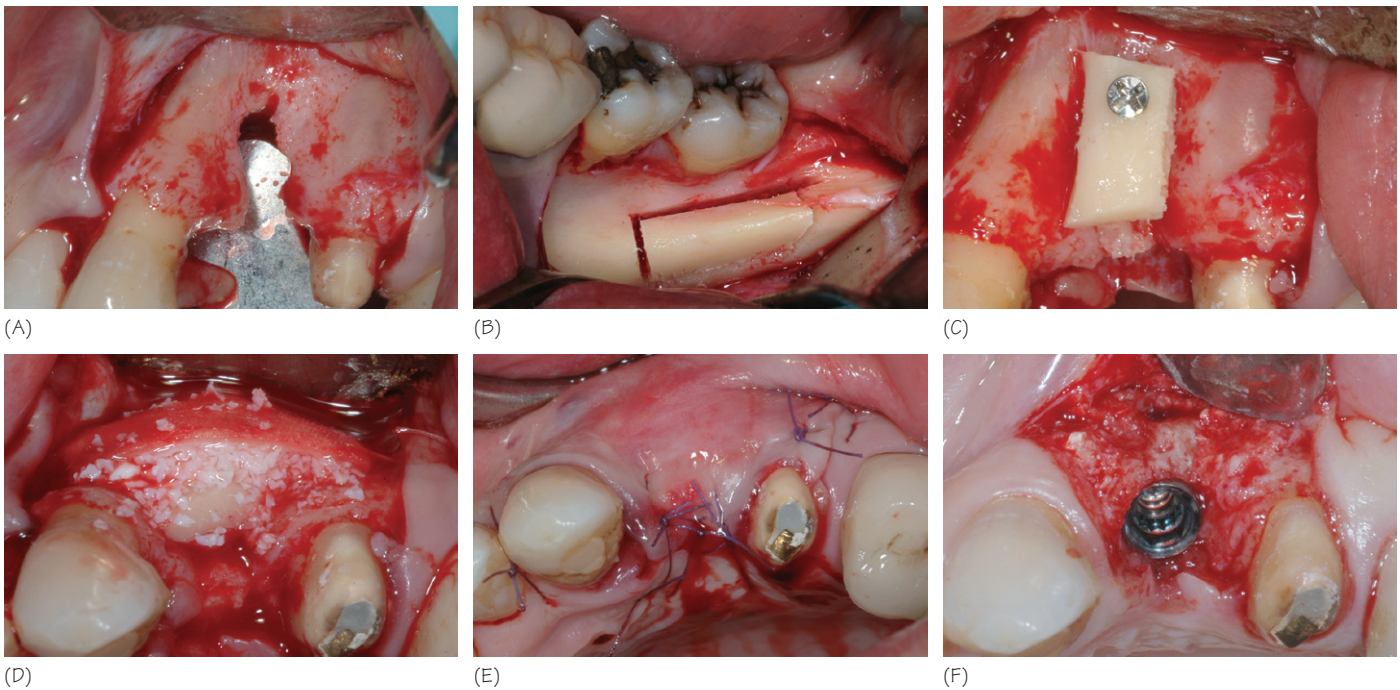


Figure 39.3 Horizontal bone augmentation. (A) Preparation of the recipient site. (B) Bone block graft harvested from the ramus. (C) Graft fixation with a titanium screw. (D) A bone graft substitute (Bio-Oss®) is placed to fill the spaces and a resorbable membrane is adapted on the site. (E) Soft tissue covering and sutures without any tension. (F) Second-stage surgery 4 months later and implant placement.

Table 39.1 Harvesting sites of autogenous bone block grafts

	Intraoral		Extraoral	
	Symphysis	Ramus	Iliac crest	Calvarium
Bone quantity	Low	Medium	High	High
Graft resorption	Low	Low	High	Low
Morbidity	Medium	Low	High	Low
Indication	Small defect Ramus unavailable	Small to medium size defect	Large defect Calvarium unavailable	Large defect

Rationale

Bone grafts taken from patient themselves are the “gold standard” in bone reconstruction. Autogenous bone grafts can be harvested from intraoral sites (Fig. 39.1) for small defects, or from extraoral sites (calvaria, iliac crest, tibia) for larger defects.

We will focus on intraoral harvesting sites performed under local anesthesia, i.e. mental symphysis (chin) (Fig. 39.2), retromolar mandible region (ramus) (Fig. 39.3), and maxillary tuberosity.

Results

Bone augmentation: during the healing process, block bone grafts provide a scaffold for new bone growth, and simultaneously undergo a resorption process. This resorption is greater the first year after grafting, and stabilizes after 1 year of implant loading (Chiapasco *et al.*, 2009).

Implant survival: survival rates of dental implants inserted into block bone grafts are lower than those for implants placed in native bone. Furthermore, a two-stage approach (implant placement after 4 months of healing) is associated with better survival rates than a one-stage approach (simultaneous implant placement).

Rough surface implants have a better survival rate than machined surface implants, when placed into bone block grafts.

Limited data are available in the literature.

Technical procedures

Preoperative examination

CBCT or CT scan is performed to precisely visualize the alveolar ridge defect and to explore the donor site.

Recipient site

A full-thickness flap with good visibility of the bone plate is mandatory. Bone is freed from all soft tissues (Fig. 39.3A) and small perforations of the buccal plate are performed to improve blood supply.

Graft harvesting

Bone is harvested with a handpiece saw, an oscillating saw, or a piezo-electric surgical device (Fig. 39.3B). The latter is easier to use and allows better visibility. It is recommended to harvest enough bone to overbuild the defect and to anticipate graft resorption. Bone chips are collected for filling spaces. The donor site is sutured.

Graft adaptation

The bone block is modified to perfectly fit into the defect. For vertical defects, part of the bone block is placed on top of the ridge. The contact surface between the bone graft and the recipient site must be as intimate as possible.

Graft fixation

Bone blocks must be locked on the recipient site to avoid any movement that could impair healing. Usually, titanium screws are used to secure the bone graft (Fig. 39.3C).

Additional procedures

Graft materials can be used to fill the spaces and augment the final bone volume. The use of regenerative resorbable membranes is recommended to prevent the resorption process, and to secure the graft materials (Fig. 39.3D).

Simultaneous implant placement is not recommended with bone block grafts.

Soft tissue covering

Sutures without any soft tissue tension are a prerequisite to avoid bone graft exposure and complications (Fig. 39.3E).

Second-stage surgery

A 4–6-month period is required before second-stage surgery. Fixation screw removal and implant placement are performed during the same surgery (Fig. 39.3F).

Advantages

Bone block graft is a relatively well-documented technique (except for maxillary tuberosity) and gives predictable results for horizontal defects. Usually, the healing phase is uneventful and allows the placement of implants in good-quality bone.

Disadvantages

Compared to other techniques, the presence of a donor site (particularly if extraoral) leads to greater *morbidity*. However, this biological cost is limited with intraoral harvesting, in particular with ramus sites.

It is a technically sensitive technique and there is a limited quantity of bone (intraoral).

The correction of vertical defects shows poorly predictable results, and more complications.

It is a two-stage procedure and consequently, a time-consuming and high financial cost technique.

Indications

It is difficult to choose this technique over another, on a scientific basis, because of the lack of comparative studies. However, situations where the bone volume is insufficient to allow implant stabilization in the residual ridge (horizontal or vertical severe resorption) or placement in the optimal implant position (esthetic) are good indications (Chen *et al.*, 2009).

Intraoral harvesting is preferred for small and moderate defects, while extraoral harvesting is indicated for extended defects (Table 39.1).

Bone block grafts can be performed whatever the defect morphology: horizontal, vertical, and a combination of vertical and horizontal. However, horizontal defects are the indication of choice.

Complications

Bone augmentation

For horizontal defects, block bone grafts allow higher gains and lower complications compared to GBR techniques with graft materials. For vertical defects, there are more complications than with horizontal defects (Esposito *et al.*, 2009).

Harvesting site

During harvesting at the mental symphysis site, injury of the incisal nerve can occur, leading to permanent paresthesia of anterior mandibular teeth (prevalence 10%).

Complications are uncommon with the ramus site.

Iliac crest harvesting is associated with pain and gait disturbances (prevalence 2%), as well as a higher bone resorption (cancellous bone).

Key points

- Bone block graft is indicated when implant stabilization in a correct position is not possible in native bone.
- Horizontal augmentation is more predictable than vertical augmentation.
- The use of additional membranes and/or graft material may prevent graft resorption.
- Intraoral harvesting is the technique of choice for small or moderate defects.
- For extended defects, extraoral harvesting must be considered.

Bone augmentation: split osteotomy (split ridge technique)

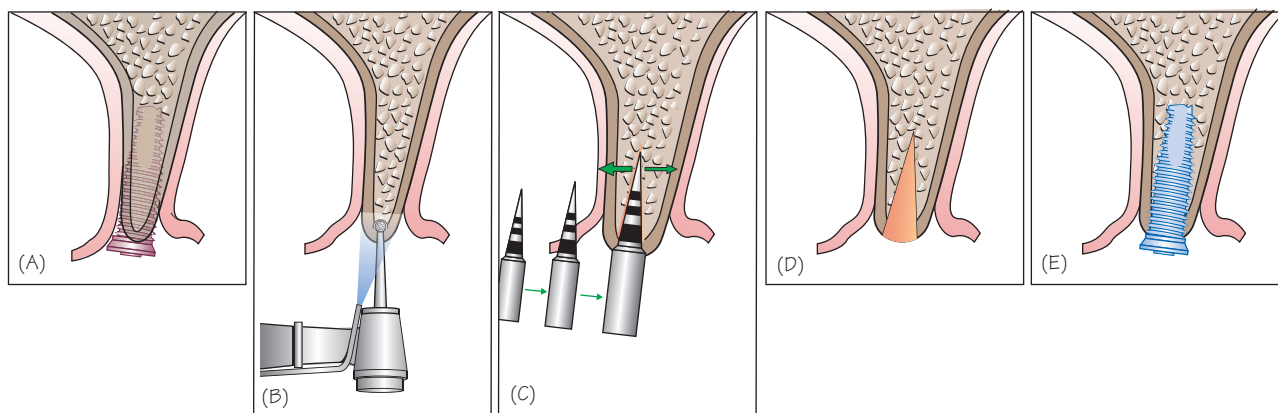


Figure 40.1 Ridge splitting technique for single dental implant placement at the maxilla. (A) The dental implant cannot be placed due to the knife-edge alveolar bone morphology. (B) Lamellar cortical splitting is initiated by using a bur. (C) A set of chisels of increasing width is used to split the alveolar ridge. (D) The gap created by splitting is left empty. (E) Transverse expansion allows for immediate dental implant installation.

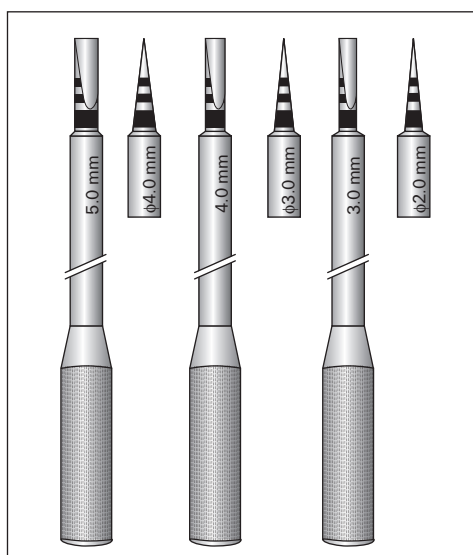


Figure 40.2 Set of chisels for split osteotomy.

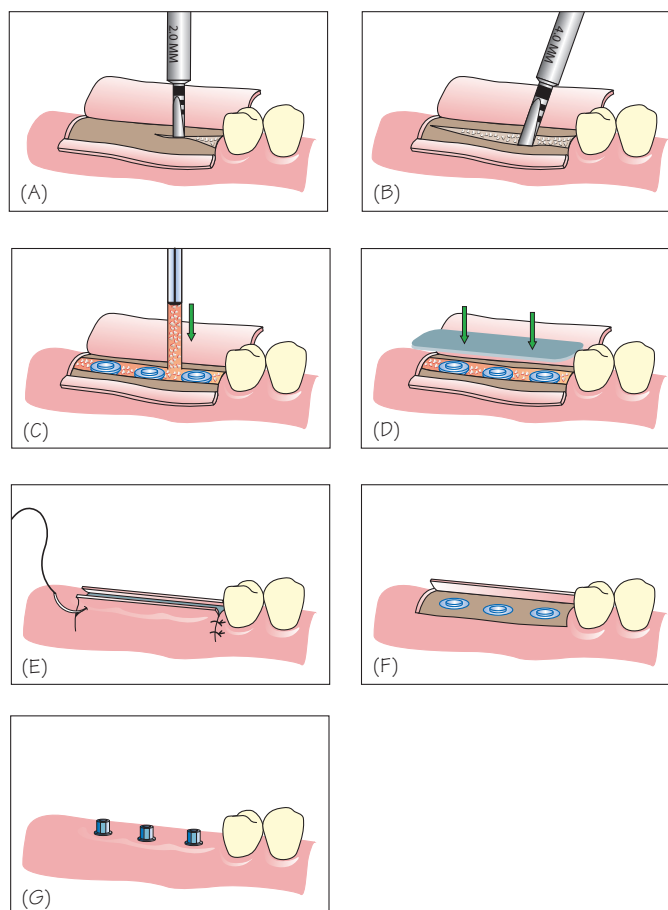


Figure 40.3 Split osteotomy at the mandible. (A) Lamellar cortical splitting with a 3 mm chisel. (B) The gap is progressively created by the use of different chisels. (C) The dental implants are placed and the gap is filled with a bone substitute. (D) (E) A resorbable membrane is trimmed and adapted over the implants before closure. (F) Three months later, the uncovering procedure can be performed. The regenerated tissue has filled the gap. (G) The prosthetic phase can begin 1 month after the uncovering procedure.

Rationale

Split ridge and expansion techniques are effective for the correction of moderately resorbed edentulous ridges in selected cases. Transverse expansion is based on osseous plasticity obtained by corticotomy. It progressively allows for an adequate transversal intercortical diameter large enough to insert one or several dental implants. The gap created by sagittal osteotomy expansion undergoes spontaneous ossification, following a mechanism similar to that occurring in fractures (Fig. 40.1).

Products and devices

Various ridge splitting/expanding chisels (from 3 mm to 6 mm) are designed to define the appropriate shape and size of the osteotomy (Fig. 40.2). Ultrasonic units may facilitate and improve the safety of the procedure.

Technical procedure (Fig. 40.3)

- *Full-thickness crestal incision* with vertical releasing incisions one tooth further than the site being treated.
- *Elevation of a mucoperiosteal flap* palatally and buccally to expose the bone ridge.
- *Lamellar cortical splitting* is initiated by one horizontal crestal osteotomy using a diamond disk, a bur or, preferably, a piezosurgery tip. The longitudinal split can be limited by placing transverse cuts in the bone. Two additional vertical cuts, 2 mm distal to the site of implantation and 1 mm mesial to the adjacent teeth, can be performed to facilitate the expansion.
- *Longitudinal splitting* of the alveolar ridge is performed using a set of chisels of increasing width. They are optimally used by pressing the instrument manually into the bone or chisels are gently tapped with a hammer. Normally, the chisels are extended to a depth of 5–7 mm, but the penetration depends on the width of the ridge. The direction of chisel force should be aimed palatally to decrease the damage exerted on fragile and thin buccal plates. The chisel should be removed by movement in a mesial-distal direction. Facial-lingual movement should be avoided so as not to further deform the buccal plate.
- *The gap created by splitting* can either be left empty or filled with different materials, such as collagen sponge, autogenous bone chips, and bone substitute. The split ridge can be covered with membranes. However, there is a lack of evidence concerning the split ridge technique with interpositional graft materials or with covering membranes.
- *Dental implant placement.* The implants can be placed at the same time or later on according to a standard procedure. There is a lack of evidence for delayed implant placement when using the split ridge technique. When placed immediately, primary implant stability is achieved by placing the implants at the most apical non-fractured portion of the jawbone. To improve primary stability of the implants and to prevent fracture of the buccal plate, the use of osteotomes to prepare the implant bed is recommended.
- *Wound closure* with vertical mattress sutures.
- *Dental rehabilitation* may be started 3–6 months afterwards.

Indications and advantages

The split ridge/ridge expansion technique is indicated in selected situations where atrophy of the edentulous ridge has developed horizon-

tally and cancellous bone is present between the oral and facial cortical plates, and adequate residual height exists. This technique is mainly indicated in the maxilla.

The procedure results in a significant increase (range 87.5–100%) in the width of the alveolar ridge (Donos *et al.*, 2008), and allows a gain of 4–5.5 mm of thickness. Survival rates of implants placed at sites augmented using these techniques are similar to those of implants inserted in native bone, i.e. ranging from 98% to 100% at 8 months post loading (Chen *et al.* 2009).

Contraindication and limitations

Unfavorable bone angularity

Excessive facial inclination of the alveolar ridge may contraindicate this procedure, as it may worsen the initial situation from a prosthetic and esthetic point of view. When excessive buccal inclination of the implants creates problems, GBR or bone grafting techniques seem more suitable.

Severe horizontal atrophy

The technique can only be applied when the buccal and palate/lingual plates are separated by spongy bone. Therefore, the indications are more limited compared to onlay bone grafts and GBR, which can also be applied in cases presenting severe horizontal atrophy.

Ridge expansion in the mandible

Although possible, ridge expansion in the mandible is frequently difficult due to the rigidity of the bone. The risk of fracture of the osteotomized fragment is higher than at the maxilla.

Complications

Basal greenstick fracture of the segments during widening has not been controllable to date. Thus, fracture of the buccal plate is the most common complication. Care must be taken in the presence of undercuts that may increase the risk of bone fracture. A minimum width of 2–3 mm of the coronal alveolar crest is necessary to avoid bone fracture.

Loosening or fracture of microscrews may occur.

A labyrinthine concussion may occur during tapping of an osteotome.

The patient may experience a *benign positional vertigo*.

Key points

- Bone splitting/expansion seems to be a reliable and relatively non-invasive technique to correct narrow residual edentulous ridges.
- It is mainly indicated at the maxilla.
- Bone fracture is the most frequent complication.
- The procedure is technically demanding.
- Piezosurgery facilitates and improves the safety of the procedure.

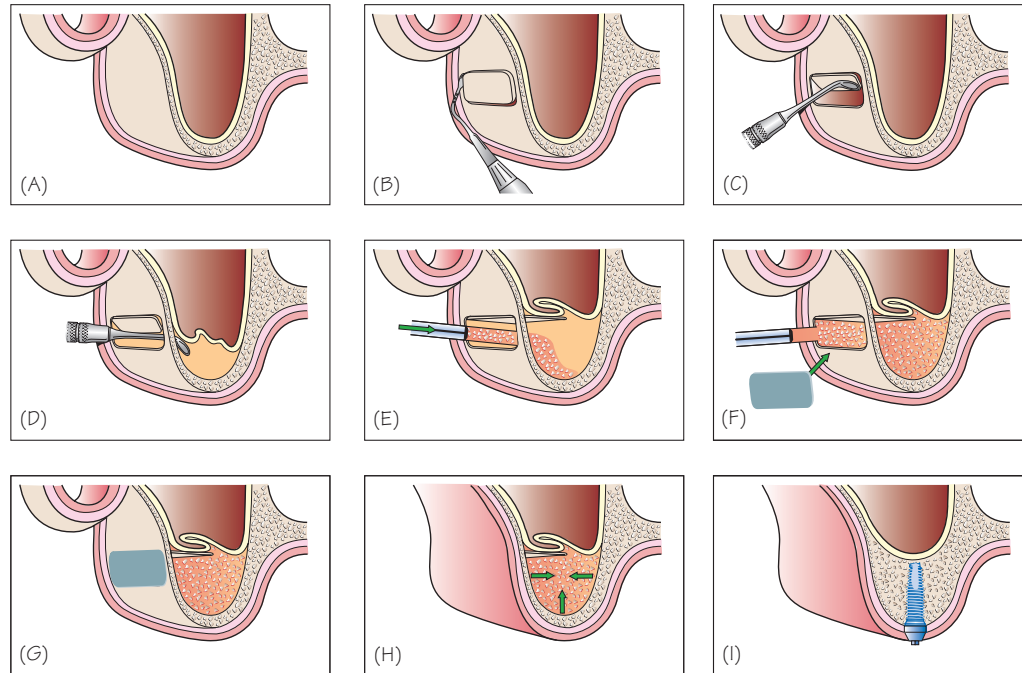


Figure 41.1 Lateral approach, two-stage technique. (A) A mucoperiosteal flap is reflected to expose the buccal wall of bone. (B) The osteotomy is prepared with a piezo tip (or a round bur). (C) The osteotomy is complete. The osseous window is reflected medially and superiorly using a spoon elevator. (D) The sinus membrane is elevated with blunt sinus curettes. At the end of this stage, the Valsalva maneuver indicates that the sinus membrane is intact. (E) The compartment is filled with the grafting material through the window. (F) The bone graft material is extended to the

osteotomy border and packed into the osteotomy site. A resorbable membrane is trimmed and adapted to the lateral window (3 mm at least beyond the osteotomy lines). (G) The window is completely covered with the resorbable membrane. Care is taken not to leave graft material particles outside the sinus cavity. (H) Soft tissues are closed with mattress sutures, and the graft material is used as a scaffold for new bone formation. (I) The dental implants are inserted about 4 months after sinus elevation.

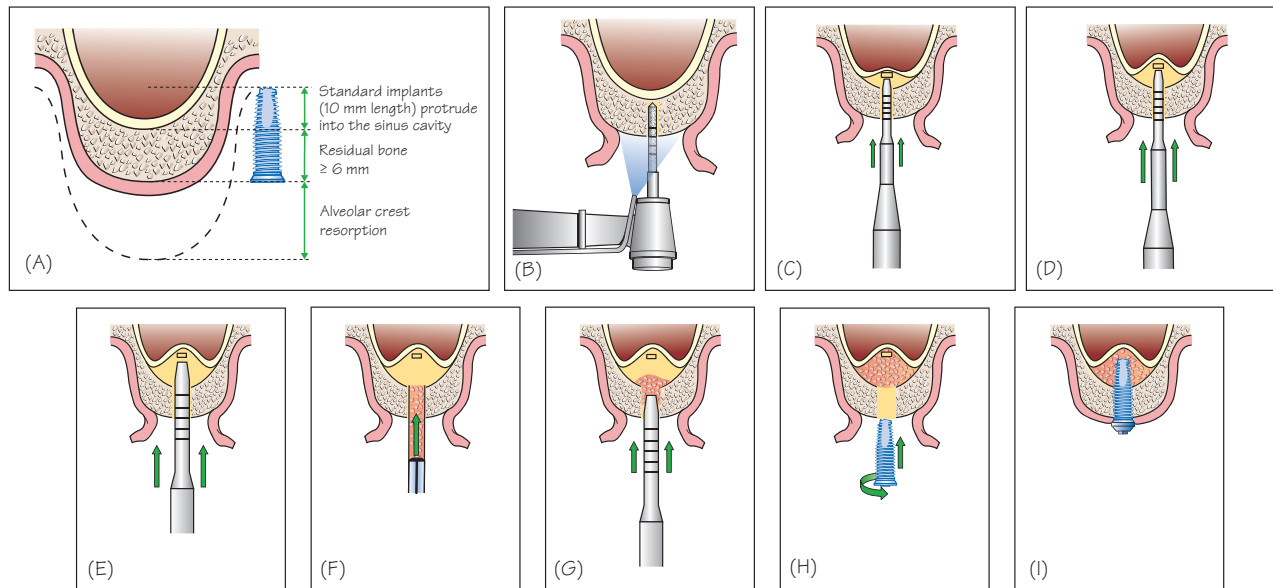


Figure 41.2 Transalveolar approach. (A) A minimum height of 6 mm of bone is needed to ensure primary stability of the implant. (B) The alveolar bone is drilled (ϕ 2 mm) to within 2 mm of the sinus floor. Care is taken not to drill the sinus floor. (C) The sinus floor is carefully fractured with the tip of the first osteotome (ϕ >2 mm). (D,E) Osteotomes of wider diameters are used to compress and expand the bone opening. (F) The sinus is filled with a bone

substitute through the canal created by the osteotomes. (G) Prior to implant placement, the bone graft material is packed with the tip of the wider diameter osteotome into the osteotomy site. (H,I) The implants are inserted immediately. The prosthetic phase can begin about 4 months after sinus elevation.

Rationale

The biological rationale for this procedure is based on the ability of a graft material to promote bone formation in a compartment, which is surgically created between the Schneiderian membrane and the sinus walls (Esposito *et al.*, 2010).

Products and devices

Nowadays, only rough surface implants are used in sinus floor elevation procedures.

Specific instrumentation

Lateral approach

- Round carbide and diamond burs
- Piezoelectric surgical device (optional)
- Sinus curettes

Transalveolar approach (syn. osteotome technique, Summers technique)

Osteotomes

Graft materials

Bone substitutes are now preferred to autogenous bone because of the lack of donor site morbidity. Allografts, alloplasts, and xenografts can be used alone or in combination with autogenous bone. Xenografts (Bio-Oss®) are now extensively used and well documented. No relevant differences between grafting materials in terms of ISR (96.3% to 99.8%) are found for rough surface dental implants (Chiapasco *et al.*, 2009; Nkenke & Stelzle, 2009).

Barrier membranes

In the lateral approach, procedures performed with resorbable membrane coverage of the lateral window show a higher ISR than when no membranes are used (Tonetti & Hammerle, 2008).

Technical procedures

Lateral approach (Fig. 41.1)

A mid-crestal incision is performed, and a buccal releasing incision is extended into the buccal vestibulum. A mucoperiosteal flap is elevated. The outline of the window is marked onto the lateral sinus wall with a small round carbide bur or with the saw of the piezoelectric device.

The osteotomy is performed with a #6 round diamond until the transparency of the sinus membrane appears as a blue/gray line. Piezoelectric osteotomy is time-consuming but safer than the bur technique. Diamond-coated tips are used for window cut and do minimal damage to the sinus membrane.

The sinus membrane is elevated with blunt sinus curettes. The bone attached to the membrane forms the roof of the space to graft. The bone window attached to the membrane can be removed to facilitate access for membrane elevation, and thus to avoid tearing.

One-stage technique

Before implant insertion, the medial part of the compartment is filled with the grafting material, the implants are inserted, and the remaining space is filled to the bone surface. The window is then covered with a resorbable membrane, and the flap is closed with tension-free sutures.

Two-stage technique

The compartment is filled to the bone surface with the grafting material and covered with a resorbable membrane. The dental implants are inserted about 4 months after sinus elevation.

The transalveolar approach (Fig. 41.2)

The implant bed is drilled to the sinus floor. A microfracture of the sinus floor is carefully performed with the osteotome tip from 1 to 2 mm into the sinus. The graft material is placed within the implant bed and carefully inserted within the sinus. The sinus floor can be elevated up to 5 mm without membrane perforations (Engelke & Deckwer, 1997). The implant is then inserted.

There is no need for additional graft material when the sinus floor elevation does not exceed 2 mm. In soft bone (type III and IV), the implant bed can be prepared solely through the use of osteotomes. When primary stability is not achieved, implant placement must be postponed.

Indications

The ISR after sinus floor elevation is greater than 90% after 3 years (Wallace & Froum, 2003; Graziani *et al.*, 2004; Pjetursson *et al.*, 2008).

The lateral approach

Residual bone height in the maxillary posterior area, which does not allow implant placement with the transalveolar approach.

The transalveolar approach

Residual bone height of 5–6 mm in the maxillary posterior area (Tan *et al.*, 2008).

Contraindications

- Untreated maxillary sinus pathology.
- Cigarette smoking has a negative effect on ISR. There are no data supporting the fact that smoking is a contraindication. However, smokers must be informed that (1) postoperative complications are more frequent and severe, and (2) the ISR is lower than in non-smokers.

Complications

These are not frequent, but they can significantly affect the outcomes and patient morbidity.

The most frequent complication is perforation of the sinus membrane that occurs in about 20% of the procedures. Small perforations are well tolerated and can be managed by extended elevation of the sinus membrane laterally to the perforation, and by placement of a resorbable membrane within the sinus cavity to cover the tear. Implant survival is generally not affected by perforation of the sinus membrane, irrespective of the technique. If there is a large tear of the sinus membrane, the procedure is stopped and a second attempt can be performed 6–9 months later.

Infections of the grafted sinus are rare (approximately 3%) and are generally associated with perforation of the membrane. Sinusitis tends to occur in previously unhealthy sinuses. Graft loss results from severe complications and occurs at a rate of approximately 2%.

Key points

- Sinus floor elevation procedures are predictable treatment methods.
- Perforation of the sinus membrane is the main complication.
- The technique is demanding and requires adequate operator training to perform the procedure as well as clinical expertise to manage the complications.

Bone augmentation: alveolar distraction osteogenesis

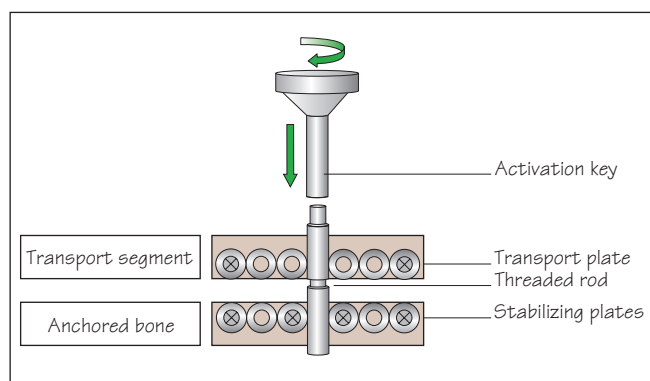


Figure 42.1 The three components of a miniature intraoral distraction device.

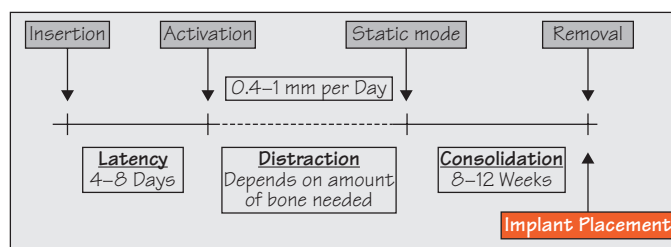


Figure 42.3 Traditional time schedule of the distraction protocol.

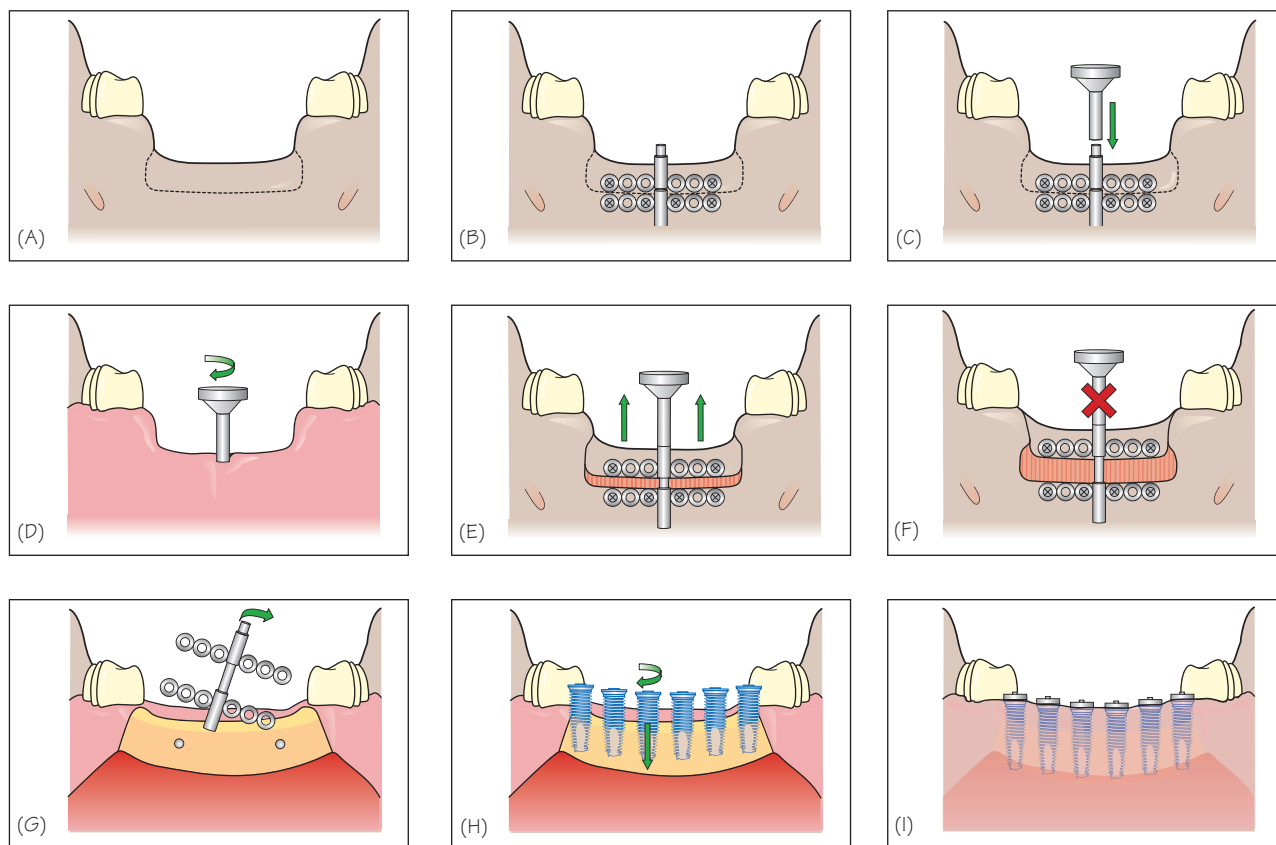


Figure 42.2 Alveolar distraction technique at the mandible. (A) Osteotomy is performed. (B) The stabilizing plate is fixed to the jaw bone and the transport plate is secured to the transport fragment. (C) The activation key is slightly turned to ensure the mobility of the transport fragment. (D) The distractor is activated with the key by the patient or a family member.

(E) The transport segment is slowly mobilized in a coronal direction. (F) A consolidation period in static mode allows the calcification of the regeneration chamber. (G) The distractor is removed. (H) The implants are inserted at the same time. (I) The flap is secured around the implants neck. A two-stage procedure can also be performed.

Rationale

Distraction osteogenesis involves gradual, controlled displacement of surgically created fractures which results in simultaneous expansion of soft tissue and bone volume. The regeneration chamber created by the displacement of the bone segment is gradually filled with immature non-calcified bone that calcifies during a subsequent fixation period.

The principles of distraction osteogenesis have been adapted to implant surgery to increase alveolar bone volume (Chin, 1999).

Products and devices

Various distraction devices are commercially available (Fig. 42.1). Basically, the device consists of three components (Fig. 42.2):

- a threaded rod, which activates the device by turning the hexagonal head
- a transport plate, which is attached to the transport segment
- a stabilizing plate, which is attached to the bone bordering the horizontal osteotomy.

Technical procedures

The segment to be distracted has to be at least 3 mm in height.

- *Buccal full-thickness flap* reflections to allow proper visualization of the ridge during the osteotomy.
- Intimate *adaptation of the fixation plates* to the cortical bone.
- *Transient fixation of the distractor* in its planned position by self-tapping miniscrews.
- The osteotomy site is scribed using a small round bur or a Piezosurgery® device.
- Removal of the distractor.
- *Osteotomies* are performed using an oscillating saw or a Piezosurgery® device. Care is taken to ensure the cuts do not protrude beyond the lingual cortex, which is the only source of vascular supply.
- *Mobilization of the transport segment* by placing an osteotome within the osteotomy lines.
- *Final fixation of the distractor*. Plates are secured to the bone using self-tapping microscrews. Care is taken that the threaded rod does not interfere with the occlusion.
- Transient activation of the distractor (screwing) to ensure the mobility of the transport segment and to return to its passive state (unscrewing).
- Soft tissue closure.
- *Activation of the distractor* after 4–8 days. An instructed family member turns the threaded rod 0.5 mm every half day by using a wrench.
- Periapical radiographs can be used to follow the consolidation and maturation of the regeneration chamber.
- After the *consolidation period* (Fig. 42.3), the distractor is removed and two-stage implants can be placed at the same time. A 4–6-month osseointegration period is recommended.

Indications

Distraction osteogenesis is a technique-sensitive procedure and is recommended for well-trained surgeons (Chen *et al.*, 2009).

Expansion occurs only in the direction of transport. Horizontal distractors have recently been proposed but have not yet been fully evaluated. The technique performs better at the mandible than at the maxillary.

Alveolar distraction osteogenesis allows for more vertical bone augmentation than other regenerative techniques (Esposito *et al.*,

2009). Alveolar distraction procedures report a range of bone gain of 5–15 mm (Tonetti *et al.*, 2008).

This technique is more expensive than GBR and bone grafting, but may reduce treatment time. When horizontal augmentation is necessary at the same time, it can be combined with other techniques. These situations make the use of the alveolar distraction technique questionable, compared with GBR and onlay bone grafting that allow for a three-dimensional bone augmentation.

Contraindications

- Insufficient bone quantity to allow adequate anchorage of the plates. The use of the technique is not indicated in severely deficient mandibles, which are at risk of neural damage and/or fracture. Similarly, the presence of maxillary sinus and/or nasal cavities may be a contraindication.
 - Presence of a thin knife-edge bone.
 - Lack of patient co-operation during the activation process.
- Nevertheless, the procedure seems well accepted by patients (Allais *et al.*, 2007).

Complications

These are frequent (27%) but total failure of the procedure is only reported in 1.1% of patients (Chiapasco *et al.*, 2009). Corrections with prosthetic/orthodontic appliances or further minor augmentation procedures are often needed to allow dental implant placement.

- Change of the distraction vector. This is the most frequent complication, varying from 13% to 35.4% (Chiapasco *et al.*, 2009). The bone fragment may incline during the distraction phase due to the traction on the osteotomized segment by muscle forces, in particular in the anterior area of the lower jaw where traction by the muscles of the floor of the mouth is important (Chiapasco *et al.*, 2007). Similarly, the inelastic palatal mucosa may negatively influence the distraction vector.
- Incomplete distraction.
- Premature consolidation.
- Inability to move the distracted fragment.
- Fracture of the distracting device.
- Partial relapse of the initial bone gain.
- Marginal bone loss of the most coronal part of the distracted segment is frequent and may lead to a slight overcorrection at the completion of transport.
- Transient paresthesia at the mandible.
- Fractures of the basal bone or the distracted segment.

Key points

- Expansion occurs only in one direction (vertical or horizontal).
- The technique performs better at the mandible than at the maxilla.
- Complications after distraction are frequent.
- The advantages of the technique are lost when additional corrective procedures are needed.
- Distraction osteogenesis is only recommended for well-trained surgeons.

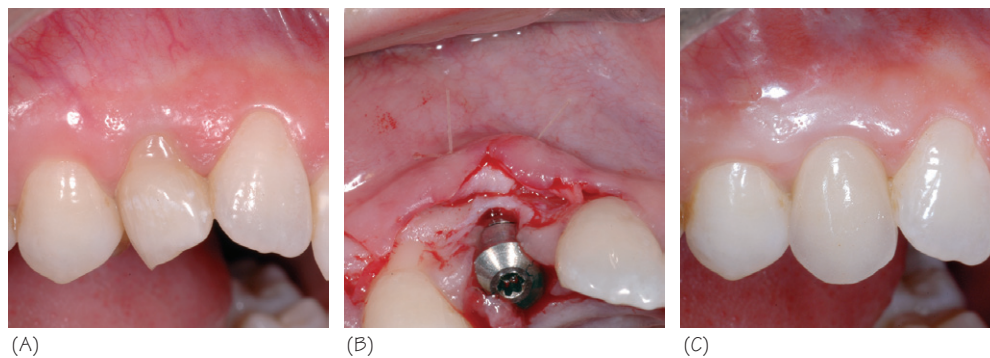


Figure 43.1 Connective tissue graft. Thin biotype. (A) The deciduous tooth must be replaced by a dental implant. Note the thin biotype. (B) A connective tissue graft is performed during implant surgery, to thicken the buccal mucosa. (C) Clinical view after 6 years.

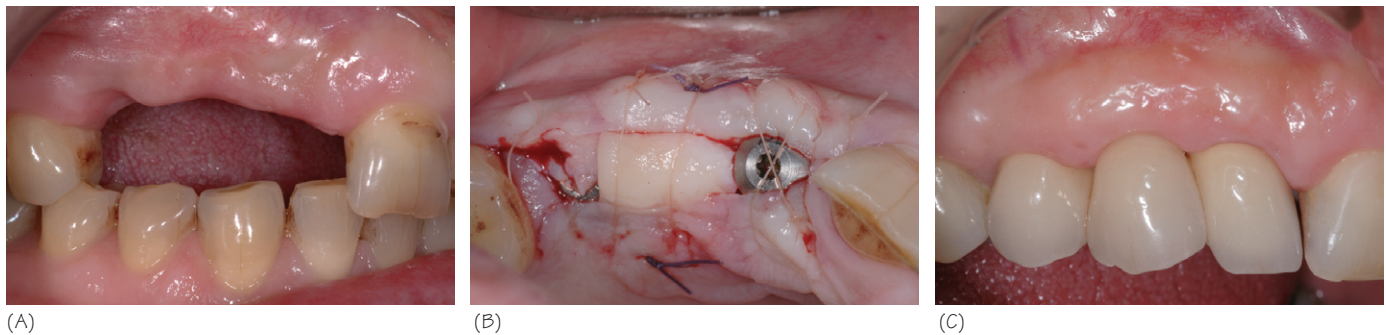


Figure 43.2 Soft tissue ridge augmentation. (A) Horizontal and vertical defect. A 3-unit bridge supported by two dental implants (teeth 12 and 14) is planned. (B) A connective tissue graft increases the soft tissue volume in the area of ridge defect to improve the shape of the pontic. (Tooth 13) (C) Clinical view after 5 years showing the esthetic improvement due to the soft tissue augmentation.

Table 43.1 Guidelines for soft tissue augmentation procedures

	Esthetic	Keratinized augmentation	Volume augmentation	Morbidity
Apically positioned flap	Moderate	Moderate	Low	Low
Rotational flap	High	Moderate	Low	Low
Free gingival graft	Low	High	Moderate	High
Allogenic graft	Moderate	Moderate	Moderate	Low
Subepithelial connective tissue graft	High	Low	High	Moderate

Rationale

Peri-implant soft tissues differ from periodontal tissues in terms of structure (more collagen fibers in a parallel arrangement) and defense capacity (fewer cells) (see Chapter 2). The role of soft tissue in implant success is still questionable.

Although the presence of keratinized tissue is not essential for peri-implant tissue health and implant survival (Wennstrom *et al.*, 1994), it can certainly facilitate plaque control, which is a crucial prerequisite to long-term implant success. Moreover, soft tissue quality and quantity around implants can have implications for esthetic results and soft tissue margin stability.

Soft tissue augmentation techniques aim to create an optimum soft tissue environment around implants, to improve implant prognosis and/or prosthetic cosmetic integration.

However, it should be noted that the recommendations that follow are essentially based on clinicians' opinions, as scientific data regarding indications or technique selection (Klinge & Flemmig, 2009) are very limited in the literature.

Indications

The indications for soft tissue augmentation procedures can be divided into two groups.

- **Keratinized tissue augmentation** is required when:
 - a *reduced keratinized tissue* height (less than 2 mm) or width (less than 1 mm) is associated with insufficient plaque control
 - a *shallow vestibule* prevents access to oral hygiene originally or after tissue displacement (bone regenerative procedures)
 - soft tissue quantity is too small to assure covering of augmented bone areas.
- **Soft tissue volume augmentation** is performed in the following situations:
 - *thin biotype* when long-term soft tissue margin stability is required (esthetic)
 - *ridge defects* correction to improve pontic design for esthetic or plaque control (Seibert & Salama, 1996)
 - *primary soft tissue closure* on fresh extraction socket for ridge preservation (see Chapter 32, Fig. 32.1) or covering of GBR material (Jung *et al.*, 2004).

The decision to perform a soft tissue augmentation is based on *risk assessment* (implant survival or esthetic) and the *morbidity* of the surgery. These two parameters should be evaluated at the beginning of the treatment, as additional surgery is not always well received by the patient.

Technical procedures (Table 43.1)

All the techniques described below are derived from periodontal plastic surgery (Bouchard *et al.*, 2001).

Technique selection depends on the quantity of residual keratinized mucosa and the type of indication. The first choice is the less invasive one (low morbidity).

Apically positioned flap (APF) is a simple technique that can be applied during implant placement or at second-stage surgery. The

initial incision is displaced on the lingual/palatal side to manage a band of keratinized tissue on the vestibule. It is the technique of choice for non-esthetic areas. APF is performed when the keratinized mucosa quantity is limited, at the time of implant placement (one-stage implant) or at second-stage surgery.

Rotational flap (RF) techniques have been developed to augment soft tissue volume for esthetics (small defects) (Scharf & Tarnow, 1992), or to allow adequate closure after GBR procedures. Tissue manipulation can be delicate and requires sufficient skill. The presence of a pedicle allows good vascular nutrition of the displaced tissue.

Free gingival graft (FGG) allows a better keratinized tissue augmentation than all other procedures (Thoma *et al.*, 2009). The esthetic result is generally bad, and therefore this technique is not recommended in esthetic areas.

Allogenic graft: freeze-dried skin allograft, acellular dermal matrix graft, could be an alternative to free gingival graft for tissue stabilization, with less morbidity. Clinical documentation is limited.

Subepithelial connective tissue graft (SECTG) is the technique of choice when soft tissue volume augmentation is required (Thoma *et al.*, 2009) especially in esthetic areas: thin biotype (Fig. 43.1), extraction socket closure, ridge defects (Fig. 43.2). As for FGG, quantity is limited by anatomical parameters (donor site).

Timing for soft tissue augmentation

From a clinical point of view, evaluation of peri-implant mucosa should be done at each treatment step. The global approach is to prevent soft tissue loss and to limit the number of surgeries.

Two-stage implants: decision making for soft tissue augmentation can be performed at second-stage surgery (except for esthetic cases).

One-stage implants: soft tissue quality has to be adequate at the time of implant placement. In compromised cases, a soft tissue augmentation must be performed 6 weeks before implant placement.

Bone augmentation areas: a good soft tissue environment is required for GBR and bone graft procedures. In cases of limited keratinized tissue, soft tissue augmentation can be performed 6 weeks before bone surgery, to improve soft tissue manipulation and site covering. However, the vascular supply can be decreased (scar tissue) by this first surgery, which is thus indicated only for compromised cases.

Demanding esthetic cases: as several soft tissue augmentations could be indicated, they should be performed as soon as possible: at the time of tooth extraction (FGG, SECTG), at the time of implant placement (RF, SECTG), or at second-stage surgery (RF, SECTG).

Key points

- Keratinized mucosa around implants is not a prerequisite for the survival of dental implants but may improve plaque control and esthetics in some situations.
- The flap design should preserve the keratinized tissues around the implants.
- In an esthetic area SECTG is the gold standard.

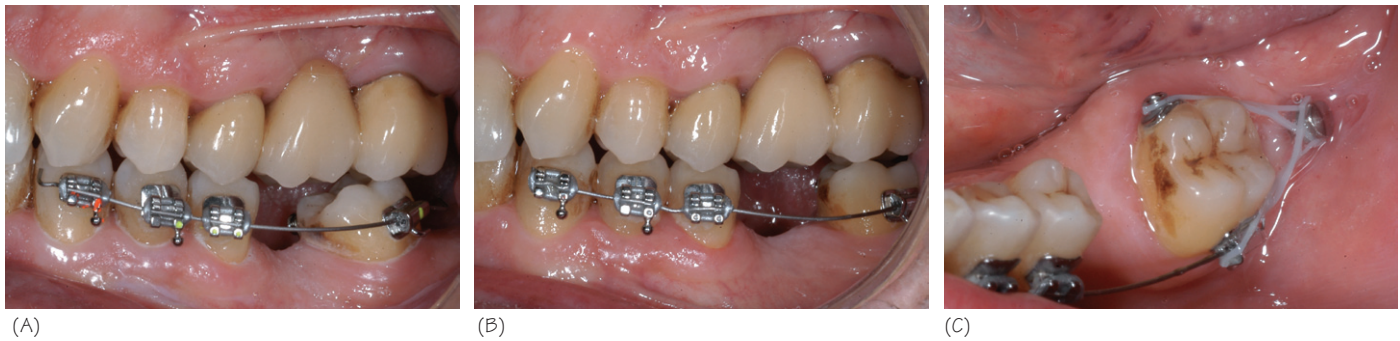


Figure 44.1 Miniscrew used as distal anchorage to increase the inter-dental distance. (A) Preoperative view. Note the tilting of the second molar. (B) Clinical view at 6 months. (C) Detail of the orthodontic appliance.

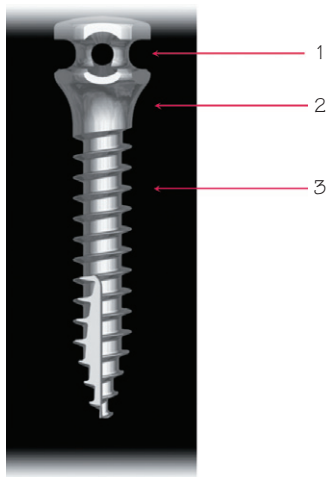


Figure 44.2 Miniscrew design. 1: Head, 2: Gingival portion, 3: Body.

Table 44.1 Miniscrew: design and function

Miniscrew element	Function
Screw head	Connection of an orthodontic device No soft tissue injury
Gingival portion	Soft tissue integration
Screw body: thread design	Greater depth for primary stability
Body diameter	Mechanical resistance

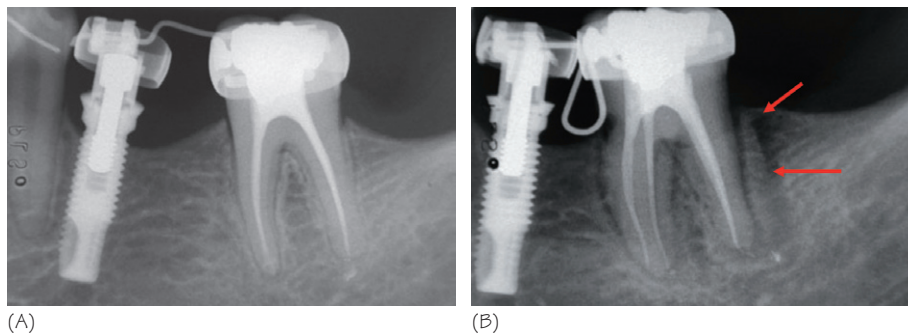


Figure 44.3 Dental implants used as orthodontic anchorage. (A) A temporary crown is placed on the osseointegrated implant. The orthodontic appliance is connected to the crown. (B) The straightening and the mesial translation of the tooth 37 is performed. Note the distal bone apposition (red arrows).

Orthodontic patients may need dental implants either to replace missing teeth after optimal space management or to facilitate orthodontic movement by providing an additional anchorage.

Dental implants for patients with tooth agenesis

Optimal time for implantation

The replacement of teeth by implants is usually restricted to patients with completed craniofacial growth. In the last few years, an exception to this restriction was reported in children suffering from extended hypodontia or even anodontia.

In cases of residual growth after implant placement, the dental implant will not follow the migration of the alveolar process, leading to disharmony between implant and adjacent teeth. Consequently, it is essential to evaluate the completion of *alveolar bone growth* before implant placement in esthetic areas. In general, this happens around 18 years old. However, wide variation is observed among different face types. No changes with the superimposition of cephalometric radiographs taken 6 months apart is a good evaluation process (Heij *et al.*, 2006).

Orthodontic space opening should allow for adequate intercoronal and inter-radicular space for optimal implant placement. As it is usually performed during adolescence, an effective provisional retention device (resin-bonded bridge) must be placed to prevent coronal and apical migration.

Alveolar bone dimensions

Agenesis is often associated with insufficient bone growth and poor bone density. Bone augmentation procedures are indicated before or during implant placement.

Dental implants used as orthodontic “absolute” anchorage

Special implants: orthodontic miniscrews

Definition

A special implant is a dental implant with a diameter of less than 3 mm. It is used for a limited period of time and should not be confused with the narrow implants which are used for regular cases for which a long-term osseointegration is required. The terms “mini-implants,” “micro-implants,” “miniscrews” or “microscrews” are often used as synonyms (Table 44.1). Mini-implants are considered as an effective source of anchorage by orthodontists (Reynders *et al.*, 2009) (Fig. 44.1). Therefore, the term “orthodontic implant” is sometimes used for this purpose.

Advantages, other than their narrow diameters, include minimally invasive surgeries and lower costs.

As the osseointegration process is not a prerequisite for their use, the special implants can be loaded at different times between 1 day and 4 weeks. An immediate loading protocol (within 48 hours) seems to enhance mini-implant success rate (Melsen & Costa, 2000).

Implant design (Fig. 44.2)

Many special implants are now available. Their diameters vary from 1.8 to 2.5 mm, and their lengths vary from 6 to 15 mm.

Preimplant diagnostic protocol

The clinical examination includes a meticulous examination of the periodontal tissues to evaluate the gingival biotype, the location of the mucogingival line, and the attachments of the frena. A dental cast can help the clinician to confirm the location of the periodontal tissues. In addition to a panoramic X-ray, a periapical X-ray of the implant zone is compulsory. This is to evaluate the bone density and to determine a safe area for implantation, i.e. free of anatomical and dental structures that could be damaged. The combination of cast and X-ray identifies the exact area of implantation. In complex cases, a surgical template can be used.

Surgical technique

Basically, surgical implant placement seems very easy because there is no need for flap elevation. Nevertheless, complications such as mucositis, root trauma, nerve and/or microvascular injury, implant fracture, and sinus perforation have been described. Care must be taken in the follow-up of patients because these complications can show up over time, 1 year later in some cases. A greater risk of failure is reported for younger patients, and for mini-implants placed in the mandibular arch.

Mini-implants are effective as anchorage, and their success depends on proper initial mechanical stability and loading quality and quantity.

Dental implants

For partially edentulous patients, dental implants can be used as orthodontic anchorage during orthodontic treatment, and subsequently as prosthetic devices (Fig. 44.3). Proper implant location is carefully chosen according to the orthodontic set-up, decided during treatment planning.

After osseointegration, a provisional restoration is placed on the implant, and is used as anchorage during orthodontic treatment.

Orthodontic forces applied on the implants are of a different nature from occlusal forces. They are unidirectional and continuous and, below a certain threshold, orthodontic forces positively influence the turnover of the alveolar implant-surrounding bone, leading to bone apposition and densification (Melsen & Lang, 2001).

During treatment planning and orthodontic treatment, a team approach is essential to optimize the final result.

Key points

- Precise evaluation of facial growth completion is essential before implant placement in esthetic areas.
- Mini-implants are effective orthodontic anchorage devices that can be immediately loaded.
- A team approach is required for implant/orthodontic patients.

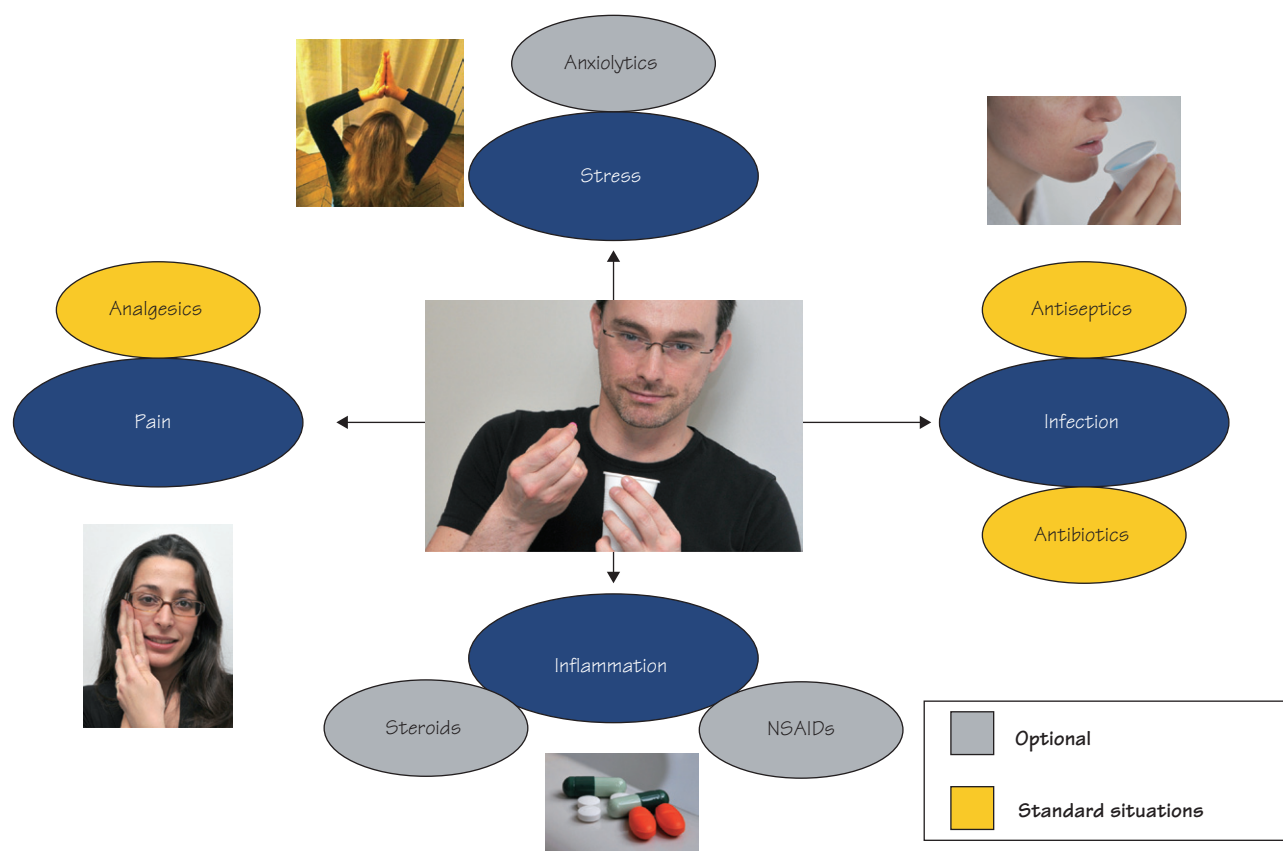


Figure 45.1 Medications that can be prescribed after dental implant placement according to patient condition.

In ordinary conditions,¹ dental implant placement is at low risk of postoperative infection and is not painful. A standard pharmacological protocol is hard to define after dental implant placement, not only because the guidelines are different from country to country, but also because many general and local variables need to be considered. Basically, all the preoperative and postoperative prescriptions aim to reduce surgical discomfort and the risk of infection.

The following medications must be considered after dental implant placement in ordinary conditions (Fig. 45.1):

- anxiolytic premedications
- local antiseptics
- systemic antibiotics
- analgesics
- NSAIDs
- steroids.

The prescription of these drugs should always take into account the possibility of an allergy to prescribed medicines.

Anxiolytic premedications

Anxiolytic premedication may prevent an increase of preoperative anxiety levels and may reduce pain levels during dental implant placement but it is often associated with moderate/severe drowsiness in the postoperative period. Many types of anxiolytics, including certain herbs, are available. *There is no specific indication for this type of premedication* in ordinary conditions, unless the psychological profile of the patient suggests their use.

Local antiseptics

There is no evidence that use of a mouth rinse will prevent the risk of infective complications after dental implant placement. However, the use of 0.2% chlorhexidine gluconate alone (not in combination with alcohol) is still a reference for mouth rinse before and after dental implant placement. A 3-minute presurgical rinse reduces the bacterial load (good level of evidence). A postsurgical rinse twice daily for 2 weeks is effective in preventing bacterial colonization of the wound (low level of evidence).

Systemic antibiotics

Antibiotic prophylaxis in surgery is only indicated for patients at risk of infectious endocarditis, for patients with reduced host response, when surgery is performed in infected sites, in cases of extensive and prolonged surgical interventions, and when large foreign bodies are implanted. Thus, the use of prophylactic antibiotics in dental implant surgery has been controversial so far. However, recent data indicate that there is some evidence that 2 g of amoxicillin given orally 1 hour

¹“Ordinary conditions” mean that the patient is not medically compromised, and that dental implant placement does not imply bone augmentation procedures and/or sinus penetration.

preoperatively significantly reduces failures of dental implants placed in ordinary conditions, with no significant adverse events reported (Esposito *et al.*, 2010). It is still unclear whether postoperative antibiotics are of any additional benefit.

Analgesics

The severity and response to other medication determine the choice of agent.

Paracetamol (syn. acetaminophen)

Paracetamol is a safe, effective drug for the treatment of postoperative pain following implant placement. It is one of the most commonly used over-the-counter analgesic and is widely available around the world. It is most effective at 1000 mg dose, and can be taken at 6-hourly intervals without compromising safety. To maintain freedom from pain, drugs should be given “by the clock,” that is every 6 hours, rather than “on demand.” Thus, in ordinary conditions, a 1000 mg dose four times daily for 3–4 days is sufficient for postoperative pain control in dental implant surgeries.

Opiates and morphinomimetics

These drugs are rarely used to control pain and discomfort after dental implant therapy.

Non-steroidal anti-inflammatory drugs (NSAIDs)

Aspirin and other non-steroidal anti-inflammatory drugs are not indicated after surgery because they have more side-effects than paracetamol and increase the risk of hemorrhage.

Steroids

There is no reason for the use of corticosteroids when dental implants are placed in ordinary conditions. They may cause a range of side-effects, including the risk of bleeding and infections. However, corticosteroids may also relieve inflammation, pain, and discomfort after advanced dental implant surgeries, such as alveolar ridge augmentation or sinus procedures. These drugs should be reserved for these specific indications in combination with the use of antibiotics.

Key points

Provided that a possible allergy is proven by the medical questionnaire, in ordinary conditions, the prescription should include the following:

- amoxicillin 1000 mg: 2 tablets 1 hour before the surgery
- paracetamol 1000 mg: 1 tablet every 6 hours for 4 days
- chlorhexidine 0.2% mouth rinse: rinse twice daily for 2 weeks.

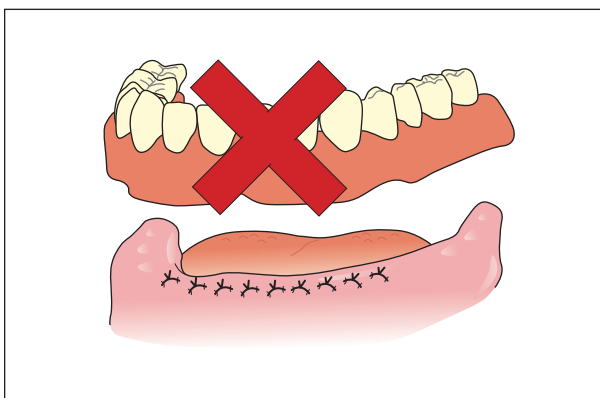
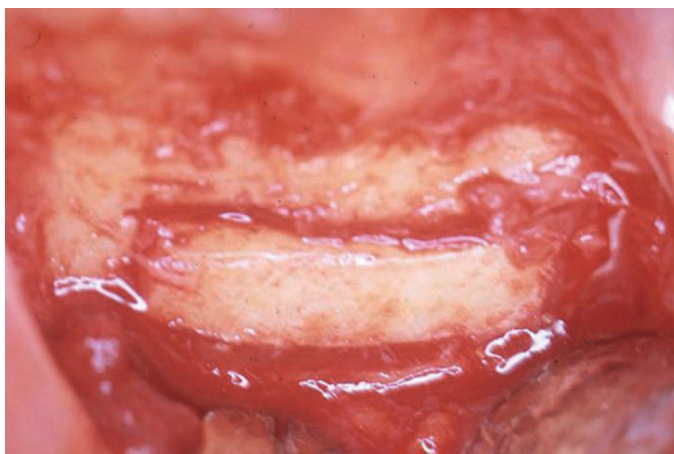


Figure 46.1 Patients are not allowed to wear a removable denture for 10 days after the surgical procedure.



Figure 46.2 An ice pack is applied immediately after surgery.



(A)



(B)

Figure 46.3 Advanced surgical procedures: specific postoperative management. (A) Chin bone harvesting. (B) Elastic tapes are used to provide pressure to the chin.

Patients are instructed to contact the doctor's office immediately if they are concerned about any abnormalities. If a postoperative complication occurs, it must be managed as soon as possible (see Chapter 47). Postoperative instructions must be provided to the patient *before* the surgical procedure, with the informed consent form. A written form is convenient and can be customized by the surgeon (see Appendix E).

Whatever the procedure, patients are asked not to wear a removable denture for 10 days postoperatively if there is a risk of hard pressure on the wound (Fig. 46.1). Provisional FPDs can be inserted immediately. Care is taken to avoid pressure from the provisional restoration on the wound.

Standard procedure

The postoperative considerations are similar to those applied for most oral surgeries, i.e. the postoperative course is often minimal. Recuperation normally takes 1–5 days after implant placement, depending on patient condition and patient compliance with prescription. Sutures are optimally removed 10 days after the surgical procedure. Standard hygiene procedures can be reintroduced. The denture is carefully relined with a soft material after primary healing of the wound (at least 10 days).

Cold therapy is beneficial to reduce bleeding, swelling, and muscle spasm, and to decrease metabolic rate (Fig. 46.2). Instant ice packs, activated by squeezing the pack with both hands, are convenient.

Pressure at the surgical site, elevation of the head, and rest are recommended. The patient is advised to stop smoking and to discontinue any physical activity, which may lead to bleeding or suture disruption, or interfere with wound healing.

Tooth brushing should be continued, except on the surgical site. Chlorhexidine mouth rinses should be used (twice daily for 2 weeks) to reduce the risk of infection at the surgical site. Chlorhexidine gel applications (3 per day) may also be helpful.

Advanced procedures

The postoperative management of advanced procedures is similar to the standard procedure. However, in advanced procedures, prescriptions differ from those of standard implant placement procedures. Antibiotics are prescribed for a minimum of 7 days. NSAIDs or cor-

ticosteroids may be used to reduce the inflammatory process. Pain is controlled with appropriate analgesics, including opiates and morphinomimetics if necessary. Depending on the surgical procedure employed, specific advice can be given.

Chin bone harvesting (Fig. 46.3)

A pressure dressing should be applied to the chin for 5 days to minimize swelling and hematoma formation, and to ensure close adaptation of the mentalis muscles. Elastic tapes are usually used to provide pressure to the chin region. Postoperative pain at the donor site is usually minimal to moderate and can be controlled by regular analgesics.

Ramus harvesting

The postoperative course is reduced, compared to bone chin harvesting, and complications are less frequent.

Sinus procedures

Postoperative considerations for the maxillary sinus grafting procedure are similar to those for most oral surgery and sinus manipulation procedures. Swelling and bruising are the chief postoperative sequelae. Occasionally, minor bleeding may arise from the nose. Recuperation normally takes 1–2 weeks.

Blowing the nose and sucking liquid through a straw create negative pressure and should be avoided for at least 2 weeks after a sinus grafting procedure. Coughing or sneezing should be done with an open mouth to relieve pressure. Decongestants can be prescribed to minimize sneezing. A nasal spray may be used on an as-needed basis for nasal congestion. Air travel and sports such as scuba diving must be absolutely avoided during the first 2 weeks after sinus procedures.

Key points

- Postoperative instructions must be provided to the patient *before* the surgical procedure.
- The postoperative considerations are similar to those applied for most oral surgeries.
- Cold therapy is efficient.
- Advanced surgical procedures require special attention.

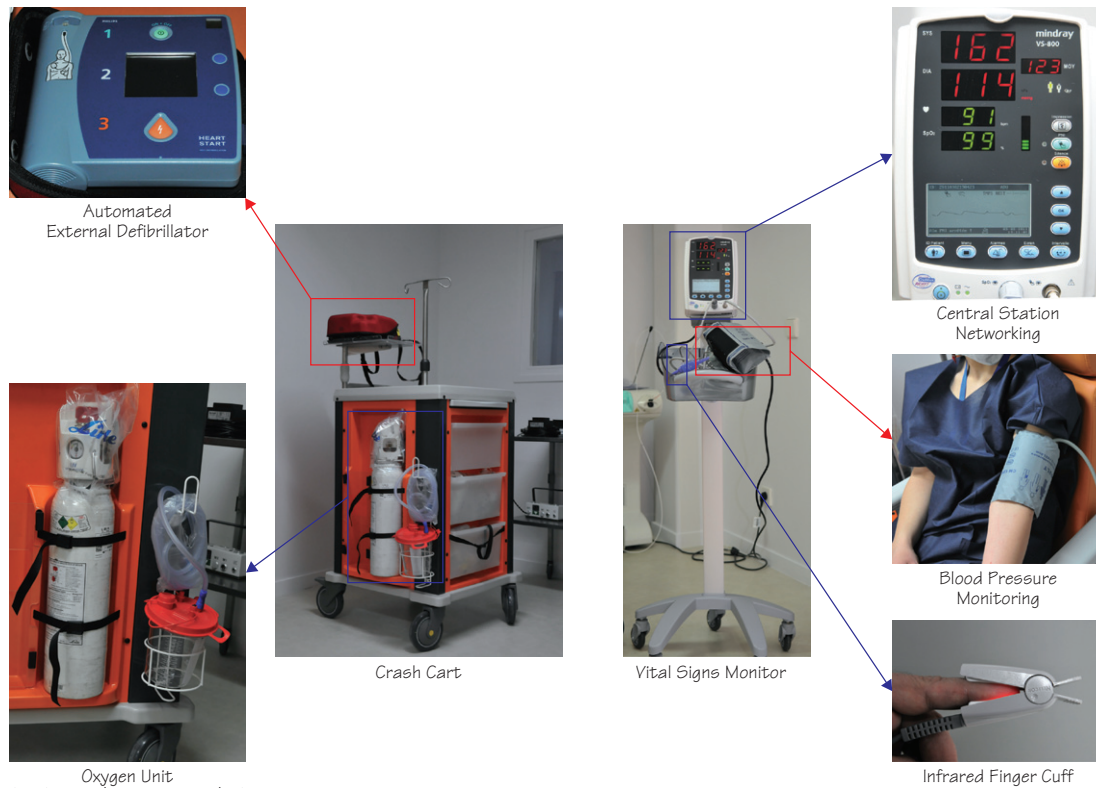


Figure 47.1 Monitoring and emergency devices.

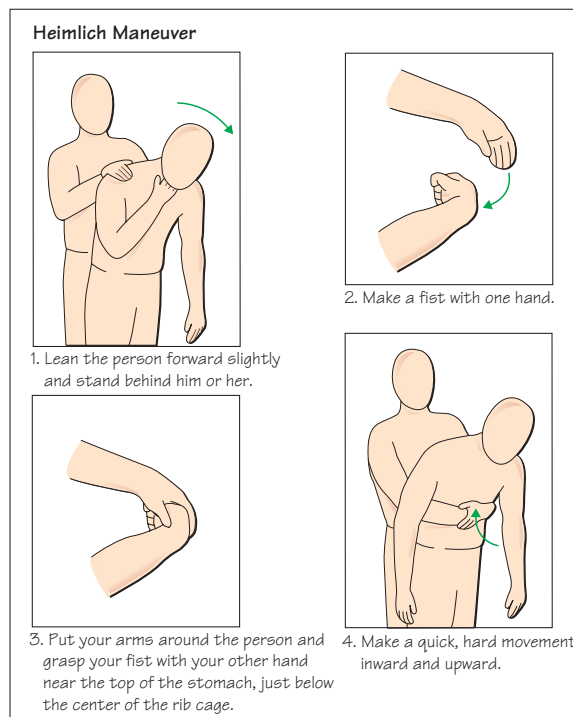


Figure 47.2 The Heimlich maneuver.

Life-threatening complications are, fortunately, extremely rare. In any case, the surgeon must have the phone number of the closest emergency medical center. The operating room (OR) should be equipped with monitoring and emergency devices (Fig. 47.1). An automated external defibrillator (AED) and an oxygen unit should be located in the dental setting or in the operating room.

A vital signs monitor that can measure the blood pressure, pulse rate, and blood oxygen saturation is recommended in the OR. A crash cart containing the tools and drugs needed to treat a person in or near cardiac arrest should be located close to the OR. However, the emergency training of the operator may not be sufficient for adequate use of the drugs included in the crash cart.

The most serious complications occur during surgery and may be life-threatening (Box 47.1).

Hemorrhages

Hemorrhages during dental implant surgeries are normally limited to class I, i.e. blood loss does not involve more than 15% of the blood volume and does not require fluid resuscitation (Manning, 2004). Thus, bleeding is usually controlled locally (Box 47.2). Hemorrhages occur most frequently at the mandible in the interforaminal region (Hofschneider *et al.*, 1999).

Excessive bleeding of the implant bed is usually stopped by inserting the implant.

Blood supply to the mandibular lingual surface is provided by two arteries, with anastomoses between them. These arteries give off branches which penetrate into the bone and can be damaged during drilling.

- The *sublingual artery* is responsible for bleeding in the anterior, lingual region. It can be severed and may then retract into the sublingual space. Even though the sublingual artery may be small, the anastomoses may create a copious blood flow.
- The *submental artery* is responsible for bleeding in the medial, lingual region. Usually larger than the sublingual artery, this artery can produce much more blood flow than the sublingual artery. It may be controlled by strong finger pressure in the inferior medial mandibular border.

In fact, the arteries themselves are not often damaged during implant placement, but the intraosseous branches are more liable to be damaged.

Foreign body ingestion/aspiration

Ingestion of a direction indicator or a dental implant is normally not a major complication. The object can pass through naturally. In contrast, aspiration of an instrument can be a life-threatening complication. Staff should be familiar with the Heimlich maneuver (Fig. 47.2).

Even without any symptoms, a patient who has swallowed a foreign body must be referred for evaluation to a physician specialist.

When using a screwdriver or a direction indicator, a suture can be tied to the instrument to prevent accidents. Intraoral gauze can also be used like a net during surgery to more easily retrieve an object accidentally dropped in the mouth.

Box 47.1 Life-threatening complications

Airway obstruction by hemorrhage

Damage to the mandibular lingual cortical plate is usually described in association with hemorrhagic accidents during dental implant placement. There is much anatomical variation in this area, making identification of a bleeding artery difficult.

Floor-of-the-mouth bleeding can lead to respiratory obstruction (a life-threatening complication).

Massive internal hemorrhage of the floor of the mouth results in a dramatic swelling that produces protrusion and displacement of the tongue, obstructing the airways. This dramatic complication may occur several hours after the surgical procedure (ten Bruggenkate *et al.*, 1993)

If the symptoms persist, call for emergency help.

Airway obstruction by foreign body aspiration

Aspiration of an instrument or a dental implant may be a life-threatening complication. Acute episode of coughing is the most common but inconstant sign. Acute choking, with respiratory failure associated with tracheal or laryngeal foreign body obstruction, may be successfully treated at the scene with the Heimlich maneuver.

Box 47.2 Management of vascular complications

1. Compression
2. Infiltration of vasoconstrictor
Local anesthetic injection directly in the bleeding site (soft tissues and/or bone canal)
3. Local hemostatic agents
Glue, sponge, powder, dressing, mesh
4. Bone wax
Intraosseous bleeding
5. Electrocoagulation
6. Vessel ligation

If bleeding persists, call for emergency help.

Key points

- Some surgical complications can be life-threatening.
- An emergency medical center near the operating room is mandatory.

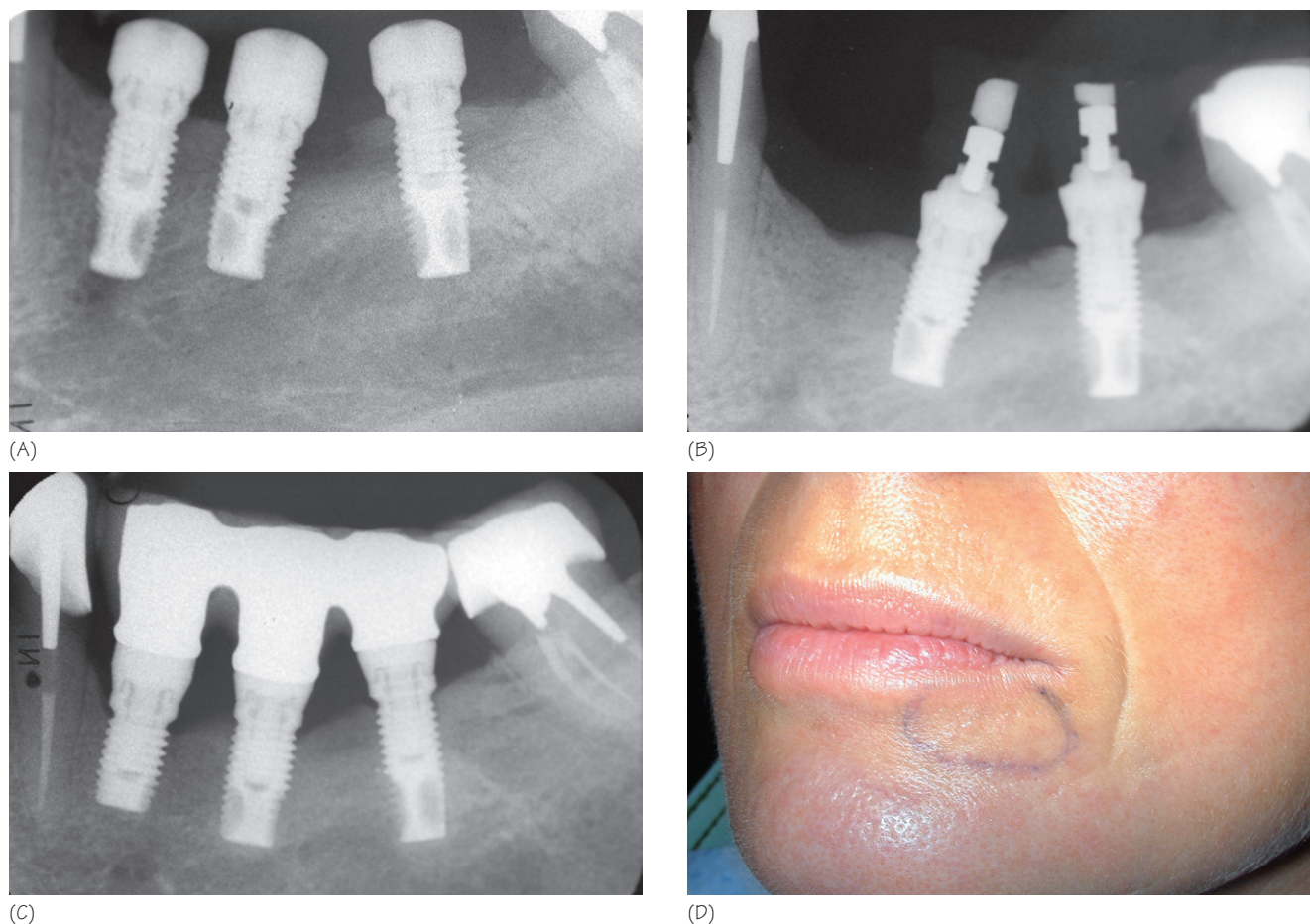


Figure 48.1 Clinical management of inferior alveolar nerve injury. (A) The implant 34 is placed too close to the mental foramen, leading to a paresthesia. (B) The implant is removed. (C) A shorter implant is placed 3 months later. At this stage the paresthesia area has decreased but still persists. (D) Five years later the paresthesia persists (area lined in blue on the skin).

Surgical complications are uncommon and can be minimized (Box 48.1).

Perioperative complications

Dental implant mobility

When primary stability is lacking (horizontal mobility) (Box 48.2), the dental implant may be replaced by a wider and/or longer self-tapping implant. When primary stability is questionable (ongoing rotation after the final tightening), it is sometimes possible to retain the implant with new implant surfaces. In this case, the *healing period must be extended*. If the dental implant is still loose, it must be removed, and the surgical placement postponed by at least 2 months.

Bone dehiscence and fenestration

This may occur during the surgery when the implant axis is tilted and not adequately placed between the cortical plates (facial malposition). Small defects do not jeopardize the implant prognosis. However, when

combined with a thin soft tissue biotype, there is a risk of *postoperative recession* of the facial mucosal margin (Chen & Buser, 2009). A classic grafting approach may be used to fill the bone defect.

Maxillary sinus or nasal fossa penetration

Violation of the maxillary or nasal floor while drilling requires an antibiotic regimen. Dental implants inadvertently placed a few millimeters into the sinus or nasal cavities are normally well tolerated (Branemark *et al.*, 1984).

Postoperative complications

Wound dehiscence

This is the most common postoperative complication for submerged implants (Giglio *et al.*, 1998). It can be prevented during surgery by a tension-free coaptation of the flaps. After surgery, the best prevention is to avoid any trauma to the wound, in particular with dentures that must be carefully relined after primary healing of the wound (at least

Box 48.1 General factors that may prevent surgical complications

- Training of surgical staff
- Knowledge of anatomy
- Preoperative imaging (CT scan)
- Thorough medical examination
- Thorough presurgical planning
- Aseptic environment
- Knowledge of the working equipment
- Dental implant size, shape, and dimension
- Atraumatic and planning surgical procedures
 - Incisions in the keratinized tissues
 - Limited extent of flap reflection
 - No high vertical releasing incisions
 - Deep sutures and flap adaptation
 - Safety margin of 2 mm between the implant body and any nerve canal
- Duration of intervention no more than 2.5 hours (local anesthesia)
- Strict postsurgical follow-up

Box 48.2 Factors that may negatively influence primary stability

Overworking of the implant bed

Prevention

- Sequential and controlled drilling
- Use of osteotomes in conjunction with drilling

Poor bone quality (class IV)

Prevention

- Use of imaging (CT scan) to determine the regional bone quality
- Use of self-tapping implants dedicated to poor bone quality
- Underdimensioned bed preparation

Implant placement in fresh extraction sockets

Prevention – see Chapter 27

10 days). The management of such dehiscence is often done by using topical application or rinses of chlorhexidine. If the follow-up indicates a risk of infection, an antibiotic regimen and/or resuturing may be considered.

Ecchymosis and hematoma

These complications are not infrequent and occur in about 24% of surgical sites (Goodacre *et al.*, 2003). They can be reduced with careful soft tissue management and by avoiding high vertical releasing incisions. Skin discoloration usually appears after 1–2 days and disappears in 2–3 weeks.

Neurosensory dysfunctions

Anesthesia, hypoesthesia, hyperesthesia, paresthesia or dysesthesia may occur after dental implant placement and must be managed (Box 48.3). These dysfunctions are the consequences of injury to the branches of the mandibular nerve, which include the following.

Box 48.3 Management of neurosensory dysfunctions

- In cases where perioperative or postoperative radiographs indicate a violation of anatomical structures that contain a branch of the mandibular nerve, the *implant must be removed* and replaced, if possible, by a shorter implant.
- If the patient suffers paresthesia and the implants are correctly located, with no evidence of damage to the inferior alveolar nerve, it is recommended to *wait for recovery*. Return to normal sensitivity may take from 5 weeks to 10 months.
- The level of neurosensory dysfunction *must be documented* during follow-up.

The lingual nerve

This can be damaged by careless elevation of lingual flaps, by excessive flap reflection or by the use of lingual vertical releasing incisions.

The inferior alveolar nerve

This may be definitively damaged if the mandibular canal is violated. If the apical part of the dental implant is too close to the mandibular canal, the subsequent pressure due to the apical hematoma may induce a reversible neurosensory dysfunction (Fig. 48.1).

The mental nerve

Damage may induce neurosensory alterations in the chin and lower lip. The best way to prevent injury of the mental nerve is to display the mental foramen and to visualize the nerve.

Rare complications

Nowadays, most of these can be easily avoided.

Mandibular fractures

This infrequent perioperative or postoperative complication has been described. Dental implant placement in atrophic mandible must be atraumatic and requires a minimum bone volume of be at least 7 mm height and 6 mm width (Park & Wang, 2005).

Damage of the adjacent teeth

This surgical error can be easily avoided by respecting the parallelism of the dental implant with the neighboring tooth.

Drill fracture within the implant bed

Disposable drills must be used to avoid this problem. When it occurs, the broken instrument must be removed by using a surgical trepan with a wider diameter.

Displacement of the implant into the maxillary sinus cavity

This can accidentally happen during surgery or in the postoperative period. In either case, the implant must be removed by creating a window into the sinus.

Key points

- Surgical complications are infrequent.
- Some surgical complications are rare.
- Most surgical complications can be prevented.

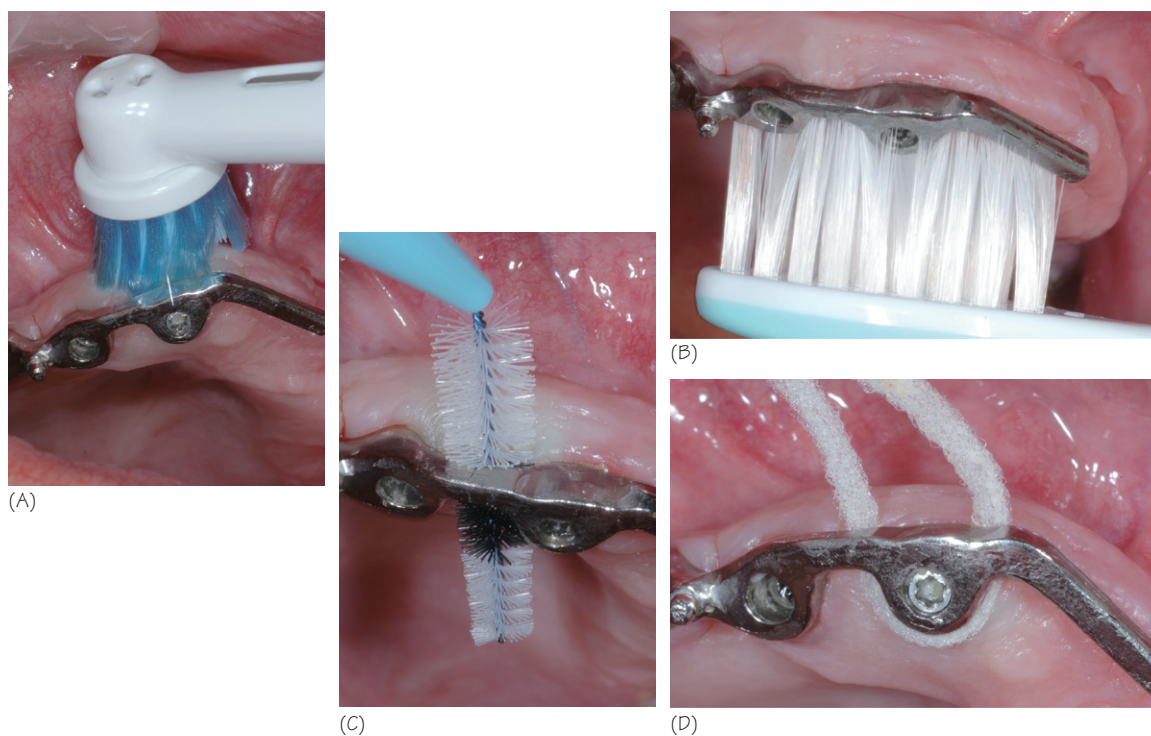


Figure 49.1 Materials for individual plaque control around dental implants. (A) Powered toothbrush. (B) Soft sulcular toothbrush. (C) Interproximal brush. (D) Special floss.

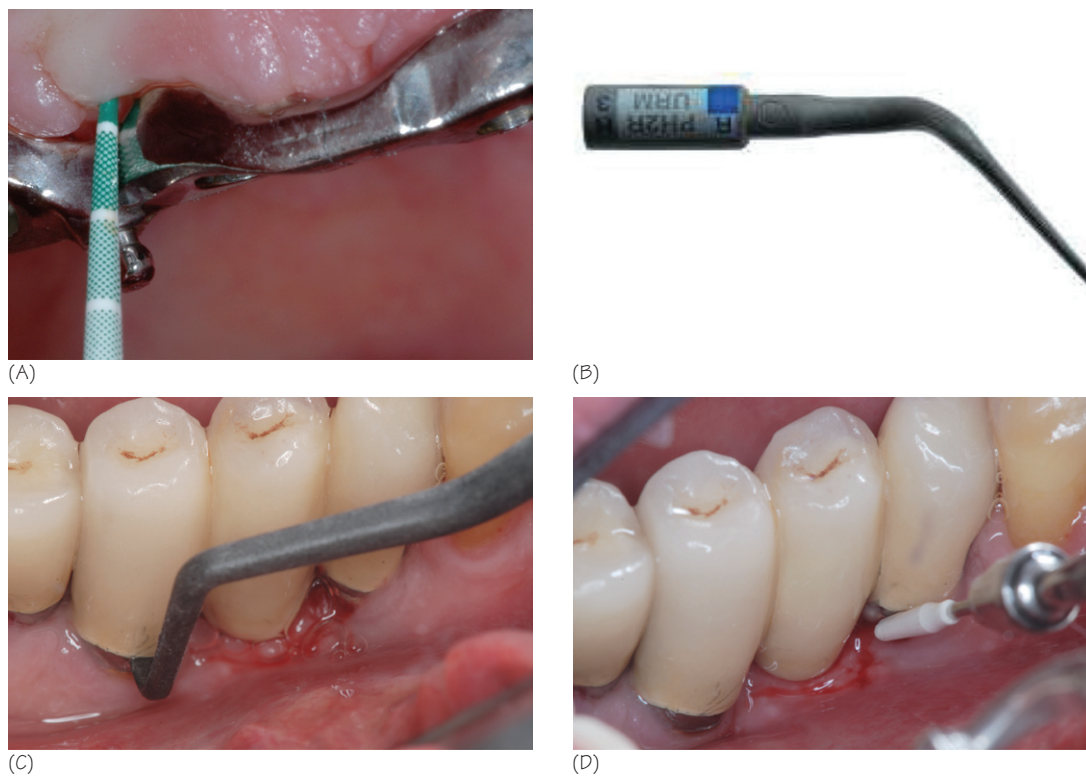


Figure 49.2 Materials for professional plaque control around dental implants. (A) Plastic periodontal probe for peri-implant probing. (B) Graphite tip scaler for sonic scalers. (C) Graphite implant scalers. (D) Plastic tip scaler for sonic scalers.

One of the key factors in the long-term success of oral implants is the maintenance of healthy tissues around them. Besides the maintenance of the prosthesis, patients who have experienced the benefits of implant dentistry must be enrolled in a systematic individualized supportive care program, alternating visitations between the surgeon and the restorative dentist, to maintain the health of the peri-implant tissues. They must be informed of this before implant placement (see Appendix E).

Rationale for plaque elimination around dental implants

Experimental and human studies have shown that long-standing plaque accumulation around dental implants induces inflammatory changes in the soft tissues that increase the risk of peri-implant diseases (Schou *et al.*, 1993; Pontoriero *et al.*, 1994). Consequently, one of the key factors for the long-term success of dental implants is the maintenance of healthy tissues around them (Esposito *et al.*, 2010). However, there is no reliable evidence as to which regimens are most effective for long-term maintenance.

The development of peri-implant diseases is associated with an increase of bacterial species, such as *P. gingivalis*, *T. forsythia*, and *A. actinomycetemcomitans*, which are involved in the pathogenesis of periodontal diseases (Heitz-Mayfield & Lang, 2010). Therefore, it is not surprising that the prevention of peri-implant diseases is similar to the prevention of periodontal diseases and may include daily implant cleaning techniques by patients and regular cleaning by dental professionals.

Individual plaque control (Fig. 49.1)

At baseline, at the time of prosthesis insertion, the patient must be informed about how to carry out individual plaque control procedures. Powered toothbrushes or soft sulcular toothbrushes are primary plaque control devices; they are both effective in reducing plaque and marginal bleeding around implant-supported reconstructions. There is no evidence that powered toothbrushes perform better than manual toothbrushes.

The design of the implant-supported prosthesis must allow access for individual and professional plaque control to prevent inflammation

in the peri-implant tissues. Depending on the design of the prosthetic reconstruction, different types of toothbrushes and/or floss should be used. Gauze strips, yarn, thicker dental floss or dental tape can also assist with plaque control. An interproximal brush is indicated when embrasure space permits (wire center coated with plastic or nylon). For smaller spaces, an end-tuft brush may be a convenient device.

Daily use of triclosan or stannous fluoride dentifrices is safe after dental implant placement.

Antibacterial mouth rinses, such as chlorhexidine or fluoride/stannous fluoride mouthwash, can help reduce plaque around dental implants.

Professional plaque control (Fig. 49.2)

The recall frequency for follow-up of implant-treated patients should be adapted to individual risk factors. A maintenance appointment once a year may be sufficient when patients are free of risk, and compliant with dental hygiene procedures.

During the maintenance appointment, the dentist or dental hygienist should remove calculus, bacterial plaque, and staining. Cleaning is accomplished with implant-safe instruments: plastic (not very efficient), graphite (fragile and brittle), titanium, and gold-tipped cures. An ultrasonic tip may only be used with a plastic covering that prevents damages to the implant surface. The visible portion of the implant, if any, can be polished with rubber cups and non-abrasive polishing paste.

Numerous local antibacterial agents that can be professionally administered have been proposed to maintain soft tissue health. There is no reliable evidence to recommend their use for long-term maintenance in the absence of peri-implant pathology.

Key points

- The maintenance of peri-implant soft tissue health is a key factor for long-term success.
- The prevention of peri-implant diseases is similar to the prevention of periodontal diseases.

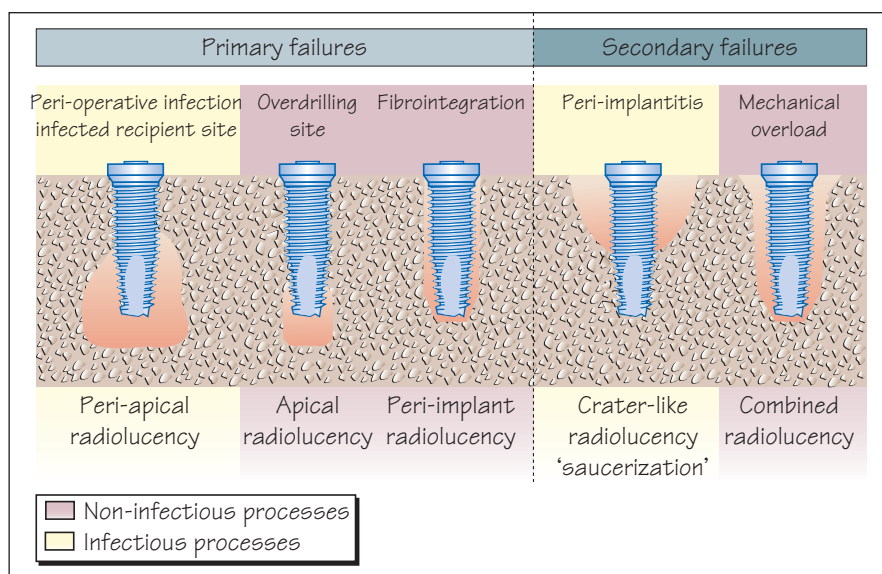
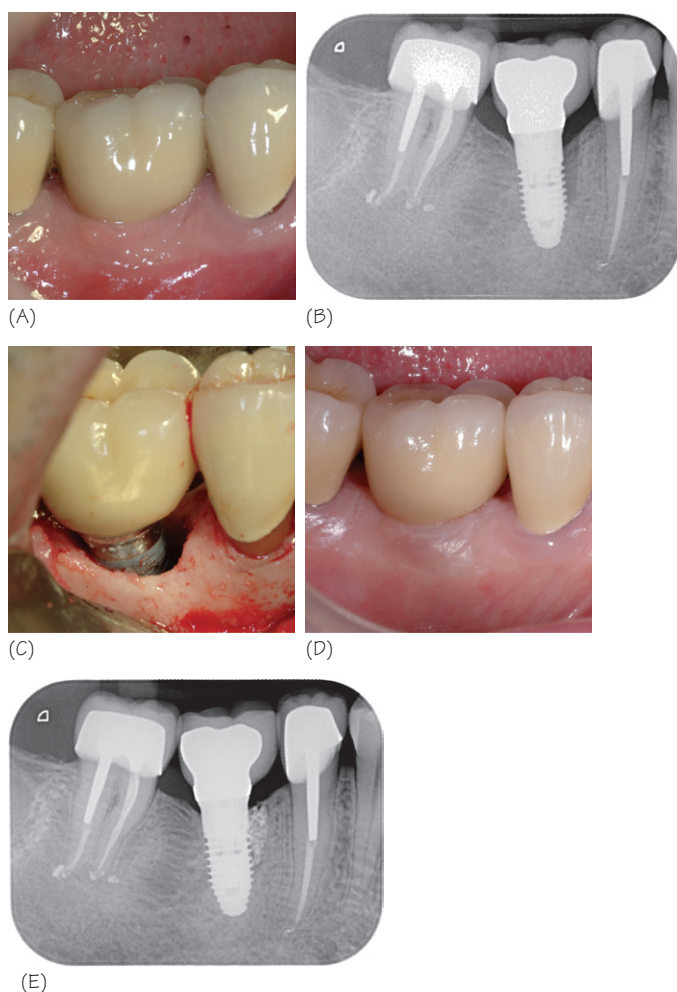


Figure 50.1 Radiographic interpretation of bone loss around dental implants.



Box 50.1 Clinical parameters recorded at baseline evaluation and routinely used to longitudinally assess peri-implant condition

- Plaque assessment
- Soft tissue conditions
 - Bleeding on probing (dichotomic measurement)
- Probing depth
 - Light forces (0.2–0.25 N)
- Suppuration
- Implant mobility
- Radiographic evaluation
 - Long-cone paralleling technique
 - At 1 year follow-up, then adapted to individual clinical assessment

Figure 50.2 Localized peri-implantitis: surgical procedure. (A) Preoperative view. (B) Preoperative radiography. (C) Perioperative view. Note the bone defect morphology, which is characteristic of peri-implant defects. (D) One-year postoperative view. (E) One-year postoperative radiography.

Animal studies have shown that excessive mechanical load does not result *per se* in marginal bone loss in the presence of healthy peri-implant mucosal tissues (Heitz-Mayfield *et al.*, 2004), but can rather lead to loss of osseointegration (Isidor, 1996, 1997). In contrast, in the absence of mechanical stress, dental plaque accumulation may lead to marginal peri-implant bone loss and ultimately to dental implant loss. The pathological process may also be initiated by iatrogenic conditions that can lead to plaque accumulation, such as excess cement remnants, overcontouring restorations, implant malpositioning, technical complications, and inadequate restoration seating. Thus, plaque-induced peri-implant diseases can develop and need to be prevented.

Diagnostic parameters

Systematic monitoring of peri-implant tissues is recommended over time (Lang *et al.*, 2004). Clinical parameters can be easily used to assess peri-implant condition (Box 50.1). The follow-up measurements must be compared to baseline values at the time of prosthesis placement (end-of-treatment appraisal).

Under healthy conditions the peri-implant probing depth ranges from 2 to 4 mm. However, deeper baseline values may be found, specifically in areas where soft tissue augmentations have been required for esthetic reasons.

Radiographs are essential, (1) to verify the lack of complications during the bone healing process, (2) to better understand the reasons for the pathological condition, and (3) for follow-up of the peri-implant bone level. A radiographic interpretation of the failures may be convenient in clinical practice (Fig. 50.1). There is no evidence for specific scheduling of radiographic monitoring. However, the association of BOP and increased PD over time at a probing site indicates that a radiograph is mandatory.

Dental implant mobility indicates the loss of osseointegration, and consequently has no predictive value. There is no treatment for implant mobility except explantation.

Other parameters, such as analysis of peri-implant sulcus fluid, microbiological evaluation of the peri-implant pocket or evaluation of the implant stability by resonance frequency analysis, are currently of little help in routine practice.

Peri-implant mucositis

The clinical characteristics are similar to those of gingivitis. If left untreated, it may lead to peri-implantitis (Mombelli, 1999). BOP, as a surrogate variable of peri-implant mucositis, seems highly prevalent around dental implants (73–90%). Limited evidence indicates that mucositis is a reversible process.

Box 50.2 Guidelines for the treatment of peri-implant diseases

Peri-implant mucositis

Non-surgical therapy

- Mechanical debridement
- Polishing
- Antiseptics

Peri-implantitis

- Non-surgical therapy + local antibiotics
- Surgical therapy + systemic antibiotics

Peri-implantitis

Peri-implantitis is infectious by nature, and pus is a common finding in peri-implantitis sites. The occurrence of peri-implantitis is not rare. The prevalence ranges from 25% to 45% (Berglundh *et al.*, 2008).

Patients at risk for implant failure may constitute a specific group. Failures seem concentrated within a small number of patients (Ellegaard *et al.*, 1997; Roos-Jansåker, 2006). An increasing risk of implant loss has been shown in patients who have experienced a previous implant failure (Weyant & Burt, 1993).

Treatments

The microflora associated with peri-implant diseases closely resembles that which is found in chronic periodontitis. Consequently, it is not surprising that peri-implant therapies are based on the available evidence for the treatment of periodontal diseases.

Treatment procedures must be aimed at eliminating the infection to resolve inflammatory lesions in peri-implant tissues. Thus, the initial phase of therapy must always include plaque control procedures.

The following main treatments, alone or combined, have been proposed to treat peri-implant diseases in humans (Box 50.3).

Box 50.3 Standard surgical protocols based on the personal opinion and clinical experience of the authors

Open flap debridement

Granulation tissue removal

- Titanium curets in contact with the bone surface and not with the implant surface¹
- Ultrasonic with carbon fiber tip
- Implant surface smoothing (optional)
- Elimination of threads and roughness with carbide burs
- Thorough rinsing with saline for 1 minute
- Decontamination of the implant surface
- Tetracycline hydrochloride (50 mg/ml) burnished into the implant surface with small pieces of gauze for 5 minutes
- Thorough rinsing with saline for 1 minute
- Treatment of the bone surface
- Perforation of the cortical bone
- Osteoplasty

Additional regenerative surgery²

- Bone-derived xenograft (Bio-Oss® 0.25–1 mm particles) moistened with saline³

Antimicrobial regimen⁴

- Amoxicillin per os 1000 mg twice a day for 7 days
- Chlorhexidine rinses TID for 10 days

¹Manual plastic scalers are not efficient to remove the granulation tissue.

²Animal studies indicate that re-osseointegration is partially possible but unpredictable on a previously contaminated implant surface (Renvert *et al.*, 2009). This may justify a surgical regenerative approach. However, the decision is left to the personal experience of the surgeon.

³Resorbable membranes (Bio-Gide®) can be used to cover the bone substitute. However, membranes need to be submerged beneath the flap. This implies the removal of the prosthesis.

⁴Prescribed after open flap debridement and regenerative surgery.

Mechanical debridement and polishing

- Manual with plastic scalers
- Ultrasonic with carbon fibre tip
- Polishing:
 - Rubber cup with toothpaste or polishing paste
 - Airpolishing with sodium bicarbonate or hydroxyapatite particles

Laser beam

Er:YAG laser.

Pharmaceutical therapy

- Local antiseptics:
 - Mouth rinses
 - Subgingival irrigation with 0.2% chlorhexidine irrigation/gel
 - Chlorhexidine chips
- Local antibiotics:
 - Subgingival injection of metronidazole gel 25%
 - Subgingival injection of doxycycline gel 8.5%
 - Rubbing a tetracycline hydrochloride solution onto the implant surface
- Systemic antibiotics: amoxicillin 50 mg/kg/day for 8 days per os

Surgical procedures (OFD) (Fig. 50.2)

The surgeon must evaluate the percentage of success of a surgical reintervention because the risk of recurrence of peri-implantitis appears to be high after 1 year (Esposito *et al.*, 2010).

- Granulation tissue removal
- Implant surface smoothening
- Decontamination of the implant surface using antibacterial agents or laser beam

- Correction of the anatomical conditions by osteoplasty
- Regeneration of the surrounding bone using different materials:
 - Nanocrystalline hydroxyapatite
 - Bovine-derived xenograft
 - Resorbable membrane

Summary

It is not known which therapeutic approach is best. Consequently, peri-implant treatment protocols are mostly based on expert opinion. However, the differences between peri-implant mucositis and peri-implantitis must be considered in the selection of strategies for treatment of the disease (Box 50.2).

Decision-making approaches using relevant predetermined protocols and decision trees have been proposed but program-based therapies based on strong evidence are still lacking. In light of the current literature, guidelines should be proposed for the treatment of peri-implant diseases (Box 50.3).

Key points

- Systematic monitoring of peri-implant tissues is recommended to prevent peri-implant pathologies. Once a year seems reasonable.
- A follow-up regime with more frequent controls than usual is recommended for patients at risk for peri-implant diseases.
- Radiographic evaluation, BOP, and PD are adequate parameters, when used together, for early detection of peri-implant pathologies.
- The initial phase of therapy must always include plaque control procedures.

Appendix A: Glossary

Allograft (adjective, allogeneic): living tissue transferred between two genetically different individuals of the same species (Stevenson, 1999).

Autograft (adjective, autogenous or autogeneic): a graft moved from one site to another within the same individual.

Bioactive: refers to a material that induces specific biological activity, as opposed to bioinert (Williams, 1987).

Combined tooth/implant-supported prosthesis: non-removable (fixed) prosthetic device, which is tooth and implant supported.

Conventional loading: implants are functional 2 months or more following implantation.

Delayed implantation: *Syn.: early implantation with partial bone healing*: Implant placement at least 2 months after tooth extraction.

Dental implant: in a general sense, a biomedical device usually composed of an inert metal or metallic alloy that is surgically placed (implanted) on or within the osseous tissues. Nowadays, the biomedical device refers to a titanium threaded root-form osseointegrated implant that is placed within the bone. *Syn.: oral implant, fixture, implant, osseointegrated implants*.

Denture: removable prosthetic device, which is supported by soft tissue only, or by soft tissue and roots remaining in the jaw bone if present.

Early loading: implants are functional between 1 week and 2 months following implantation.

End-of-treatment appraisal: critical appraisal of the outcome at the time of prosthesis placement. The recording measurements include BOP, PD, radiographic, and esthetic evaluation. *Syn.: baseline evaluation*.

Immediate-delayed implantation: any implant placed in an extraction socket within 8 weeks after tooth extraction. *Syn.: early implantation with soft tissue healing*.

Immediate implantation: implant placement within the extraction socket at the time of the extraction.

Immediate loading: implants are functional within 1 week following implantation.

Implant: non-viable material, such as bone that has been frozen, freeze-dried, or sterilized by irradiation (Urist, 1980; Burwell, 1994).

Implant failure: the dental implant and the prosthetic reconstruction, if any, cannot be used or are no longer present in the mouth of the patient. *Syn.: implant loss*.

Implant restoration: dental prosthesis attached to the implant by means of components (American Academy of Periodontology, 2000) *Syn.: implant reconstruction*.

Implant-supported prosthesis: removable or non-removable (fixed) prosthetic device, which is implant supported.

Late implantation: implant placement after complete bone healing of the extraction site.

Osseointegration: a process whereby clinically asymptomatic rigid fixation of alloplastic materials is achieved, and maintained, in bone

during functional loading (Albrektsson & Johansson, 2001). The stable anchorage of a dental implant is achieved by direct bone-to-implant contact (Brånemark *et al.*, 1977).

Osteoconduction: the process by which bone grows to a surface (Albrektsson & Johansson, 2001). This phenomenon is regularly seen in the case of bone implants. In the case of dental implants, bone conduction is not only dependent on conditions for bone repair, but also on the biomaterial used and its reactions.

Osteogenesis: in a general sense, osteogenesis refers to bone formation with no indication of cellular origin; new bone may originate from live cells in the graft or cells of host origin (Stevenson, 1999). In a stricter and more commonly used definition, osteogenesis refers to bone formation by transplanted living cells (Mulliken *et al.*, 1984; Fitch *et al.*, 1997).

Osteoinduction: the process by which osteogenesis is induced (Albrektsson & Johansson, 2001). It implies the recruitment of primitive, undifferentiated and pluripotent cells, and the stimulation of these cells to develop into preosteoblasts. It involves the participation of tissue factors.

Osteoproduction: bone proliferation resulting from the combined properties (i.e. osteoinductive, osteoconductive, and/or osteogenic properties) of a grafting material.

Overdenture: removable or non-removable prosthetic device with a denture design, which is supported by dental implants only, or by soft tissues and dental implants.

Peri-implant diseases: inflammatory processes that involve the soft tissues and/or the bone surrounding a functioning dental implant.

Peri-implant mucositis: reversible plaque-induced inflammatory process of the peri-implant soft tissues without appreciable bone loss (Salvi & Lang, 2004; Grusovin *et al.*, 2010).

Peri-implantitis: plaque-induced inflammatory process of the peri-implant tissues characterized by localized marginal bone loss with or without soft tissue complications (Salvi & Lang, 2004; Esposito *et al.*, 2010).

Primary stability: absence of implant mobility immediately after the final tightening of the implant at the time of surgery. It can be evaluated by subjective hand-felt perception and/or by insertion torque.

Prosthetic failure: the reconstruction cannot be used or is no longer present in the mouth of the patient.

Removable prosthesis: prosthetic device that can be removed by the patient without the aid of a professional.

Secondary stability: absence of implant mobility after the healing phase. It can be evaluated by subjective hand-felt perception and/or by resonance frequency analysis.

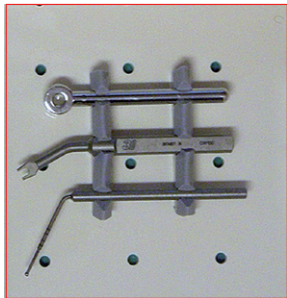
Teeth-retained prosthesis: removable or non-removable (fixed) prosthetic device, which is tooth supported.

Xenograft (adjective, xenogeneic): transfer of viable tissue from a donor of a different species.

References

- American Academy of Periodontology. Parameter on placement and management of the dental implant. *J Periodontol* 2000;71(5 Suppl):870–872.
- Brånemark PI, Hansson BO, Adell R et al. Osseointegrated titanium implants in the treatment of the edentulous jaw. *Scand J Plast Reconstr Surg* 1977;11(Suppl 16):1–175.
- Burwell RG. History of bone grafting and bone substitutes with special reference to osteogenic induction. In: Urist MR, O'Connor BT, Burwell RG, editors. *Bone Grafts, Derivatives and Substitutes*. Cambridge: Butterworth-Heinemann, 1994, pp.1–102.
- Esposito M, Grusovin MG, Tzanetia E, Piattelli A, Worthington HV. Interventions for replacing missing teeth: treatment of perimplantitis. *Cochrane Database Syst Rev* 2010;6:CD004970.
- Fitch R, Kerwin S, Newman-Gage H, Sinibaldi KR. Bone autografts and allografts in dogs. *Comp Cont Ed Pract Vet* 1997;19(5):558–578.
- Grusovin MG, Coulthard P, Worthington HV, George P, Esposito M. Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants. *Cochrane Database Syst Rev* 2010;8:CD003069.
- Mulliken JB, Kaban LB, Glowacki J. Current research review – induced osteogenesis – the biological concept and clinical applications. *J Surg Res* 1984;37:487–496.
- Salvi GE, Lang NP. Diagnostic parameters for monitoring peri-implant conditions. *Int J Oral Maxillofac Implants* 2004;19(Suppl):116–127.
- Stevenson S. Biology of bone grafts. *Orthop Clin North Am* 1999;30(4):543–551.
- Urist MR. Bone transplants and implants. In: Urist MR, editor. *Fundamental and Clinical Bone Physiology*. Philadelphia: Lippincott, 1980, pp.331–368.
- Williams DF. *Definitions in Biomaterials*. Progress in Biomedical Engineering. Amsterdam: Elsevier, 1987.

Appendix B: Basic surgical table and instrumentation



Irrigation



Anesthesia



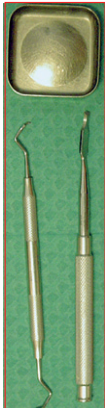
Incision



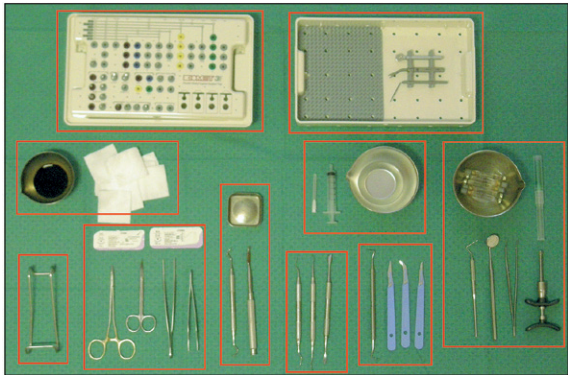
Elevation



Bone scraping



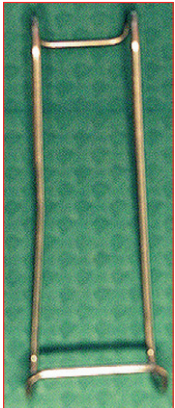
Implant placement



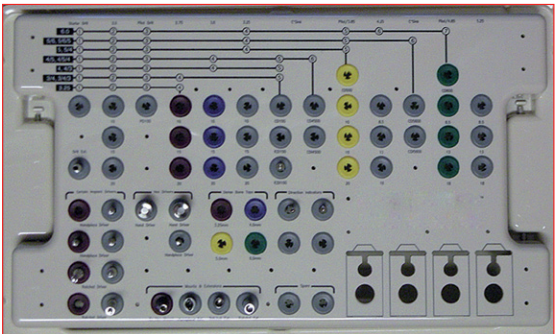
Suturing



Retraction



Scrubbing



Appendix C: Preparation of the members of the sterile team



Appendix D: Medical history form

Patient's copy

Your answers on this form will help your surgeon understand your medical concerns and conditions better. If you are uncomfortable with any question, do not answer it. If you cannot remember specific details, please provide your best guess.

Name: _____	Date: <input type="checkbox"/> Day <input type="checkbox"/> Month <input type="checkbox"/> Year
Occupation: _____	Retired <input type="checkbox"/>
Live with: <input type="checkbox"/> Parents <input type="checkbox"/> Children <input type="checkbox"/> Friends <input type="checkbox"/> Spouse/Partner <input type="checkbox"/> Alone	
Person to notify in case of emergency: _____ Phone _____	

How would you rate your general health? <input type="checkbox"/> Excellent <input type="checkbox"/> Good <input type="checkbox"/> Fair <input type="checkbox"/> Poor <input type="checkbox"/> Don't know
--

Main reason for your visit? _____ Other concerns: _____
--

Last medical check-up: <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Don't Know
Last blood tests: <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Don't Know

Are you or have you been treated for a cancer?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know
Have you had an organ transplant?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know
Do you have prosthetic material in your body?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know
If yes, what type of prosthetic material do you have? <input type="checkbox"/> Artificial heart valves <input type="checkbox"/> Pacemaker <input type="checkbox"/> Artificial joints <input type="checkbox"/> Other	

Are you nervous or anxious about implant surgery?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know
If yes, would you say that your anxiety is:	<input type="checkbox"/> Very high <input type="checkbox"/> High <input type="checkbox"/> Mild
If yes, could you say why? _____ _____ _____	

Medical status

For women: <input type="checkbox"/> Pregnant <input type="checkbox"/> Planning pregnancy <input type="checkbox"/> Nursing <input type="checkbox"/> Birth control pills <input type="checkbox"/> IUD <input type="checkbox"/> Menopause Do you have hormonal therapy? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know
--

I am not aware of any current or past medical condition or any disease that could be applicable to me. I am healthy and having read the contents of the box below, I am able to answer “no” to each item.

Name:

Signature:

Please check the following in the box below, and indicate if it is a current or a past condition (if applicable).

Genetic Disease

☐ Yes ☐ No ☐ Don't know

If yes, what type of genetic disease do you have?.....

Heart and Vascular Diseases ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of heart and vascular diseases do you have?

☐ Rheumatic fever ☐ Heart murmur ☐ Mitral valve prolapse

☐ Chest pain/angina ☐ Heart attack(s) ☐ Stroke ☐ Other ☐ Don't know

If other, what type of cardiovascular disease do you have?.....

Bleeding Disorder ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of bleeding disorder do you have?

☐ Hemophilia ☐ Anemia ☐ Leukemia ☐ Other ☐ Don't know

If other, what type of bleeding disorder do you have?.....

High Blood Pressure ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, are you treated for this high blood pressure? ☐ Yes ☐ No ☐ Don't know

Cancer ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of cancer do you have?.....

What type of treatment do you have? ☐ Chemotherapy ☐ Radiation treatment ☐ Other ☐ Don't know

If you have radiation treatment, is it to head/neck? ☐ Yes ☐ No ☐ Don't know

If other, what type of treatment do you have?.....

Kidney Disease ☐ Yes ☐ No ☐ don't know ☐ Current ☐ Past

If yes, what type of disease do you have?.....

Are you on dialysis? ☐ Yes ☐ No ☐ Don't know

Liver Disease ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of liver disease do you have? ☐ Hepatitis ☐ Cirrhosis ☐ Other ☐ Don't know

If other, what type of liver disease do you have?.....

Diabetes ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of diabetes do you have?.....

If yes, how is your diabetes controlled?

☐ Well controlled ☐ Poorly controlled ☐ Not controlled ☐ Don't know

If yes, do you have complications? ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of complication?.....

Bone Disease ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of bone disease do you have?

☐ Osteoporosis ☐ Rheumatoid arthritis ☐ Paget's disease ☐ Arthritis ☐ Other ☐ Don't know

If other, what type of bone disease do you have?.....

Transmissible Disease ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of transmissible disease do you have?

☐ AIDS/HIV positive ☐ Tuberculosis ☐ Venereal disease ☐ Other ☐ Don't know

If other, what type of transmissible disease do you have?.....

Respiratory Disease ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of respiratory disease do you have?

☐ Lung disease ☐ Emphysema ☐ Shortness of breath ☐ Asthma ☐ Sleep apnea ☐ Other ☐ Don't know

If other, what type of respiratory disease do you have?.....

Sinus Trouble ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of sinus trouble do you have?.....

Have you been operated for sinus trouble? ☐ Yes ☐ No ☐

If yes, what type of operation have you had?.....

Stomach Disease ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of stomach disease do you have?

☐ Reflux ☐ Ulcer ☐ Crohn's disease ☐ Other ☐ Don't know

If other, what type of stomach disease do you have?.....

Skin Disease ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of skin disease do you have?

☐ Scleroderma ☐ Lichen planus ☐ Ectodermal dysplasia ☐ Arthritis ☐ Other ☐ Don't know

If other, what type of skin disease do you have?.....

Psychiatric/Neurological Disorders ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, what type of disorder do you have?

☐ Depression ☐ Epilepsy/seizures ☐ Convulsions ☐ Parkinson's disease ☐ Other ☐ Don't know

If other, what type of disorder do you have?.....

Miscellaneous ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

Do you have the following condition?

☐ Eating disorder ☐ Sjögren's disease ☐ Lupus ☐ Thyroid disease ☐ Glaucoma ☐ Other ☐ Don't know

Do you have any disease or condition that has not been listed so far?

☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, please detail:

.....
.....
.....
.....
.....

Medication intake

Do you take the following medications?

Bisphosphonates ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If past, when did you stop the bisphosphonates?.....

If yes, why do you take bisphosphonates?.....

If yes, do you take the bisphosphonates by ☐ Pills ☐ Injections ☐ Don't know

Anticoagulants ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, why do you take anticoagulants?.....

Aspirin ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, why do you take aspirin?.....

Steroids of any type ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, why do you take steroids?.....

Please **list all the current medications you take** (including appetite suppressants, vitamins, herbal supplements, or any homeopathic medication):

MEDICATION	DOSAGE	FREQUENCY	MEDICATION	DOSAGE	FREQUENCY

Allergies

Please check the following in the box below, and indicate if it is a current or a past condition (if applicable).

Do you have or have you had in the past any **allergies and/or sensitivities** to the following substances?

Antibiotics ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, indicate if possible the type of antibiotic:.....

Local anesthetics ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, indicate if you can the type of anesthetics:.....

Latex ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

Other ☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, indicate if you can the type of substance:.....

Personal behavior

Please check the following in the box below, and indicate if it is a current or a past condition (if applicable).

Cigarette Smoking ☐ Never smoker ☐ Current smoker ☐ Former smoker ☐ Passive smoker

Current smoker: number of cigarettes per day? ☐ Number of years ☐

Former smoker: number of cigarettes per day? ☐ Number of years ☐ Quit date

Passive smoker: Number of years ☐

Other Tobacco Use ☐ Cigar ☐ Pipe ☐ Snuff ☐ Chew

Consumption (number per day):

Are you interested in quitting? ☐ Yes ☐ No ☐ Don't know

Alcohol Use ☐ Yes ☐ No ☐ Former drinker

If yes, indicate the number of glasses per week: ☐ Wine ☐ Beer ☐ Aperitif ☐ Other

If yes, is your alcohol use a concern for you and/or others? ☐ Yes ☐ No ☐ Don't know

Drug Use ☐ Yes ☐ No ☐ Former drug user

Any other habit or behavior that you consider as an addiction (please detail)?

.....

Surgical history

Previous dental treatment

Have you had any previous local anesthesia for a dental treatment?

☐ Yes ☐ No ☐ Don't know ☐ Current ☐ Past

If yes, have you had any abnormal reaction following this anesthesia? ☐ Yes ☐ No

If yes, indicate the type of reaction:.....

Indicate when you experienced this reaction: ☐ Year

Please list all **previous hospitalization/operations**, including cosmetic, in the **last 5 years** (details)

YEAR	DESCRIPTION	COMPLICATION (if any)

In your opinion, is there any additional information on your health state that would be of interest to the surgeon? ☐ Yes ☐ No ☐ Don't know

If yes, please detail:

.....
.....
.....
.....
.....

I hereby state that I have answered all of the questions accurately to the best of my knowledge. This form will reveal my complete medical history and assist my surgeon in providing the best care possible. I will not hold the surgeon or the clinic responsible for any errors or omissions that I have made in completing this form.

Signature of patient/parent or guardian if minor

Date ☐ ☐ ☐

Reviewed by: ☐ ☐

Doctor's initials

The information in this document is intended only for the person/persons directly involved with the patients' care and may contain confidential and/or privileged material. Any review, retransmission, dissemination or other use of or taking of any action in reliance upon this information by persons or entities other than the intended care provider is prohibited by law.

Appendix E: Consent form for dental implant surgery

Please read this form carefully before signing it and ask about anything that you do not understand.

You have the right to be given information about your proposed implant placement so that you are able to make the decision as to whether to proceed with the surgery. What you are being asked to sign is a confirmation that we have discussed the nature and purpose of the treatment, the known risks associated with the treatment, and the feasible treatment alternatives; that you have been given an opportunity to ask questions; that all your questions have been answered in a satisfactory manner.

After a study of my oral condition, the dentist has advised me that my missing tooth/teeth may be replaced with artificial teeth supported by one or more dental implants. The procedure involves placing dental implant into the jawbone. This procedure has two phases: a surgical phase (*placing the dental implants to serve as anchors to replace a missing tooth or teeth*), followed, after a healing phase from 2 to 6 months, by a prosthetic phase (*getting a crown, cap, bridge or denture attached to the dental implant*). **This office only does the surgical phase. I understand that my general dentist or prosthodontist will do the prosthetic phase and that the cost for that work is not included in the charge for the surgical procedure.¹**

Surgical options

We will utilize the options that are best suited for your condition. **The decision is made in agreement with the general dentist or prosthodontist who will do the prosthetic phase.**

One-stage/two-stage

I understand that dental implants may be placed by either a one-stage technique or two-stage technique. One-stage technique requires only one surgery to place the implant and the healing cap. Two-stage surgery requires two surgeries: (1) to place the implant; (2) to uncover the implant and place a healing cap.

Your procedure is intended to be: ☐ One-stage ☐ Two-stage

Immediate loading

In certain unusual circumstances, and with very specific criteria, we may elect to restore some or all of the implants immediately or shortly after the placement procedure. This technique carries some increased concerns about bone and implant healing.

Your dental implants are intended to be:

☐ Normally loaded ☐ Immediately loaded

Temporary dental implants

In certain unusual circumstances, additional special implants may be placed to temporarily anchor a provisional dental restoration while the other dental implants heal. These special implants are usually surgically removed in the final treatment phase.

¹The phrases in blue are optional, according to whether the practitioner performs all the procedures or not.

Your treatment is intended to include temporary implants:

☐ Yes ☐ No

Additional materials and procedures

In certain cases, the surgery may involve gum and/or bone augmentation using bone grafts, artificial bone substitute, and/or healing membranes associated with fixation devices. When planned, these additional procedures are subject to a separate consent form. However, the need for those procedures may not be apparent until after the surgery has begun. Consequently, complete information is given to you before the surgery on the nature of these materials, whether or not they are planned to be used during the surgical procedure.

Your procedure intends to use:

☐ Gingival grafting ☐ Bone grafting ☐ Bone substitute
☐ Healing membrane ☐ Fixation screws ☐ Sinus lift procedures

Anesthesia

I have been informed on a separate consent form of the anesthetic risks.

Initials

The anesthetic I have chosen for my surgery is:

☐ Local ☐ Local with Nitrous Oxide/Oxygen Analgesia
☐ Local with Oral Premedication
☐ Local with Intravenous Sedation ☐ General Anesthesia

Surgical procedure

The gum will be incised (cut) and pulled away to expose the jawbone; a hole or holes will be drilled into the jawbone, and the titanium dental implant screw(s) will be placed within the hole.

One-stage technique

The gum will be closed by sutures around the dental implant neck. Thus, a portion of the dental implant will protrude through the gum at the completion of the surgery, and will remain uncovered during the 2–6-month healing phase.

Two-stage technique

The gum will be closed by sutures over the dental implant, which will probably remain covered by the gum during the 2–6-month healing phase. A second surgical procedure will be required to uncover the top of the dental implant to prepare for the prosthetic phase, which may start 4–5 weeks after.

Whatever the technique, if non-resorbable sutures are used, they will be removed 8–14 days after the surgical procedure.

It has been explained to me that during the course of surgery unforeseen conditions may be revealed that will necessitate extension of the original procedure or a different procedure from that which was planned (for example, changing from a one-stage to a two-stage process, use of bone grafting techniques involving substitute material or locally available particles, etc.). I give my permission for such unforeseen additional procedures, and I authorize the surgeon to do

whatever he/she deems necessary and advisable under the circumstances according to his/her professional judgment.

Initials

Principal risks and complications of the surgery

These include, but are not limited to, the following.

- Postoperative discomfort and swelling that may require several days of at-home recuperation. Prolonged or heavy bleeding that may require additional treatment.
- Skin discoloration may rarely occur after 1–2 days. Discoloration is usually gone in 2–3 weeks.
- Damage to adjacent teeth or roots of adjacent teeth.
- Postoperative infection that may require additional treatment, and possible loss of the implant(s).
- Stretching of the corners of the mouth that may cause cracking and bruising and may heal slowly.
- Restricted mouth opening for several days. Sometimes related to swelling and muscle soreness and sometimes related to stress on the jaw joints.
- Injury to sensory nerve branches in the jaw or soft tissue resulting in tingling, numbness, or pain in the chin, lips, cheek, gums, tongue (including possible loss of taste sensation) or teeth on the operated side(s). These symptoms usually persist for several weeks or months, and in some cases may be permanent.
- Opening into the sinus (a normal hollow chamber in the bone above the roots of back upper teeth) requiring additional treatment. If the sinus is entered there may be symptoms of sinusitis for several weeks that may require certain medications and additional recovery time.
- Fracture of the jaw or of thin bony plates.
- Bone loss around the implants.
- Certain other fixation devices may be used (screws, plates, membranes, etc.) that may either stay in place permanently or require later removal by another surgery. There may be unexpected exposure of these devices through the gum, causing their premature loss or removal, and possible loss of the implant.
- Implant or prosthesis failure. Rarely, the implant or parts of the structure holding the replacement tooth, or the replacement tooth itself, may fail due to chewing stresses.

No warranty or guarantee

Some patients do not respond successfully to dental implant surgery and in such cases, the implant may be lost. If the implant is lost during the healing phase, it is usually possible to replace it in a later surgery after the bony defect has healed or been bone grafted to achieve adequate bone volume for another implant placement procedure. Should it happen, I understand that a charge will be made for this procedure. It is also always possible to have a successful, solid dental implant and the connection between the implant and the gum and/or bone may fail months or years later, necessitating the removal of the implant.

Therefore, I hereby acknowledge that no guarantee, warranty or assurance has been given to me that the proposed surgery will be completely successful in eliminating all pretreatment symptoms or complaints. I acknowledge that there is the risk of failure, relapse, selective retreatment, or worsening of my present condition, despite efforts at optimal care. In the event of implant failure, there will be no refund of fees.

I understand that once the implant is inserted, the entire treatment plan must be followed and completed on schedule. If the planned schedule is not carried out, the implant(s) may fail.

I understand that my doctor is not a seller of the implant device itself and makes no warranty or guarantee regarding success or failure of the implant or its attachments used in this procedure.

Initials

Alternatives to dental implant(s)

The advantages and disadvantages of possible alternative methods of replacing my missing teeth have been explained to me, including:

- no treatment at all
- keeping, or attempting to improve, my present denture or bridge
- restoring missing teeth with a new standard dental prosthesis such as removable dentures and/or dental bridges.

Finally, after reviewing the pros and cons of the non-implant-based restorations and of the dental implant therapies, I choose to proceed with insertion of the dental implant(s).

Initials

Patient co-operation

I agree and understand that the degree of success of any dental treatment is related to my co-operation. I have read and understood the postsurgical instruction form, and I will be compliant with it. Specifically, I agree, if applicable, not to wear my denture for 1–2 weeks after the surgical procedure according to my surgeon's advice.

I understand that tobacco use is extremely detrimental to the success of dental implant therapy. I agree to make efforts to cease all use of tobacco in view of the surgical procedure and during the healing phase. I also understand that any abuse, including alcohol, drug, and dietary practices, may jeopardize the dental implant success.

I understand that the success of dental implants depends to a great extent on my maintenance and hygiene throughout my mouth and especially around the implant posts where they come through the gum tissue.

I agree to return at regular intervals as specified by the doctor for inspection of my mouth and implant cleansings by the doctor or the hygienist and to have performed such dental services as may be needed to maintain my oral health.

I agree to report immediately any evidence of pain, swelling, or inflammation around my implant(s) and agree to attend the office/hospital if necessary.

Initials

Authorization of use of dental records

I authorize that photographs, X-rays, or other viewing of my care and treatment during its progress may be used for educational purposes and research.

I authorize sending any documents and other information pertaining to my treatment before, during, and after its completion with my insurance carriers, the doctor's billing agency, my general dentist, and any other healthcare provider I may have who may have a need to know about my dental treatment.

Initials

I certify that I have read and fully understand the above informed consent form and that all my questions have been fully answered. I have had the opportunity to take this form and to review it before signing it. I understand and agree that my initial on each page along with my signature below will be considered conclusive proof that I have read and understand the content of this document. I have been informed on the nature of the different materials that can be used during the surgical procedure. I acknowledge that the procedure has been explained to my full understanding, including the number and location of incisions and the type of implant(s) that will be used. Consequently I hereby give my consent to proceed with dental implant

treatment and related surgery, including any ancillary grafting procedures.

Signature of Patient or Guardian Guardian's Relationship to Patient

Surgeon Signature

Witness Signature

Date: _____

Appendix F: Postoperative patient records: stage 1

POSTOPERATIVE RECORD (Stage 1) Contact Clinic									
LAST NAME			First Name				Date of Birth		
Home Address									
Phone		Business		Home		Mobile			
Referred by									
STAGE 1					Date of the Surgery				
Surgeon					Nurse				
Premedication									
Anesthesia		Local		EMONO*		I.V.		General	
Tooth # (implant location)									
Dental Implant	Brand								
	Type								
	Length								
	Diameter								
	Angulation								
	Head								
	Neck								
	Reference								
Immediate Implant	YES								
Loading	Immediate								
	Early								
Submerged	YES								
	NO								
Healing Abutment	Height								
	Diameter								
Bone Resorption	A (Low)								
	B (Moderate)								
	C (Advanced)								
Bone Density	1 (Extreme)								
	2 (High)								
	3 (Moderate)								
	4 (Poor)								
Primary Stability	Good								
	Questionable								
Comments									
Prescription									
POSTOPERATIVE CONTROLS									
Date	Radiographs	Comments							
TRACEABILITY									

Appendix G: Postoperative patient records: stage 2

POSTOPERATIVE RECORD (Stage 2)									
Contact Clinic									
LAST NAME			First name				Date of Birth		
Home Address									
Phone		Business		Home		Mobile			
Referred by									
STAGE 2				Date of the Surgery					
Surgeon					Nurse				
Premedication									
Anesthesia	Local		EMONO*		I.V.		General		
Tooth # (implant location)									
Healing Abutment	Height								
	Diameter								
Secondary Stability	Good								
	Questionable								
Comments									
Prescription									
POSTOPERATIVE CONTROLS									
Date	Radiographs	Comments							
CONTROLS AFTER LOADING									
Date	Radiographs	Comments							

Appendix H: Postoperative instructions

Do not drive on the day of surgery or while taking narcotic pain medication.

Medications

- Do not stop your regular medications prescribed by your physician (for diabetes, high blood pressure, etc.) unless advised to do otherwise.
- Take the medications that have been prescribed by the surgeon (painkillers, antibiotics, etc.), and respect the drug dosage.

Pain

- Pain will be most severe within the first 6–8 hours after the operation. Moderate pain usually does not last longer than 48 hours, and mild discomfort usually diminishes after the third day.
- If the pain seems beyond your tolerance, please call the office.

Healing

- DO NOT DISTURB THE AREA OF SURGERY.
- Do not chew on the surgical area for 10 days.
- Do not brush on the surgical area until the day after surgery.
- Avoid checking the implant with your tongue.
- Smokers must refrain from smoking during healing. Try to avoid smoking completely, for at least 4 days after surgery.

Bleeding

- Minor bleeding or oozing from the operative site is expected. Thus, during the few hours after the surgery, your saliva may be red.
- The best thing for bleeding control is pressure. You can wrap a moistened tea bag (a good blood-clotting agent) in a gauze sponge and gently bite on it. This minor bleeding may continue throughout the first day. Renew the gauze every 30–45 minutes until cessation of bleeding.
- Do not rinse your mouth on the day of the surgery.
- Do not spit. Wipe your mouth with a tissue.

Swelling and bruising

- Mild swelling usually develops, if it does occur, during the first 24–48 hours following surgery. It should begin to subside by the third day.
- Some blue/yellow marks (bruising) may rarely appear on the skin of the face during the first few days after surgery. They will slowly disappear within a week. It is unesthetic but does not jeopardize the outcome of the surgery.
- Swelling and bruising can be minimized a great deal by using an ice pack on the sides of your face, 10 minutes on and 10 minutes off, as often as possible during the first day following the surgery.

Rest

- Limit physical activity during the first 24–48 hours after surgery and avoid strenuous exercise for 1 week. Overexertion may lead to postoperative bleeding and discomfort.

- When you lie down, keep your head elevated on a pillow. You may wish to place a towel on your pillowcase to avoid staining from any blood-tainted saliva.

Diet

- Drink plenty of fluids; cold water, soda, tea or juices are suitable.
- Avoid hot liquids.
- Do not use a straw for 1 week.
- Do not drink alcoholic beverages while taking prescription medication.
- Eat soft, cool foods. They are most easily tolerated. Eating prevents nausea.
- Yogurt with active cultures or acidophilus should be taken while on antibiotics, if applicable, to prevent diarrhea.

Oral hygiene

- You need to brush the area after the first 24 hours with a very soft toothbrush. Be gentle on the stitches. The tooth brushing on the surgical area must be painless. If this is not the case, delay the brushing 1 day more.
- Do not use a syringe or Water Pik®.
- Do not rinse forcefully.

Denture or nightguard

- If you wear a denture or a nightguard, follow the instruction of your surgeon to set the right time for its reinsertion. Insertion of removable dentures too early may jeopardize a successful healing process.
- You can wear your denture or nightguard from

Special Procedures

Special procedures may imply a longer postoperative period, and require special attention in addition to the above recommendations.

Bone grafting

You may find some small granules in your mouth for the first several days. This will not jeopardize the outcome of the surgery.

Sinus grafting

ANYTHING THAT CAUSES PRESSURE IN YOUR NASAL CAVITY MUST BE AVOIDED.

- Do not blow your nose.
- If you must sneeze, do so with your mouth open.
- Scuba diving, flying in pressurized aircraft, playing a wind instrument, blowing up balloons should be avoided.
- You may have some bleeding from the nose. This is not uncommon and should pass quickly. Lie down with your head back, and place cotton in the nostril that is bleeding.

Next appointment

Your next appointment is scheduled on
for suture removal (if applicable) and postoperative evaluation.

Emergency Calls

If bleeding persists or is active; if swelling and/or bruising are
excessive or do not decrease; if you have any postoperative
problem or additional question, call the following phone number
.....

Appendix I: Treatment planning: fully edentulous patient

Table I.1 Prosthetic options according the number of implant, placed in the mandible

Number of implants	Removable option			
	Prosthetic design	Attachment system	Retention	Number of replaced teeth
2	Overdenture	Ball/bar/magnet	Friction/clip/magnetism	All
4	Overdenture	Bar	Clip	All
5	Overdenture	Bar	Clip	All
6	NA	NA	NA	NA
8	NA	NA	NA	NA

Number of implants	Fixed option			
	Prosthetic design	Attachment system	Retention	Number of replaced teeth
2	NA	NA	NA	NA
4	Denture design (tilted implants)	Metal framework	Screw	10
5	Denture design (parallel implants)	Metal framework	Screw	10 to 12
6	Denture/bridge design	Metal framework/ porcelain-fused-to-metal	Screw/screw or cement	10 to 14
8	Bridge design	Porcelain-fused-to-metal	Screw or cement	14

Table I.2 Prosthetic options according the number of implants placed in the maxilla

Number of implants	Removable option			
	Prosthetic design	Attachment system	Retention	Number of replaced teeth
4	Overdenture	Bar	Clips/spring pins/others	All
6	Overdenture	Bar	Clips/spring pins/others	All
8 to 10	NA	NA	NA	NA

Number of implants	Fixed option			
	Prosthetic design	Attachment system	Retention	Number of replaced teeth
4	Denture design (tilted implants)	Metal framework	Screw	10
6	Denture/bridge design	Metal framework/ porcelain-fused-to-metal	Screw/screw or cement	10 to 12
8 to 10	Bridge design	Porcelain-fused-to-metal	Screw or cement	12 to 14

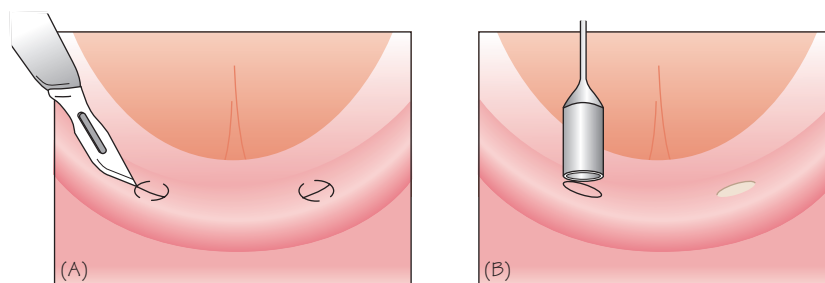
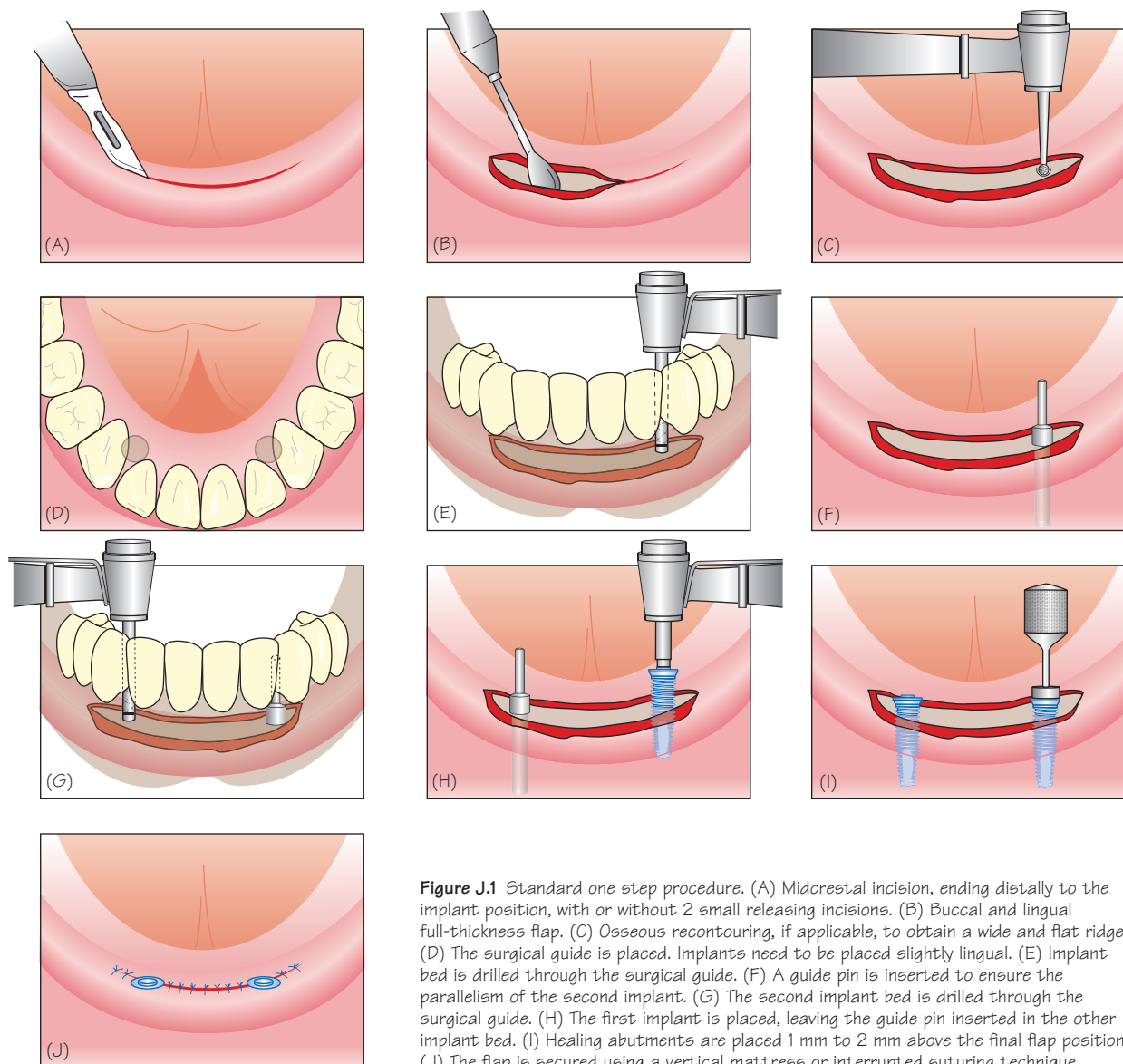
Table 1.3 Advantages/disadvantages of removable overdentures over fixed prosthesis

<ul style="list-style-type: none"> • Advantages <ul style="list-style-type: none"> – Fewer implants – Fewer surgical augmentation procedures – Easier management of esthetics – Easier provisional phase – Easier oral hygiene maintenance – Easier repair – Allow for easier changes to other types of reconstruction – Immediate lower costs 	<ul style="list-style-type: none"> • Disadvantages <ul style="list-style-type: none"> – Removability <ul style="list-style-type: none"> • May not correspond to patient's expectation – Higher space for prosthetic components <ul style="list-style-type: none"> • Specially with bars at the maxilla – Demanding professional maintenance requirement <ul style="list-style-type: none"> • Attachments replacement • Relines • Overdenture replacement due to the wear – Long-term costs
---	---

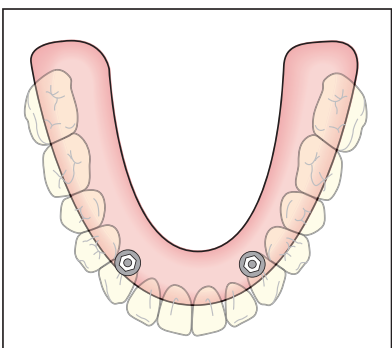
Table 1.4 Advantages and disadvantages of fixed denture design restorations versus fixed bridge design restorations

	Denture design	Bridge design	
	Screw-retained	Screw-retained	Cement-retained
Advantages	<ul style="list-style-type: none"> Can compensate the volume of bone resorption Can be removed for professional maintenance Lower cost 	<ul style="list-style-type: none"> Allow porcelain-fused-to-metal restoration Can be removed for professional maintenance Allow the replacement of all teeth with a minimum of 8 implants 	<ul style="list-style-type: none"> Allow porcelain-fused-to-metal restoration Allow the replacement of all teeth with a minimum of 8 implants Possible psychological advantage
Disadvantages	<ul style="list-style-type: none"> Possible psychological disadvantage 	<ul style="list-style-type: none"> Cannot compensate the volume of bone resorption High cost 	<ul style="list-style-type: none"> Cannot compensate the volume of bone resorption Cannot be removed for professional maintenance High cost

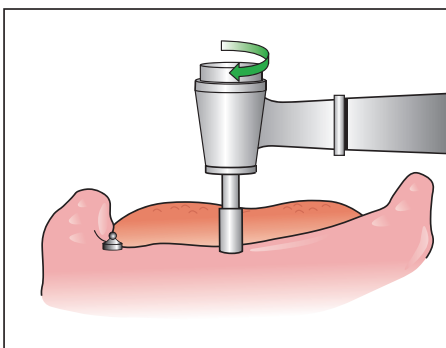
Appendix J: Overdenture supported by two implants: surgical procedure



Appendix K: Overdenture supported by two implants: prosthetic procedure

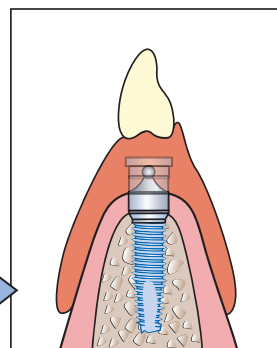


Two dental implants are placed in the canine region

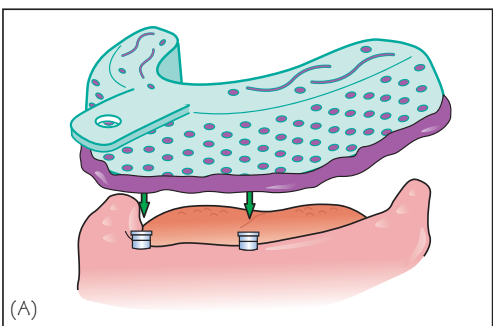


After completion of the osseointegration process, ball abutments are installed

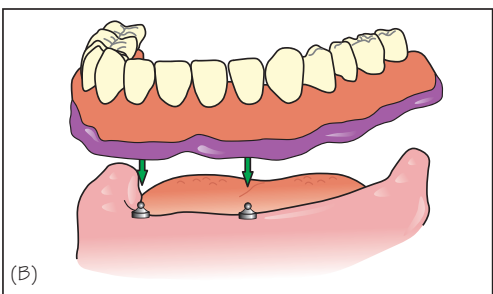
Option 1
Direct processing



The attachment females are fixed into the denture directly in the mouth using cold cure resin



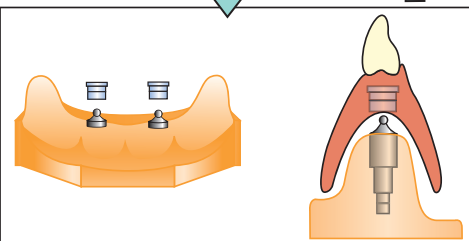
(A)



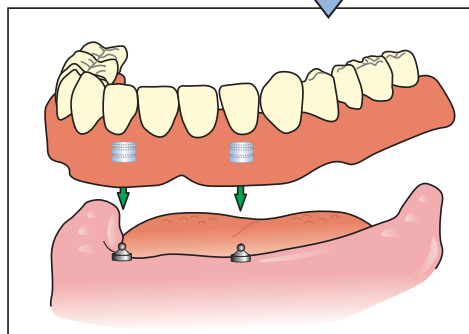
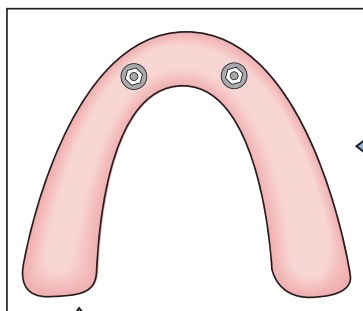
(B)

The impression may be made using a conventional tray (a) or made in occlusion using the existing denture (b). The replicas of attachments are inserted in the impression.

Option 2
Laboratory procedure



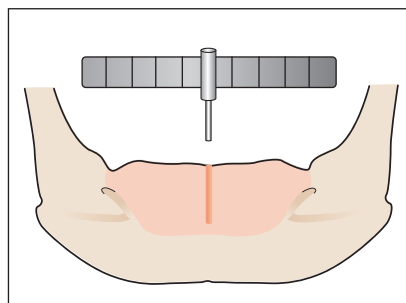
The attachment females are polymerized at the laboratory.



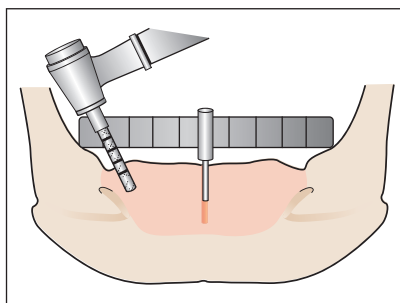
The retention force of attachment is adjusted at the prosthesis delivery.

Appendix L: Fixed prosthesis (mandible) supported by four implants

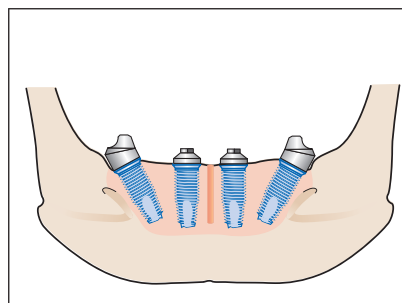
Surgical procedure



(A) after mucoperiosteal flap elevation, an osteotomy is drilled (10x2mm) in the midline and a plant guide is placed.

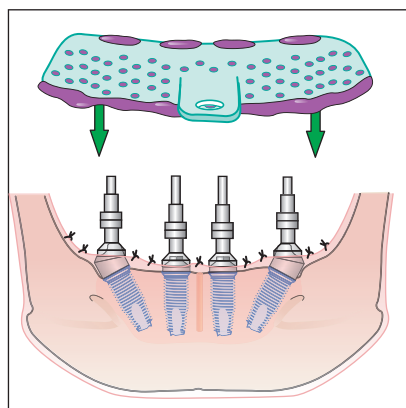


(B) after identification of the mental foraminae, 2 posterior implant beds are prepared (15x2mm; 50 Ncm) and tilted to a maximum angle of 45°. Angulated abutments (30°) are tightened (15 Ncm).

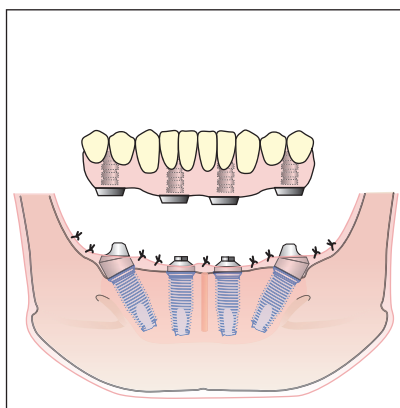


(C) after placement of the 2 posterior implants (15x4mm), 2 parallel anterior implants (10x4mm) are placed. Straight abutments are tightened (15 Ncm).

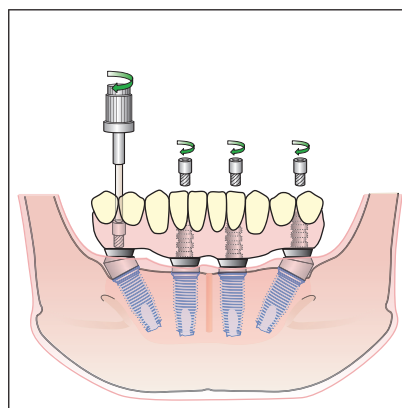
Prosthetic procedure Immediate loading



(D) An impression is taken using silicone soft putty material.

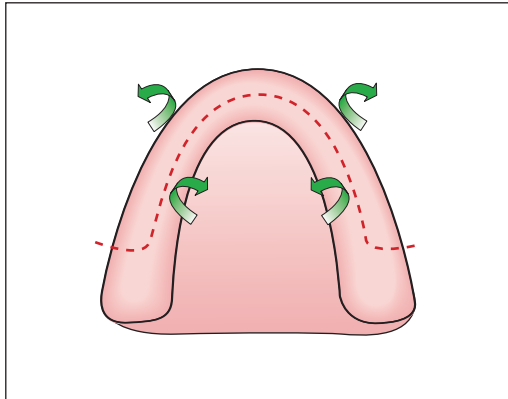


(E) After the laboratory procedure, the all-acrylic provisional restoration is placed in the patient's mouth.



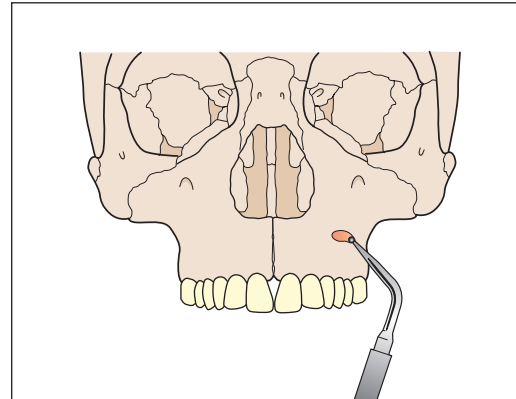
(F) The provisional restoration is connected to the abutments and the occlusion is checked.

Appendix M: Fixed prosthesis (maxilla) supported by four implants

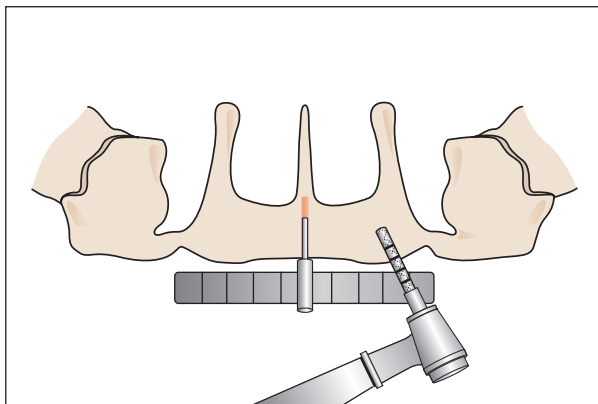


(A) One horizontal incision is made on the crest and two releasing incisions are made distally. Buccal and palatal mucoperiosteal flaps are elevated.

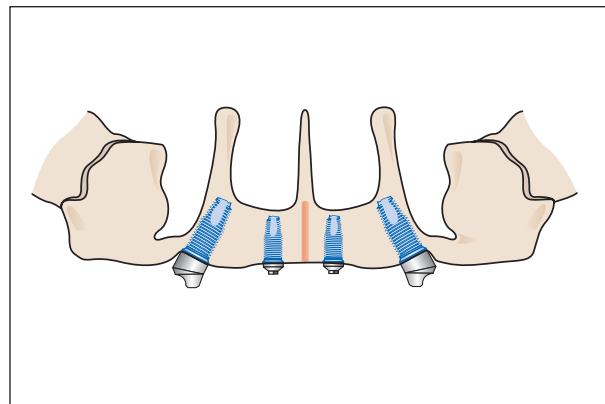
Surgical procedure



(B) The anterior wall of the maxillary sinus is explored with a periodontal probe through a small opening drilled on the lateral wall of the maxilla.



(C) The guide is placed in the midline and 2 posterior implant beds are prepared (15x2mm; 50 Ncm) 4 to 5 mm along the sinus wall and tilted to a maximum angle of 45°. Angulated abutments (30°) are tightened (15 Ncm).



(D) After placement of the 2 posterior implants (15x4mm), 2 parallel anterior implants (10x4mm) are placed at the central/lateral incisor sites. Straight abutments are tightened (15 Ncm).

Appendix N: Bone regeneration

Box N.1 Clinical recommendations for the GBR technique

- Prerequisites
 - Low plaque index (<20%)
 - No infection at the defect site
- Strict observance of the basic principles of the OFD
- Perforations in the bony surface of the defect
- Space between the inner portion of the membrane and the defect
 - May be filled by the blood clot alone
 - Use non-resorbable space-maintaining membranes only
 - May be filled by bone substitute¹ (large or non-naturally space-making defects)
 - Resorbable non-space-maintaining membranes can be used
- Complete coverage of the defect area with the membrane
- Lack of contamination of the membrane
 - Avoid contact with the saliva
 - Minimize handling
- Complete coverage of the defect area with the membrane
 - The membrane must extend by at least 3 mm beyond the defect margins
- Stabilization of the membrane
 - Fixation screws or pins may be used (large defects)
- Complete soft tissue coverage
 - Membrane completely submerged beneath the flap
 - Tension-free primary wound closure
- Strict oral hygiene maintenance plan

¹Autogenous bone was not demonstrated to promote better bone regeneration compared with non-autogenous grafting materials. In addition, it increases the morbidity (when a second surgical site is created) and the risk of infection, in particular when a special filter to collect bone particles is used.

Box N.2 Postoperative management of membrane exposure

DO NOT CLOSE THE OPENING SURGICALLY

- Exposure without infection
 - Topical application of an antiseptic gel (chlorhexidine) at least three times daily using a cotton swab or an applicator
 - Increase antibacterial rinsing protocol
 - Patient recall weekly
 - Membrane removal after at least 4 weeks¹ if the exposure is getting larger over time
- Exposure with infection (pus)
 - Immediate removal of the membrane
 - Antibiotic regimen

¹Membrane barriers should remain in place for at least 4 weeks to avoid compromising the regenerative process.

Table N.1 Advantages and disadvantages of non-resorbable and resorbable membrane barriers

	Bone formation	Surgical removal	Time control of the membrane effect	Need for additional supporting material	Membrane exposure
Consequences	Success improvement	Increased risk of stress, morbidity, tissue damage, and cost	Allows control of the risk of undesirable inflammation process	Increase the risk of inflammation and cost	Inflammation or infection, reduction of the average gain of new bone
Non-resorbable	>resorbable	Yes	Yes	No (titanium-reinforced membranes)	High
Resorbable	<non-resorbable	No	No	Yes	Medium

References and further reading

Chapter 1

- Abrahamsson I, Berglundh T, Linder E, Lang NP, Lindhe J. Early bone formation adjacent to rough and turned endosseous implant surfaces. An experimental study in the dog. *Clin Oral Implants Res* 2004;15(4):381–392.
- Berglundh T, Abrahamson I, Lang NP, Lindhe J. De novo alveolar bone formation adjacent to endosseous implants. A model study in the dog. *Clin Oral Implants Res* 2003;14(3):251–262.
- Berglundh T, Abrahamsson I, Lindhe J. Bone reactions to longstanding functional load at implants: an experimental study in dogs. *J Clin Periodontol* 2005;32(9):925–932.

Further reading

- Lindhe J, Berglundh T, Lang NP. Osseointegration. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.99–107.

Chapter 2

Further reading

- Berglundh T. Soft tissue interface and response to microbial challenge. In: Lang NP, Lindhe J and Karring T, editors. *Implant Dentistry. Proceedings of the Third European Workshop on Periodontology*. Berlin: Quintessence, 1999, pp.153–174.
- Lindhe J, Wennström JL, Berglundh T. The mucosa at teeth and implants. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.69–85.

Chapter 3

Further reading

- Greenstein G, Tarnow D. The mental foramen and nerve: clinical and anatomical factors related to dental implant placement: a literature review. *J Periodontol* 2006;77:1933–1943.

Chapter 4

Further reading

- Greenstein G, Cavallaro J, Romanos G, Tarnow D. Clinical recommendations for avoiding and managing surgical complications associated with implant dentistry: a review. *J Periodontol* 2008;79:1317–1329.

Chapter 5

- Lekholm U, Zarb GA. Patient selection. In: Brånemark PI, Zarb GA, Albrektsson T, editors. *Tissue Integrated Prostheses. Osseointegration in Clinical Dentistry*. Chicago: Quintessence, 1985, pp.199–209.
- Quirynen M, Lekholm U. The surgical site. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1068–1079.

Further reading

- Ericsson J, Randow K, Glantz PO, Lindhe J, Nilner K. Some clinical and radiographic features of submerged and non-submerged titanium implants. *Clin Oral Implants Res* 1994;5:185–189.
- Esposito M, Hirsch JM, Lekholm U, Tomsen P. Biological factors contributing to failures of osseointegrated oral implant (II). Etiopathogenesis. *Eur J Oral Sci* 1998;106:721–764.
- Rangert B, Jemt T, Jorneus L. Forces and moments on Brånemark implants. *Int J Oral Maxillofac Implants* 1989;4:241–247.

Chapter 6

- Abuhussein H, Pagni G, Rebaudi A, Wang HL. The effect of thread pattern upon implant osseointegration. *Clin Oral Implants Res* 2010;21(2):129–136.
- Esposito M. Interventions for replacing missing teeth: different types of dental implants (Review). *Cochrane Database Syst Rev* 2007;4:CD003815.
- Lang N, Tonetti M, Suvan J et al. Immediate implant placement with transmucosal healing in areas of aesthetic priority. A multicentre randomized-controlled clinical trial I. Surgical outcomes. *Clin Oral Implants Res* 2007;18:188–196.
- Renouard F, Nisand D. Impact of implant length and diameter on survival rates. *Clin Oral Implants Res* 2006;17(Suppl 2):35–51.
- Steigenga J, Al-Shammari K, Misch C, Nociti FH Jr, Wang HL. Effects of implant thread geometry on percentage of osseointegration and resistance to reverse torque in the tibia of rabbits. *J Periodontol* 2004;75:1233–1241.

Chapter 7

- Crespi R, Cappare P, Gherlone E. Radiographic evaluation of marginal bone levels around platform-switched and non-platform-switched implants used in an immediate loading protocol. *Int J Oral Maxillofac Implants* 2009;24:920–926.
- Hansson S. A conical implant-abutment interface at the level of the marginal bone improves the distribution of stresses in the supporting bone. An axisymmetric finite element analysis. *Clin Oral Implants Res* 2003;14:286–293.
- Piermatti J, Yousef H, Luke A, Mahevich R, Weiner S. An in vitro analysis of implant screw torque loss with external hex and internal connection implant systems. *Implant Dent* 2006;15:427–435.

Chapter 8

- Jarmar T, Palmquist A, Brånemark R, Hermansson L, Engqvist H, Thomsen P. Characterization of the surface properties of commercially available dental implants using scanning electron microscopy, focused ion beam and high resolution transmission electron microscopy. *Clin Implant Dent Relat Res* 2008;10:11–22.
- Wennerberg A, Albrektsson T. On implant surfaces: a review of current knowledge and opinions. *Int J Oral Maxillofac Implants* 2009;24:63–74.

Further reading

- Albrektsson T, Wennerberg A. Oral implant surfaces. part 1: review focusing on topographic and chemical properties of different surfaces and in vivo responses to them. *Int J Prosth Dent* 2004;17:536–543.
- Albrektsson T, Wennerberg A. Oral implant surfaces, part 2: review focusing on clinical knowledge of different surfaces. *Int J Prosth Dent* 2004;17:544–564.
- Albrektsson T, Zarb G, Worthington P, Eriksson RA. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants* 1986;1:11–25.

Chapter 9

- Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *J Clin Periodontol* 2002;29(Suppl. 3):197–212.
- Blanes RJ. To what extent does the crown-implant ratio affect the survival and complications of implant-supported reconstructions? A systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):67–72.
- Bouchard P, Renouard F, Bourgeois D, Fromentin O, Jeanneret MH, Beresniak A. Cost-effectiveness modeling of dental implant vs. bridge. *Clin Oral Implants Res* 2009;20:583–587.

- Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. *Cochrane Database Syst Rev* 2009;1:CD003878.
- Karoussis IK, Bragger U, Salvi GE, B rgin W, Lang NP. Effect of implant design on survival and success rates of titanium oral implants: a 10-year prospective cohort study of the ITIs Dental Implant System. *Clin Oral Implants Res* 2004;15:8–17.
- Lang NP, Salvi GE. Implants in restorative dentistry. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1138–1145.
- Lang NP, Berglundh T, Heitz-Mayfield LJ, Pjetursson BE, Salvi GE, Sanz M. Consensus statements and recommended clinical procedures regarding implant survival and complications. *Int J Oral Maxillofac Implants* 2004;19(Suppl):150–154.
- P t rsson BE. Systematic reviews of survival and complication rates of implant-supported fixed dental prostheses and single crowns, 14–26. In: Jokstad A, editor. *Osseointegration and Dental Implants*. Oxford: Wiley-Blackwell, 2008, p.429.
- Popelut A, Rousval B, Fromentin O, Feghali M, Mora F, Bouchard P. Tooth extraction decision model in periodontitis patients. *Clin Oral Implants Res* 2010;21:80–89.
- Popelut A, Valet F, Fromentin O, Thomas A, Bouchard P. Relationship between sponsorship and failure rate of dental implants: a systematic approach. *PLoS ONE* 2010;5(4):e10274.

Further reading

- Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *J Clin Periodontol* 2002;29(Suppl. 3):197–212.
- Lang NP, Pjetursson BE, Tan K, Br gger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. II. Combined tooth-implant-supported FPDs. *Clin Oral Implants Res* 2004;15(6):643–653.
- Pjetursson BE, Tan K, Lang NP, Br gger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. *Clin Oral Implants Res* 2004;15(6):625–642.
- Tan K, Pjetursson BE, Lang NP, Chan ES. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. *Clin Oral Implants Res* 2004;15(6):654–666.
- Zurdo J, Rom o C, Wennstr m JL. Survival and complication rates of implant-supported fixed partial dentures with cantilevers: a systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):59–66.

Chapter 12

- Brasseur M, Brogniez V, Gr goire V et al. Effects of irradiation on bone remodelling around mandibular implants: an experimental study in dogs. *Int J Oral Maxillofac Surg* 2006;35(9):850–855.
- British National Formulary 52. London: RPSGB/BMA, 2006, pp.24–25.
- Esposito M, Grusovin MG, Patel S, Worthington HV, Coulthard P. Interventions for replacing missing teeth: hyperbaric oxygen therapy for irradiated patients who require dental implants. *Cochrane Database Syst Rev* 2008;1:CD003603.
- Lazarovici TS, Yahalom R, Taicher S, Schwartz-Arad D, Peleg O, Yarom N. Bisphosphonate-related osteonecrosis of the jaw associated with dental implants. *J Oral Maxillofac Surg* 2010;68(4):790–796.
- Madrid C, Sanz M. What influence do anticoagulants have on oral implant therapy? A systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):96–106.
- National Patient Safety Agency. *Managing Patients Who are Taking Warfarin and Undergoing Dental Treatment*. London: National Patient Safety Agency/British Dental Association/British Society for Haematology, 2007.

- Sanz M, Naert I. Biomechanics/risk management (Working Group 2). *Clin Oral Implants Res* 2009;20(Suppl 4):107–111.

Chapter 13

- Bornstein MM, Cionca N, Mombelli A. Systemic conditions and treatments as risks for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):12–27.
- Cochran DL, Schou S, Heitz-Mayfield LJ, Bornstein MM, Salvi GE, Martin WC. Consensus statements and recommended clinical procedures regarding risk factors in implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):86–89.
- Ferreira SD, Silva GL, Cortelli JR, Costa JE, Costa FO. Prevalence and risk variables for peri-implant disease in Brazilian subjects. *J Clin Periodontol* 2006;33(12):929–935.
- Heitz-Mayfield LJ, Huynh-Ba G. History of treated periodontitis and smoking as risks for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):39–68.
- Madrid C, Sanz M. What impact do systemically administered bisphosphonates have on oral implant therapy? A systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):87–95.
- Yap AK, Klineberg I. Dental implants in patients with ectodermal dysplasia and tooth agenesis: a critical review of the literature. *Int J Prosthodont* 2009;22(3):268–276.

Chapter 14

- Bengazi F, Wennstr m JL, Lekholm U. Recession of the soft tissue margin at the oral implants. A 2 year longitudinal prospective study. *Clin Oral Implants Res* 1996;7:303–310.
- Cochran DL, Schou S, Heitz-Mayfield LJ, Bornstein MM, Salvi GE, Martin WC. Consensus statements and recommended clinical procedures regarding risk factors in implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):86–89.
- H mmerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. *Int J Oral Maxillofac Implants* 2004;19(Suppl):26–28.
- Martin W, Lewis E, Nicol A. Local risk factors for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):28–38.
- Molly L. Bone density and primary stability in implant therapy. *Clin Oral Implants Res* 2006;17(Suppl 2):124–135.

Further reading

- Jung R, Pjetursson B, Glauser R, Zembic A, Zwahlen M, Lang NP. A systematic review of the 5-year survival and complication rates of implant-supported single crowns. *Clin Oral Implants Res* 2008;19:119–130.
- Villa R, Rangert B. Immediate and early function of implants placed in extraction sockets of maxillary infected teeth. A pilot study. *J Prosthet Dent* 2007;97(6 Suppl):S96–S108.

Chapter 15

- Heitz-Mayfield LJ, Huynh-Ba G. History of treated periodontitis and smoking as risks for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):39–68.
- Salvi GE, Bragger U. Mechanical and technical risks in implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):69–85.
- Van Steenberghe D, Lekholm U, Bolender C et al. Applicability of osseointegrated oral implants in the rehabilitation of partial edentulism: a prospective multicenter study on 558 fixtures. *Int J Oral Maxillofac Implants* 1990;5:272–281.

Chapter 16

- Cochran DL, Schou S, Heitz-Mayfield LJ, Bornstein MM, Salvi GE, Martin WC. Consensus statements and recommended clinical procedures regarding

- risk factors in implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):86–89.
- Heitz-Mayfield LJ, Huynh-Ba G. History of treated periodontitis and smoking as risks for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):39–68.
- Ong CTT, Ivanovski S, Needleman IG et al. Systematic review of implant outcomes in treated periodontitis subjects. *J Clin Periodontol* 2008;35:438–462.
- Popelut A, Rousval B, Fromentin O, Feghali M, Mora F, Bouchard P. Tooth extraction decision model in periodontitis patients. *Clin Oral Implants Res* 2010;21:80–89.

Chapter 17

- Araújo M, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. *J Clin Periodontol* 2005;32:212–218.
- Buser D, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. *Int J Oral Maxillofac Implants* 2004;19(Suppl):43–61.
- Choquet V, Hermans M, Adriaenssens P, Daelemans P, Tarnow DP, Malevez C. Clinical and radiographic evaluation of the papilla level adjacent to single-tooth dental implants. A retrospective study in the maxillary anterior region. *J Periodontol* 2001;72:1364–1371.
- Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. *J Clin Periodontol* 1991;18:78–82.
- Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. *J Periodontol* 2000;71:546–549.

Chapter 20

Further reading

- Jacobs R. Preoperative radiologic planning of implant surgery in compromised patients. *Periodontology* 2000 2003;33:12–25.
- Tyndall DA, Brooks SL. Selection criteria for dental implant site imaging: a position paper of the American Academy of Oral and Maxillofacial radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;89:630–637.
- Zitzmann NU, Margolin MD, Filippi A, Weiger R, Krastl G. Patient assessment and diagnosis in implant treatment. *Aust Dent J* 2008;53(Suppl 1):S3–10.

Chapter 22

- Belser U, Buser D, Bernard JP. Implants in the posterior dentition. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1175–1207.
- Belser U, Bernard JP, Buser D. Implants in the esthetic zone. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1146–1174.
- Renouard F, Rangert B. *Risk Factors in Implant Dentistry*. Chicago: Quintessence Books, 1999.

Further reading

- Glantz PO, Nilner K. Biomechanical aspects of prosthetic implant-bone reconstructions. *Periodontology* 2000 1998;17:119–124.
- Lang NP, Wilson T, Corbet EF. Biological complications with dental implants: their prevention, diagnosis and treatment. *Clin Oral Implants Res* 2000;11(Suppl 1):146–155.
- Magne P, Magne M, Belser UC. Natural and restorative oral esthetics. Part I: Rationale and basic strategies for successful esthetic rehabilitations. *J Esthet Dentistry* 1993;5:161–173.
- Quirynen M, van Assche N, Botticelli D, Berglundh T. How does the timing of implant placement to extraction affect outcome? *Int J Oral Maxillofac Implants* 2007;22(Suppl):203–223.
- Salvi GE, Bragger U. Mechanical and technical risks in implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):69–85.
- Weber HP, Morton D, Gallucci GO et al. Consensus statements and recommended clinical procedures regarding loading protocols. *Int J Oral Maxillofac Implants* 2009;24(Suppl):180–185.

- Zitzman NU, Marinello CP. Treatment plan for restoring the edentulous maxilla with implant supported restorations: removable overdenture versus fixed partial denture design. *J Prosthet Dentistry* 1999;82:188–196.

Chapter 23

- Ivanoff CJ, Grondahl K, Sennerby L, Bergstrom C, Lekholm U. Influence of variations in implant diameters: a 3- to 5-year retrospective clinical report. *Int J Oral Maxillofac Implants* 1999;14:173–180.
- Renouard F, Nisand D. Impact of implant length and diameter on survival rates. *Clin Oral Implants Res* 2006;17(Suppl 2):35–51.
- Telleman G, Raghoobar GM, Vissink A, den Hartog L, Huddleston Slater JJ, Meijer HJ. A systematic review of the prognosis of short (<10mm) dental implants placed in the partially edentulous patient. *J Clin Periodontol*. 2011 Jul;38(7):667–76.

Chapter 25

- Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. *Cochrane Database Syst Rev* 2009;1:CD003878.
- Roccuzzo M, Aglietta M, Cordaro L. Implant loading protocols for partially edentulous maxillary posterior sites. *Int J Oral Maxillofac Implants* 2009;24(Suppl):147–157.

Chapter 26

- Belser U, Bernard JP, Buser D. Implants in the esthetic zone. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1146–1174.
- Bouchard P, Renouard F, Bourgeois D, Fromentin O, Jeanneret MH, Beresniak A. Cost-effectiveness modeling of dental implant vs. bridge. *Clin Oral Implants Res* 2009;20:583–587.

Further reading

- Den Hartog L, Slater JJ, Vissink A, Meijer HJ, Raghoobar GM. Treatment outcome of immediate, early and conventional single-tooth implants in the aesthetic zone: a systematic review to survival, bone level, soft-tissue, aesthetics and patient satisfaction. *J Clin Periodontol* 2008;35(12):1073–1086.
- Keenan AD, Levenson D. Are ceramic and metal abutments performance similar? *Evid Based Dent* 2010;11:68–69.
- Pjetursson BE, Tan K, Lang NP, Bragger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. *Clin Oral Implants Res* 2004;15(6):625–642.
- Sailer I, Philipp A, Zembic B, Pjetursson BE, Hammerle C, Zwahlen M. A systematic review of the performance of the ceramic and metal abutments supporting fixed implant reconstructions. *Clin Oral Implants Res* 2009;20(Suppl 4):4–31.
- Salinas TJ, Eckert SE. In patients requiring single-tooth replacement, what are the outcomes of implant as compared to tooth-supported restorations? *Int J Oral Maxillofac Implants* 2007;22(Suppl):71–92.

Chapter 27

- Pjetursson B, Lang N. Prosthetic treatment planning on the basis of scientific evidence. *J Oral Rehabil* 2008;35(Suppl 1):72–79.

Chapter 28

- Cehreli MC, Karasoy D, Kökat AM, Akça K, Eckert S. A systematic review of marginal bone loss around implants retaining or supporting overdentures. *Int J Oral Maxillofac Implants* 2010;25(2):266–277.
- Cune M, Burgers M, van Kampen F, de Putter C, van der Bilt A. Mandibular overdentures retained by two implants: 10-year results from a crossover clinical trial comparing ball-socket and bar-clip attachments. *Int J Prosthodont* 2010;23(4):310–317.

- Cune M, van Kampen F, van der Bilt A, Bosman F. Patient satisfaction and preference with magnet, bar-clip, and ball-socket retained mandibular implant overdentures: a cross-over clinical trial. *Int J Prosthodont* 2005;18(2):99–105.
- Esposito M, Grusovin MG, Chew YS, Coulthard P, Worthington HV. One-stage versus two-stage implant placement. A Cochrane systematic review of randomised controlled clinical trials. *Eur J Oral Implantol* 2009;2(2):91–99.
- Gotfredsen K, Carlsson GE, Jokstad A et al, Scandinavian Society for Prosthetic Dentistry, Danish Society of Oral Implantology. Implants and/or teeth: consensus statements and recommendations. *J Oral Rehabil* 2008;35(Suppl 1):2–8.
- Preiskel HW, editor. *Overdentures Made Easy: A Guide to Implant and Root Supported Prostheses*. Chicago: Quintessence, 1996, pp.81–122.
- Sadowsky S. Treatment considerations for maxillary overdentures: a systematic review. *J Prosthet Dentistry* 2007;97(6):340–348.
- Semper W, Heberer S, Nelson K. Retrospective analysis of bar-retained dentures with cantilever extension: marginal bone level changes around dental implants over time. *Int J Oral Maxillofac Implants* 2010;25(2):385–393.

Chapter 29

- Alsabeeha N, Atieh M, Payne AG. Loading protocols for mandibular implant overdentures: a systematic review with meta-analysis. *Clin Implant Dent Relat Res* 2010;12(Suppl 1):e28–38.
- Brånemark PI, Engstrand P, Öhrnell LO et al. Brånemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. *Clin Implant Dent Relat Res* 1999;1(1):2–16.
- Bryant SR, MacDonald-Jankowski D, Kim K. Does the type of implant prosthesis affect outcomes for the completely edentulous arch? *Int J Oral Maxillofac Implants* 2007;22(Suppl):117–139.
- Feine JS, Carlsson GE, Awad MA et al. The McGill Consensus Statement on Overdentures. Montreal, Quebec, Canada. May 24–25, 2002. *Int J Prosthodont* 2002;15(4):413–414.
- Kawai Y, Taylor JA. Effect of loading time on the success of complete mandibular titanium implant retained overdentures: a systematic review. *Clin Oral Implants Res* 2007;18(4):399–408.
- Maló P, Rangert B, Nobre M. “All-on-Four” immediate-function concept with Brånemark System implants for completely edentulous mandibles: a retrospective clinical study. *Clin Implant Dent Relat Res* 2003;5(Suppl 1):2–9.
- Vercruyssen M, Marcelis K, Coucke W, Naert I, Quirynen M. Long-term, retrospective evaluation (implant and patient-centred outcome) of the two-implants-supported overdenture in the mandible. Part 1: survival rate. *Clin Oral Implants Res* 2010;21(4):357–365.

Chapter 30

- Bueno-Samper A, Hernández-Aliaga M, Calvo-Guirado JL. The implant-supported milled bar overdenture: a literature review. *Med Oral Patol Oral Cir Bucal* 2010;15(2):e375–378.
- Gallucci GO, Morton D, Weber HP. Loading protocols for dental implants in edentulous patients. *Int J Oral Maxillofac Implants* 2009;24(Suppl):132–146.
- Lambert FE, Weber HP, Susarla SM, Belser UC, Gallucci GO. Descriptive analysis of implant and prosthodontic survival rates with fixed implant-supported rehabilitations in the edentulous maxilla. *J Periodontol* 2009;80(8):1220–1230.
- Maló P, Rangert B, Nobre M. “All-on-Four” immediate-function concept with Brånemark System implants for completely edentulous mandibles: a retrospective clinical study. *Clin Implant Dent Relat Res* 2003;5(Suppl 1):2–9.
- Mericske-Stern R. Prosthodontic management of maxillary and mandibular overdentures. In: Feine JS, Carlsson GE, editors. *Implant Overdentures: The Standard of Care for Edentulous Patients*. Chicago: Quintessence, 2003, pp.83–98.

- Weber HP, Morton D, Gallucci GO, Roccuzzo M, Cordaro L, Grutter L. Consensus statements and recommended clinical procedures regarding loading protocols. *Int J Oral Maxillofac Implants* 2009;24(Suppl):180–183.

Chapter 31

- Haanaes HR. Implants and infections with special reference to oral bacteria. *J Clin Periodontol* 1990;17:516–524.
- Parienti JJ, Thibon P, Heller R et al. Hand-rubbing with an aqueous alcoholic solution vs traditional surgical hand-scrubbing and 30-day surgical site infection rates: a randomized equivalence study. *JAMA* 2002;288(6):722–727.
- Van Steenberghe D, Yoshida K, Papaioannou W, Bollen CM, Reybrouck G, Quirynen M. Complete nose coverage to prevent airborne contamination via nostrils is unnecessary. *Clin Oral Implants Res* 1997;8:512–516.

Chapter 32

- Araújo MG, Lindhe J. Ridge alterations following tooth extraction with and without flap elevation: an experimental study in the dog. *Clin Oral Implants Res* 2009a;20(6):545–549.
- Araújo MG, Lindhe J. Ridge preservation with the use of Bio-Oss collagen: a 6-month study in the dog. *Clin Oral Implants Res* 2009b;20(5):433–440.
- Araújo MG, Lindhe J. Socket grafting with the use of autologous bone: an experimental study in the dog. *Clin Oral Implants Res* 2011;22(1):9–13.
- Araújo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. *J Clin Periodontol* 2005;32:212–218.
- Araújo MG, Wennström JL, Lindhe J. Modeling of the buccal and lingual bone walls of fresh extraction sites following implant installation. *Clin Oral Implants Res* 2006;17:600–614.
- Darby I, Chen ST, Buser D. Ridge preservation techniques for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl):260–271.
- Esposito M, Worthington HV, Loli V, Coulthard P, Grusovin MG. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. *Cochrane Database Syst Rev* 2010;7:CD004152.

Further reading

- Carmagnola D, Adriaens P, Berglundh T. Healing of human extraction sockets filled with Bio-Oss. *Clin Oral Implants Res* 2003;17:137–143.
- Fickl S, Zühr O, Wachtel H, Bolz W, Huerzeler M. Tissue alterations after tooth extraction with and without surgical trauma. A volumetric study in the beagle dog. *J Clin Periodontol* 2008;35:356–363.
- Fiorellini J, Howell T, Cochran D et al. Randomized study evaluating recombinant human bone morphogenetic protein-2 for extraction socket augmentation. *J Periodontol* 2005;76:605–613.
- Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1 year results. *Int J Periodont Restorat Dent* 2000;20:11–17.
- Iasella JM, Greenwell H, Miller RH et al. Ridge preservation with freeze-dried bone allograft and a collagen membrane compared to extraction alone for implant site development: a clinical and histologic study in humans. *J Periodontol* 2003;74:990–999.
- Quirynen M, van Assche N, Botticelli D, Berglundh T. How does the timing of implant placement to extraction affect outcome? *Int J Oral Maxillofac Implants* 2008;23(1):203–223.
- Serino G, Rao W, Iezzi G, Piattelli A. Polylactide and polyglycolide sponge used in human extraction socket: bone formation following 3 months after its application. *Clin Oral Implants Res* 2008;19:26–31.

Chapter 33

- Quirynen M, Lekholm U. The surgical site. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1068–1079.

Further reading

Hämmerle CHF, Araújo M, Lindhe J. Timing of implant placement. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.1053–1067.

Chapter 34

- Araújo MG, Sukekava F, Wennström JL, Lindhe J. Tissue modeling following implant placement in fresh extraction sockets. *Clin Oral Implants Res* 2006;17(6):615–624.
- Botticelli D, Berglundh T, Lindhe J. Hard tissue alterations following immediate implant placement in extraction sites. *J Clin Periodontol* 2004;31:820–828.
- Chen ST, Buser D. Implants in post-extraction sites: a literature update. In: *ITI Treatment Guide, Vol 3. Implants in Extraction Sockets*. Chicago: Quintessence, 2008.
- Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in the postextraction sites. *Int J Oral Maxillofac Implants* 2009;24(Suppl):186–217.
- Esposito M, Grusovin MG, Polyzos IP, Felice P, Worthington HV. Interventions for replacing missing teeth: dental implant in fresh extraction socket (immediate, immediate-delayed, delayed implants). *Cochrane Database Syst Rev* 2010;9:CD005968.
- Sanz M, Cecchinato D, Ferrus J, Pjetursson EB, Lang NP, Lindhe J. A prospective, randomized-controlled clinical trial to evaluate bone preservation using implants with different geometry placed into extraction sockets in the maxilla. *Clin Oral Implants Res* 2010;21:13–21.

Further reading

- Hammerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. *Int J Oral Maxillofac Implants* 2004;19(Suppl):26–28.
- Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites. A prospective randomized study in 50 patients. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;101:705–710.
- Paolantonio M, Dolci M, Scarano A et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. *J Periodontol* 2001;72:1560–1571.

Chapter 35

- Hammerle CH, Stone P, Jung RE, Kapos T, Brodala N. Consensus statements and recommended clinical procedures regarding computer-assisted implant dentistry. *Int J Oral Maxillofac Implants* 2009;24(Suppl):126–131.
- Jung RE, Schneider D, Ganeles J et al. Computer technology applications in surgical implant dentistry: a systematic review. *Int J Oral Maxillofac Implants* 2009;24(Suppl):92–109.

Chapter 36

- Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *Int J Oral Maxillofac Implants* 2009;24(Suppl):237–259.
- Hammerle CH, Lang N. Single stage surgery combining transmucosal implant placement with guided bone regeneration and bioresorbable materials. *Clin Oral Implants Res* 2001;12:9–18.

Chapter 37

- Antoun H, Sitbon JM, Martinez H, Missika P. A prospective randomized study comparing two techniques of bone augmentation: onlay graft alone or associated with a membrane. *Clin Oral Implants Res* 2001;12:632–639.
- Chiapasco M, Zaniboni M. Clinical outcomes of GBR procedures to correct peri-implant dehiscences and fenestrations: a systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):113–123.
- Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. Interventions for replacing missing teeth: horizontal and vertical

bone augmentation techniques for dental implant treatment. *Cochrane Database Syst Rev* 2009;4:CD003607.

- Esposito M, Grusovin MG, Tzanetia E, Piattelli A, Worthington HV. Interventions for replacing missing teeth: treatment of perimplantitis. *Cochrane Database Syst Rev* 2010;6:CD004970.
- Klinge B, Flemmig TF. Tissue augmentation and esthetics (Working Group 3). *Clin Oral Implants Res* 2009;20(Suppl 4):166–170.
- Tonetti MS, Hammerle CH. Advances in bone augmentation to enable dental implant placement: Consensus Report of the Sixth European Workshop on Periodontology. *J Clin Periodontol* 2008;35(Suppl 8):168–172.
- Von Arx T, Cochran DL, Hermann JS, Schenk RK, Buser D. Lateral ridge augmentation using different bone fillers and barrier membrane application. A histologic and histomorphometric pilot study in the canine mandible. *Clin Oral Implants Res* 2001;12:260–269.

Chapter 38

- Anitua E. Plasma rich in growth factors: preliminary results of use in the preparation of future sites of implants. *Int J Oral Maxillofac Implants* 1999;14:529–535.
- Berglundh T, Lindhe J. Healing around implants placed in bone defects treated with Bio-Oss. An experimental study in the dog. *Clin Oral Implants Res* 1997;8:117–124.
- Boyne P, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. *J Oral Surg* 1980;38:613–616.
- Carmagnola D, Berglundh T, Araújo M, Albrektsson T, Lindhe J. Bone healing around implants placed in a jaw defect augmented with Bio-Oss. An experimental study in dogs. *J Clin Periodontol* 2000;27:799–805.
- Daculsi G. Biphasic calcium phosphate concept applied to artificial bone, implant coating and injectable bone substitute. *Biomaterials* 1998;19:1473–1478.
- Davies JE, Hosseini MM. Histodynamics of endosseous wound healing. In: Davies JE, editor. *Bone Engineering*. Toronto: Em Squared Inc., 2000, pp.1–14.
- Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. Interventions for replacing missing teeth: horizontal and vertical bone augmentation techniques for dental implant treatment. *Cochrane Database Syst Rev* 2009;4:CD003607.
- Hallman M, Thor A. Bone substitutes and growth factors as an alternative/complement to autogenous bone for grafting in implant dentistry. *Periodontol* 2000 2008;47:172–192.
- Merkx MA, Fennis JP, Verhagen CM, Stoelinga PJ. Reconstruction of the mandible using preshaped 2, 3 mm titanium plates, autogenous particulate cortico-cancellous bone grafts and platelet rich plasma: a report on eight patients. *Int J Oral Maxillofac Surg* 2004;33:2029–2035.
- Piatelli M, Favero G, Scarano A, Orsini G, Piatelli A. Bone reactions to anorganic bovine (Bio-Oss) used in sinus augmentation procedures: a histologic long-term report of 20 cases in humans. *Int J Oral Maxillofac Implants* 1999;14:835–840.
- Terheyden H, Jepsen S, Möller B, Tucker MM, Kueger DC. Sinus floor augmentation with simultaneous placement of dental implants using a combination of deproteinized bone xenograft and recombinant human osteogenic protein-1. A histometric study in miniature pigs. *Clin Oral Implants Res* 1999;10:510–521.
- Thor A, Wannfors K, Sennerby L, Rasmusson L. Reconstruction of the severely resorbed maxilla with autogenous bone, platelet-rich plasma, and implants: 1-year results of a controlled prospective 5-year study. *Clin Implant Dent Relat Res* 2005;7:209–220.
- Tonetti MS, Hämmerle CHF. Advances in bone augmentation to enable dental implant placement: Consensus Report of the Sixth European Workshop on Periodontology. *J Clin Periodontol* 2008;35(Suppl 8):168–172.
- Turunen T, Peltola J, YLI-Urpo A, Happonen R. Bioactive glass granules as a bone adjunctive material in maxillary sinus floor augmentation. *Clin Oral Implants Res* 2004;15:135–141.

- Valentini P, Abensur D, Densari D, Graziani JN, Hammerle C. Histological evaluation of Bio-Oss in a 2-stage sinus floor elevation and implantation procedure. A human case report. *Clin Oral Implants Res* 1998;9:59–64.
- Wiltfang J, Schlegel KA, Schultze-Mosgau S, Nkenke E, Zimmermann R, Kessler P. Sinus floor augmentation with beta-tricalciumphosphate (beta-TCP): does platelet-rich plasma promote its osseous integration and degradation? *Clin Oral Implants Res* 2003;14:213–218.
- Yildirim M, Spiekermann H, Handt S, Edelhoff D. Maxillary sinus augmentation with the xenograft Bio-Oss and autogenous intraoral bone for qualitative improvement of the implant site: a histologic and histomorphometric clinical study in humans. *Int J Oral Maxillofac Implants* 2001;16:23–33.

Chapter 39

- Chen ST, Beagle J, Jensen SS, Chiapasco M, Darby I. Consensus statements and recommended clinical procedures regarding surgical techniques. *Int J Oral Maxillofac Implants* 2009;24(Suppl):272–278.
- Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *Int J Oral Maxillofac Implants* 2009;24(Suppl):237–259.
- Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. Interventions for replacing missing teeth: horizontal and vertical bone augmentation techniques for dental implant treatment. *Cochrane Database Syst Rev* 2009;4:CD003607.

Chapter 40

- Chen ST, Beagle J, Jensen SS, Chiapasco M, Darby I. Consensus statements and recommended clinical procedures regarding surgical techniques. *Int J Oral Maxillofac Implants* 2009;24(Suppl):272–278.
- Donos N, Mardas N, Chadha V. Clinical outcomes of implants following lateral bone augmentation: systematic assessment of available options (barrier membranes, bone grafts, split osteotomy). *J Clin Periodontol* 2008;35(Suppl 8):173–202.

Chapter 41

- Engelke W, Deckwer I. Endoscopically controlled sinus floor augmentation. A preliminary report. *Clin Oral Implants Res* 1997;8:527–531.
- Esposito M, Grusovin MG, Rees J et al. Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. *Cochrane Database Syst Rev* 2010;3:CD008397.
- Graziani F, Donos N, Needleman I, Gabriele M, Tonetti M. Comparison of implant survival following sinus floor augmentation procedures with implants placed in pristine posterior maxillary bone: a systematic review. *Clin Oral Implants Res* 2004;15(6):677–682.
- Pjetursson BE, Tan WC, Zwahlen M, Lang NP. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. Part I: Lateral approach. *J Clin Periodontol* 2008;35(Suppl 8):216–240.
- Tan WC, Lang NP, Zwahlen M, Pjetursson BE. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. Part II: Transalveolar technique. *J Clin Periodontol* 2008;35(Suppl 8):241–254.
- Wallace SS, Froum SJ. Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review. *Ann Periodontol* 2003;8:328–343.

Further reading

- Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *Int J Oral Maxillofac Implants* 2009;24(Suppl):237–259.

Chapter 42

- Allais M, Maurette PE, Mazzonetto R, Filho JRL. Patient's perception of the events during and after osteogenic alveolar distraction. *Med Oral Patol Oral Cir Bucal* 2007;12:E225–228.

- Chen ST, Beagle J, Jensen SS, Chiapasco M, Darby I. Consensus statements and recommended clinical procedures regarding surgical techniques. *Int J Oral Maxillofac Implants* 2009;24(Suppl):272–278.
- Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *Int J Oral Maxillofac Implants* 2009;24(Suppl):237–259.
- Chiapasco M, Zaniboni M, Rimondini L. Autogenous onlay bone grafts vs. alveolar distraction osteogenesis for the correction of vertically deficient edentulous ridges: a 2–4-year prospective study on humans. *Clin Oral Implants Res* 2007;18(4):432–440.
- Chin M. Distraction osteogenesis for dental implants. *Oral Maxillofac Surg Clin North Am* 1999;7(1):41–63.
- Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. Interventions for replacing missing teeth: horizontal and vertical bone augmentation techniques for dental implant treatment. *Cochrane Database Syst Rev* 2009;4:CD003607.
- Nkenke E, Stelzel F. Clinical outcomes of sinus floor augmentation for implant placement using autogenous bone or bone substitutes: a systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):124–133.
- Tonetti MS, Hammerle CHF. Advances in bone augmentation to enable dental implant placement: Consensus Report of the Sixth European Workshop on Periodontology. *J Clin Periodontol* 2008;35(Suppl 8):168–172.

Chapter 43

- Bouchard P, Malet J, Borghetti A. Decision-making in aesthetics: root coverage revisited. *Periodontol* 2000 2001;27:97–120.
- Jung JE, Siegenthaler DW, Hammerle CH. Postextraction tissue management: a soft tissue punch technique. *Int J Periodont Restorat Dent* 2004;24:545–553.
- Klinge B, Flemmig TF. Tissue augmentation and esthetics (Working Group 3). *Clin Oral Implants Res* 2009;20(Suppl 4):166–170.
- Scharf DR, Tarnow DP. Modified roll technique for localized alveolar ridge augmentation. *Int J Periodont Restorat Dent* 1992;12:415–425.
- Seibert JS, Salama H. Alveolar ridge preservation and reconstruction. *Periodontol* 2000 1996;11:69–84.
- Thoma DS, Benic GI, Zwahlen M, Hammerle CH, Jung RE. A systematic review assessing soft tissue augmentation techniques. *Clin Oral Implants Res* 2009;20(Suppl 4):146–165.
- Wennstrom JL, Bengazi F, Lekholm U. The influence of the masticatory mucosa on the peri-implant soft tissue condition. *Clin Oral Implants Res* 1994;5:1–8.

Chapter 44

- Heij DG, Opdebeeck H, van Steenberghe D, Kokich VG, Belser U, Quirynen M. Facial development, continuous tooth eruption, and mesial drift as compromising factors for implant placement. *Int J Oral Maxillofac Implants* 2006;21:867–878.
- Melsen B, Costa A. Immediate loading of implants used for orthodontic anchorage. *Clin Orthod Res* 2000;3:23–28.
- Melsen B, Lang NP. Biological reactions of alveolar bone to orthodontic loading of oral implants. *Clin Oral Implants Res* 2001;12:144–152.
- Reynders R, Ronchi L, Bipat S. Mini-implants in orthodontics: a systematic review of the literature. *Am J Orthod Dentofacial Orthop* 2009;135:564; discussion 564–565.

Chapter 45

- Esposito M, Worthington HV, Loli V, Coulthard P, Grusovin MG. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. *Cochrane Database Syst Rev* 2010;7:CD004152.

Chapter 46

- Hofschneider U, Tepper G, Gahleitner A, Ulm C. Assessment of the blood supply to the mental region for reduction of bleeding complications during

implant surgery in the interforaminal region. *Int J Oral Maxillofac Implants* 1999;14(3):379–383.

Manning JE. Fluid and blood resuscitation. In: Tintinalli J, editor. *Emergency Medicine: A Comprehensive Study Guide*. New York: McGraw-Hill, 2004, p.227.

Chapter 47

Hofschneider U, Tepper G, Gahleitner A, Ulm C. Assessment of the blood supply to the mental region for reduction of bleeding complications during implant surgery in the interforaminal region. *Int J Oral Maxillofac Implants* 1999;14(3):379–383.

Manning JE. Fluid and blood resuscitation. In: Tintinalli J, editor. *Emergency Medicine: A Comprehensive Study Guide*. New York: McGraw-Hill, 2004, p.227.

Chapter 48

Brånemark PI, Adell R, Albrektsson T et al. An experimental and clinical study of osseointegrated implants penetrating the nasal cavity and maxillary sinus. *J Oral Maxillofac Surg* 1984;42:497–505.

Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in post-extraction sites. *Int J Oral Maxillofac Implants* 2009;24(Suppl):186–217.

Giglio J, Laskin D. Perioperative errors contributing to implant failure. *Oral Maxillofac Surg Clin North Am* 1998;2:197–202.

Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent* 2003;90:121–132.

Park SH, Wang HL. Implant reversible complications: classification and treatments. *Implant Dent* 2005;14: 211–220.

Further reading

Greenstein G, Cavallaro J, Romanos G, Tarnow D. Clinical recommendations for avoiding and managing surgical complications associated with implant dentistry: a review. *J Periodontol* 2008;79(8):1317–1329.

Ten Bruggenkate CM, Krekeler G, Kraaijenhagen HA, Foitzik C, Oosterbeek HS. Hemorrhage of the floor of the mouth resulting from lingual perforation during implant placement: a clinical report. *Int J Oral Maxillofac Implants* 1993;8:329–334.

Chapter 49

Esposito M, Grusovin MG, Tzanetia E, Piattelli A, Worthington HV. Interventions for replacing missing teeth: treatment of perimplantitis. *Cochrane Database Syst Rev* 2010;6:CD004970.

Heitz-Mayfield LJ, Lang NP. Comparative biology of chronic and aggressive periodontitis vs. peri-implantitis. *Periodontology* 2000 2010;53:167–181.

Pontoriero R, Tonelli MP, Carnevale G, Mombelli A, Nyman SR, Lang NP. Experimentally induced peri-implant mucositis. A clinical study in humans. *Clin Oral Implants Res* 1994;5(4):254–259.

Schou S, Holmstrup P, Reibel J, Juhl M, Hjørting-Hansen E, Kornman KS. Ligature-induced marginal inflammation around osseointegrated implants and ankylosed teeth: stereologic and histologic observations in cynomolgus monkeys (*Macaca fascicularis*). *J Periodontol* 1993;64(6):529–537.

Further reading

Grusovin MG, Coulthard P, Worthington HV, George P, Esposito M. Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants. *Cochrane Database Syst Rev* 2010;8:CD003069.

Chapter 50

Ellegaard B, Baelum V, Karring T. Implant therapy in periodontally compromised patients. *Clin Oral Implants Res* 1997;8(3):180–188.

Heitz-Mayfield LJ, Schmid B, Weigel C et al. Does excessive occlusal load affect osseointegration? An experimental study in the dog. *Clin Oral Implants Res* 2004;15(3):259–268.

Isidor F. Loss of osseointegration caused by occlusal load of oral implants. A clinical and radiographic study in monkeys. *Clin Oral Implants Res* 1996;7(2):143–152.

Isidor F. Histological evaluation of peri-implant bone at implants subjected to occlusal overload or plaque accumulation. *Clin Oral Implants Res* 1997;8(1):1–9.

Mombelli A. Prevention and therapy of peri-implant infections. *Proceedings of the 3rd European Workshop on Periodontology and Implant Dentistry*. Berlin: Quintessence, 1999, pp.281–303.

Renvert S, Polyzois I, Maguire R. Re-osseointegration on previously contaminated surfaces: a systematic review. *Clin Oral Implants Res* 2009;20(Suppl 4):216–227.

Roos-Jansåker AM, Lindahl C, Renvert H, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part II: presence of peri-implant lesions. *J Clin Periodontol* 2006;33(4):290–295.

Weyant RJ, Burt BA. An assessment of survival rates and within-patient clustering of failures for endosseous oral implants. *J Dent Res* 1993;72(1):2–8.

Further reading

Berglundh T, Lindhe J, Lang K. Peri-implant pathology. In: Lang NP, Lindhe J, Karring T, editors. *Clinical Periodontology and Implant Dentistry*, 5th edn. Oxford: Blackwell, 2008, pp.529–538.

Esposito M, Grusovin MG, Tzanetia E, Piattelli A, Worthington HV. Interventions for replacing missing teeth: treatment of perimplantitis. *Cochrane Database Syst Rev* 2010;6:CD004970.

Lang NP, Berglundh T, Heitz-Mayfield LJ, Pjetursson BE, Salvi GE, Sanz M. Consensus statements and recommended clinical procedures regarding implant survival and complications. *Int J Oral Maxillofac Implants* 2004;19(Suppl):150–154.

Index

Note: page numbers in *italics* refer to figures; those in **bold** to tables or boxes.

- abscess, peri-implant 25
- abutment(s)
 - healing 72, 73
 - implant connection 20, **20**, 21
 - selection 59
- abutment screw 20, 21
 - fracture 24
 - loosening 21, 24
- acetaminophen 97
- acid etching, implant surfaces 23
- adjacent implants
 - distance between *see* interimplant distance
 - esthetic results 40, 41
- adjacent teeth
 - damage during surgery 103
 - drill positioning 42, 43
 - implant distance 35, 53
- age
 - of edentulism 36, 37
 - limits for implant placement 33
- AIDS 31, 33
- airway obstruction **101**
- ALARA principle 47
- allogenic soft tissue grafts 92, 93
- allografts
 - bone 83
 - defined 108
- alloplastic bone substitutes 83
- alveolar antral artery 14, 15
- alveolar bone growth, completion 95
- alveolar distraction osteogenesis 90, 91
- alveolar mucosa *see* mucosa
- alveolar process dimensions 43
- alveolar ridge
 - bone volume loss *see* bone volume loss/resorption
 - preoperative evaluation **43**
 - splitting technique *see* split osteotomy
- American Society of Anesthesiologists
 - P3 patients 31
 - P5 and P6 patients 30
 - physical status classification system **28**, 29
- amoxicillin 97, 105, **107**, 108
- analgesics 97
- anatomy, surgical 12, 13, 14, 15
- anodic oxidation, implant surface 23
- anodontia 32, 33, 95
- anterior superior alveolar arteries 14, 15
- anterior superior alveolar nerves 14, 15
- antibacterial mouth rinses 105
- antibiotics
 - peri-implantitis **107**, 108
 - prophylactic 97
- anticoagulated patients 31
 - international normalized ratio **28**, 31
 - prevention of bleeding 30, **31**
- antiseptics, local 97, 108
- anxiolytic premedication 96, 97
- apically positioned flap (APF) **92**, 93
- apical peri-implantitis 34
- apical root convergence 53
- asepsis 69
- assessment, patient *see* patient evaluation
- autograft, defined 108
- automated external defibrillator (AED) 100, 101
- bacterial colonization, implant/abutment
 - connection 21
- ball attachment systems, overdenture 64, 65, **124**
- bar attachment systems, overdenture
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients 63, **124**
- baseline appraisal *see* end-of-treatment appraisal
- bioactive, defined 108
- Bio-Col socket preservation technique 70, 71
- Bio-Gide® membranes 80, 81, **107**
- Bioglass 83
- biological width, peri-implant 10, 11
- biomechanics, implant selection 52, 53
- Bio-Oss® 89, **107**
- biotype, tissue
 - esthetic risk 40, 41
 - mucosal recession risk 34, 35
 - see also* thin tissue biotype
- biphasic tricalcium phosphate 83
- bisphosphonate-related osteonecrosis of jaws (BRONJ) 31
- bisphosphonates
 - intravenous 31
 - oral 31, 33
- blasting, implant surface 23
- bleeding *see* hemorrhage/bleeding
- bleeding on probing (BOP) 107
- block bone grafts 85
 - complications 85
 - harvesting sites 84, 85, **85**
 - risk of complications 79, **79**
 - surgical procedures 84, 85
- blood coagulation disorders 31
- blood pressure measurement 28
- body mass index (BMI) 28
- bone
 - classification 16, 17
 - clinical examination 16, 17
 - dehiscence 81, 102
 - height 41, 43
 - imaging techniques 47
 - modeling 8, 9
 - proximal 41
 - shape 16, 17
 - splitting *see* split osteotomy
 - width 43
- bone augmentation 78–91
 - alveolar distraction osteogenesis 90, 91
 - block bone grafts *see* block bone grafts
 - graft materials 82, 83
 - guided bone regeneration 80, 81
 - implant complications 79
 - one-stage simultaneous approach 78, 79
 - optimal timing 79
 - postextraction protocols 75
 - risk of complications 79, **79**
 - sinus floor elevation 88, 89
 - soft tissue augmentation 93
 - split osteotomy 86, 87
 - two-stage/staged approach 78, 79
 - see also* horizontal bone augmentation; vertical bone augmentation
- bone density 16, 17, 35
 - implant bed preparation and 73
- bone disease 33
- bone grafts 82, 83
 - allografts 83
 - autogenous 82, 83, 84, 85
 - block *see* block bone grafts
 - postoperative care 98, 99
 - sinus floor elevation 88, 89
 - socket preservation 70, 71
 - xenografts 83, 89
 - see also* bone augmentation; bone substitutes
- bone–implant contact (BIC) 19
 - effects of implant loading 9
 - immediate implant placement 35
 - implant surfaces and 23
- bone morphogenetic proteins (BMPs) 83
- bone quality 16, 17
 - evaluation 35, 47
- bone remodeling
 - after tooth extraction 41
 - implant stability and 56, 57
 - peri-implant 8, 9
- bone substitutes
 - alloplastic 83
 - sinus floor elevation 89
 - socket preservation 70, 71
 - see also* bone grafts
- bone volume loss/resorption
 - duration of edentulism and 36, 37
 - evaluation 16, 17
 - extraction sockets 71
 - fully edentulous patients 62, 63
 - immediate implantation 75
 - implant selection 53, **53**
 - peri-implant *see* marginal bone loss
 - predictability 41

- bridge(s)
 - resin-bonded cast metal 54, 55
 - survival **61**
 - temporary 54, 55
- bridge-design fixed restorations
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients 63, **125**
- bruxism 37
- buccal bone
 - concavity 42
 - esthetic aspects 41
- buccal nerve 13
- calcium phosphates 83
- calcium sulfate 83
- calvarium, bone harvesting **85**
- cancer patients 30
- cantilevers
 - implant-supported fixed partial dentures 60, 61
 - survival **61**
 - temporary 54, 55
- cardiac conditions 30, 31
- cardiac transplantation 30
- cardiac valves, prosthetic 30
- caries, extensive 37
- cast metal bridge, resin-bonded 54, 55
- casts, diagnostic 50, 51
- cemented restorations
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients **125**
 - implant-supported FDPs 61, **61**
 - single-tooth implants 59
- cementum 10, 11
- cephalometric lateral radiography **46, 47**
- chemotherapy 30
- children 32, 33, 95
- chin bone harvesting **85, 85**
 - postoperative care 98, 99
 - technique 84
- chisels, ridge splitting/expansion 86, 87
- chlorhexidine mouth rinses 97, 99, **107**
- chronic kidney disease 31
- circulating nurse 69
- clear resin tray, modified 54, 55
- clot formation 8, 9
- cold therapy 98, 99
- collagen xenogenic membranes 80, 81
- combined tooth-implant supported fixed partial denture (FDP) 24, **61**, 108
- complaint, patient's chief 49, 51
- complex care needs, patients with 49
- compliance, patient
 - early evaluation 37
 - esthetic aspects 41
- complications
 - implant 24, 25
 - surgical *see* surgical complications
- computed tomography (CT scan) 46, **46, 47**
 - computer-guided surgery 77
 - preoperative examination 47, **47**
- computer-assisted surgery 77
- computer-guided surgery 76, 76–7, **77**
- computer-navigated surgery 77, **77**
- cone beam computed tomography (CBCT) 46, **46, 47**
 - computer-guided surgery 76, 77
- congenital heart disease (CHD) 30
- connective tissue, peri-implant 10, 11
- connective tissue grafts
 - socket preservation 70, 71
 - soft tissue augmentation 92, **92, 93**
- consent, informed 49
- consent form 117–19
- contraindications 29, 30–1
 - absolute 30–1
 - relative 31
- corticosteroids 31, 97
- cost estimates, written 49
- cover screw 72, 73
- crash cart 100, 101
- cylindrical implants 19
- decision-making process 50, 51
- dehiscence
 - bone 81, 102
 - wound 102–3
- delayed implantation 75, 79, 108
 - guided bone regeneration 81
 - split osteotomy 87
- delayed loading 56, 57
- dental history 36, 37
- dental implant *see* implant(s)
- denture
 - defined 108
 - temporary partial 54, 55
 - see also* overdentures
- denture-design fixed restorations
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients 63, **125**
- deproteinized bovine bone (DBB) 83
- descending palatine artery 14
- diabetes 28, 31, 33
- dialysis patients 31
- diameter, implant 18, 19, **19**
- distraction osteogenesis, alveolar 90, 91
- doxycycline gel 108
- drills
 - extensions 42, 43
 - fractures within implant bed 103
- early loading 56, 57
 - defined **57**, 108
 - edentulous mandible 65
- ecchymosis, postoperative 103
- ectodermal dysplasia 32, 33
- edentulism
 - age of 36, 37
 - see also* fully edentulous patients; partially edentulous patients
- edentulous areas
 - bone resorption 16, 17, 36, 37
 - dimensions 43, 53
- edentulous mandible 64, 65, 128
- edentulous maxilla
 - computer-guided surgery 76
 - treatment planning 66, 67, 129
- emergency equipment 100, 101
- endocarditis, infective 30
- endodontic infection 35, 37
- endodontic surgery, failed 34, 36, 37
- end-of-treatment appraisal 49, 108
- epilepsy 31
- epithelium, peri-implant 10, 11
- equipment, operating room 68, 69
- erythema multiforme 31
- esthetic area
 - adjacent implants 40, 41
 - minimal bone volume 53, **53**
 - provisional restoration 54, 55
 - soft tissue augmentation **92, 93**
 - surgical template 45
- esthetics
 - determinants 40
 - evaluation of surgical complexity 43, **43**
 - patient evaluation 40, 41
 - postextraction procedures 75
- evaluation, patient *see* patient evaluation
- external hexagon connection 20, **20**, 21
- extraoral examination 51
- facial artery 14, 15
 - branches 13, 14, 15
- facial nerve branches 14, 15
- fenestrations 81, 102
- first appointment 51
- fixed partial dentures (FDPs)
 - combined tooth-implant supported 24
 - implant-supported *see* implant-supported fixed partial dentures
 - survival 24, **61**
 - tooth-supported *see* tooth-supported fixed partial dentures
- fixed provisional restorations 54, 55
- fixed restorations, implant-supported
 - edentulous mandible 64, 65, 128
 - edentulous maxilla 66, 67, 129
 - fully edentulous patients 62, 63, **124–5**
- flapless procedure 34, 35
 - computer-guided surgery 77
 - socket preservation 70, 71
- flap techniques
 - socket preservation 70, 71
 - standard implant protocol 72, 73
- foreign body ingestion/aspiration 100, 101, **101**
- fractures, implant 24, 25
- free gingival graft 92, **92, 93**
- fully edentulous patients
 - immediate, early and delayed loading 56, 57
 - number and position of implants 62, 63
 - pediatric 32
 - preoperative imaging **47**
 - treatment planning 62, 63, **124–5**
- gingival graft, free 92, **92, 93**
- glucocorticoids 31, 97
- glucose, blood 28
- Gore-tex™ membranes 80, 81

- greater palatine artery 14, 15
- greater palatine foramen 14, 15
- greater palatine nerve 14, 15
- greenstick fractures, basal 87
- growth factors 83
- guided bone regeneration 80, 81
 - see also* membrane barriers
- hand preparation, surgical team 69, 111
- healing
 - extraction sockets 71
 - during osseointegration 8, 9
 - patients at risk for poor 31
 - peri-implant soft tissue 11
 - standard implant placement protocol 73
 - timing of implant placement and 74
- heart disease 30, 31
- heat resistance, surgical template 45
- Heimlich maneuver 100, 101
- hematoma, postoperative 103
- hemorrhage/bleeding
 - life threatening 101, **101**
 - management **101**
 - prevention, anticoagulated patients 30, **31**
- high lip line 40, 41
- high-risk patients 30–1
- history
 - dental 36, 37
 - medical 29, 112–16
 - periodontal 37
 - tooth loss 35
- HIV infection 31, 33
- horizontal bone augmentation
 - block bone grafts 84, 85
 - guided bone regeneration 81
 - periodontal disease 39
- horizontal bone resorption
 - clinical assessment 16, 17
 - split osteotomy 86, 87
- hydroxyapatite (HA)-coated surface 22, 23
- hypertension 31
- hypodontia 33, 95
- ice packs 98, 99
- iliac crest bone harvesting **85**, 85
- imaging techniques 46, **46**, 47
 - implant monitoring 47
 - preoperative 47, **47**
- immediate-delayed implantation 75, 79, 108
- immediate function implants 55
- immediate implantation 75, 108
 - bone augmentation 79, **79**
 - esthetic outcomes 41
 - guided bone regeneration 81
 - infected sites 35, 37
 - split osteotomy 87
 - surgical technique 74, 75
- immediate loading 56, 57
 - computer-guided surgery 76, 77
 - defined **57**, 108
 - edentulous mandible 65
 - factors influencing success **57**
 - indications 57
- implant(s)
 - defined 108
 - dimensions 18, 19
 - installation 72, 73
 - macrostructure 18–23
 - osseointegration 9
 - shapes 18, 19
 - surfaces 22, 23
- implant/abutment connection 20, **20**, 21
- implant bed, preparation 72, 73
- implant failure 25, 108
 - primary (early) 25
 - radiographic monitoring 106, 107
 - risk factors 32, 33, 39
 - secondary (late) 25
- implant loading *see* loading, implant
- implant restoration, defined 108
- implant shoulder position 35, 59, 73, 75
- implant single crown (ISC) *see* single-tooth replacement
- implant-supported fixed partial dentures (FDPs) 60–1
 - advantages/disadvantages 60
 - complications 61
 - computer-guided surgery 76, 77
 - implant distribution 60, 61
 - implant/natural tooth connection 61
 - indications 61
 - screw-retained *vs* cemented 61, **61**
 - splinting of implants 61
 - survival 24, **61**
- implant-supported prosthesis 108
- implant-supported provisional restoration 55
- implant survival rate (ISR) 24, 25
 - block bone grafts 85
 - bone augmentation 79
 - periodontitis 39
 - postextraction procedures 75
 - risk factors 34, 35
 - sinus floor elevation 89
 - socket preservation 71
 - split osteotomy 87
- implant team 26, 27
 - extended 26, 27
 - leader 27
- incisive canal 12, 13, 15
- incisive foramen 14, 15
- incisive nerve 13
- infected sites
 - adjacent to implant site 37
 - implant placement into 35, 37
- infections
 - peri-implant *see* peri-implantitis
 - perioperative sources 69
- inferior alveolar artery 13
- inferior alveolar nerve 12, 13
 - damage 102, 103
- inflammatory cell infiltrate, implant/abutment connection 20, 21
- informed consent 49
- infraorbital artery 14, 15
- infraorbital nerve 14, 15
- insertion torque values 35, 57
- instrumentation
 - dental implant 73
 - sinus floor elevation 89
 - surgical 69, 110
- interarch relationship 51
- interdental distance (space) 42, 43, 51
 - multiple teeth replacement 52, 53
 - single tooth replacement 52, 53
- interdental papillae
 - esthetic zone 40, 41
 - interproximal space and 35
 - preservation/reconstruction 59
- interimplant distance 35, 41, 52, 53
- internal hexagon connection 20, **20**, 21
- international normalized ratio (INR) **28**, 31
- interocclusal distance 17, 51, 53
- interocclusal relationship, bone resorption and 16
- interproximal brush 104, 105
- interproximal space 35
- intraoral examination 51
- intraoral radiography **46**, 47
- ISC (implant single crown) *see* single-tooth replacement
- ISR *see* implant survival rate
- keratinized mucosa
 - augmentation 92, **92**, 93
 - preoperative evaluation 35, 42, 43
- kidney disease, chronic 31
- laboratory tests **28**
- labyrinthine concussion 87
- lamellar bone 8, 9
- late implantation 108
- lateral pterygoid plate 14
- Lekholm and Zarb classification 16, 17
- length, implant 18, 19, **19**
- lichen planus 31
- life-threatening surgical complications 101, **101**
- lingual foramen 12, 13
- lingual nerve 12, 13
 - damage 103
- loading, implant 9
 - conventional 57, **57**, 108
 - delayed 56, 57
 - early *see* early loading
 - immediate *see* immediate loading
 - implant selection and 52, 53
- load transmission, implant/abutment connection 21
- longevity, implant 24, 25
 - see also* implant survival rate
- long implants 19, **19**, 53
- loss, implant *see* implant failure
- lupus erythematosus 31
- maintenance program 51, 104, 105
- mandible
 - bone quality 17
 - distraction osteogenesis 90, 91
 - edentulous 64, 65, 128
 - fractures 103
 - split osteotomy 86, 87
 - surgical anatomy 12, 13
- mandibular canal 12, 13

- mandibular foramen 12, 13
- marginal bone level 47
- marginal bone loss
 - bone augmentation 79
 - implant/abutment connection and 21
 - radiographs 47, 106, 107
 - smoking and 33
- master model 59
- maxilla
 - bone quality 17
 - edentulous 66, 67, 129
 - split osteotomy 86, 87
 - surgical anatomy 14, 15
- maxillary artery branches 15
- maxillary nerve branches 15
- maxillary sinus 14, 15
 - implant displacement into 103
 - penetration during surgery 102
 - septa 15
 - see also* sinus floor elevation
- maxillary tuberosity 14, 15
- medical evaluation 28, 29
- medical history 29
 - form 112–16
- medical record 49
- medications 96, 97
- membrane barriers 81
 - complications 81
 - peri-implantitis management **107**
 - products and devices 80, 81
 - resorbable and non-resorbable 81, **81**
 - risk of complications 79, **79**
 - sinus floor elevation 88, 89
- mental artery 13
- mental foramen 12, 13
- mental nerve 12, 13
 - damage 103
- mental spines 12, 13
- metronidazole gel 108
- microgap 20, 21
- micromotion, implant 57
- middle superior alveolar nerve 14, 15
- miniscrews, orthodontic 94, **94**, 95
- mobility, implant 107
- modified clear resin tray 54, 55
- monitoring equipment 100, 101
- morphinomimetic drugs 97
- Morse taper connection 20, **20**, 21
- mouth opening, assessment 42, 43
- mouth rinses, antibacterial 105
- mucosa
 - hypertrophic 43
 - peri-implant 10, 11, 35
 - preoperative evaluation 42, 43
 - recession, thin tissue biotype 34, 35
 - see also* keratinized mucosa
- mucositis, peri-implant 25, 107, **107**, 108
- multiple teeth replacement
 - interdental distance 52, 53
 - provisional restoration 54, 55
- NanoTite™ 23
- narrow diameter implants 18, 19, **19**, 53
- nasal cavity 14, 15
- nasal fossa/floor penetration 15, 102
- nasopalatine nerves 14, 15
- neurosensory dysfunction, postoperative 103, **103**
- neurovascular structures
 - mandible 12, 13
 - maxilla 14, 15
- non-steroidal anti-inflammatory drugs (NSAIDs) 97
- occlusion, prosthetic evaluation 51
- one-component implants 20, 21
- one-stage implantation
 - postextraction protocols 74, 75
 - sinus floor elevation 89
 - soft tissue augmentation 93
 - standard protocol 72, 73
- one-stage/simultaneous approach, bone augmentation 78, 79
- open flap debridement (OFD), peri-implantitis **107**, 108
- operating room (OR) 68, 69
 - monitoring and emergency devices 100, 101
- operating room nurse 69
- operating suite 68, 69
- opiates 97
- oral hygiene 37
- orthodontic miniscrews 94, **94**, 95
- orthodontic patients 94, 95
- osseointegration 8, 9, 108
 - loss of 107
 - radiographic evaluation 47
- OsseoSpeed™ surface 22, 23
- Osseotite™ surface 22, 23
- osteoconduction 83, 108
- osteogenesis 56, 57, 108
- osteoinduction 83, 108
- osteonecrosis of jaw, bisphosphonate-related 31
- osteoporosis 33
- osteoproduction 108
- osteoradionecrosis 30
- overdentures
 - defined 108
 - fully edentulous patients 62, 63, **124**, **125**
 - mandibular 64, 65
 - maxillary 66, 67
 - supported by 2 implants 64, 65, 126–7
 - supported by 4 implants 64, 65, 66, 67
 - supported by 6 implants 66, 67
- panoramic radiography 46, 47
- papillae *see* interdental papillae
- paracetamol 97
- parallel technique, periapical radiography 46, 47
- partially edentulous patients
 - bone resorption 16, 17, 36, 37
 - immediate, early and delayed loading 56, 57
 - implant-supported fixed partial dentures 61
 - orthodontic treatment 94, 95
 - preoperative imaging **47**
 - surgical template 45
 - tooth migration 37
- patient evaluation 28–47
 - additional risk factors 34, 35
 - dental history 36, 37
- esthetic considerations 40, 41
- imaging techniques 46, **46**, 47
- implant failure risk 32, 33
- medical evaluation 28, 29
- patients at risk for surgery 30–1
- periodontal compromise 38, 39
- surgical considerations 42, 43, **43**
- surgical template 44, 45
- periapical radiography 46, 47
- peri-implant diseases 107, 108
 - monitoring 106, 107
 - prevention 104, 105
- peri-implantitis 25, 108
 - apical 34
 - risk factors 33, 39
 - treatment 106, 107, **107**
- peri-implant mucositis 25, 107, **107**, 108
- periodontal examination 27, 39
- periodontal history 37
- periodontal ligament 10, 11
- periodontitis
 - esthetic outcomes 41
 - history of treated 32, 33, 38, 39
 - risk factors 39
 - terminal 36, 37
 - treatment plan 38, 39
 - untreated 39
- physical examination 28, 51
- plaque control 37, 104, 105
- platelet-rich plasma 83
- platform, implant 18
- platform switching concept 20, 21
- polyglycolic acid membranes 80, 81
- posterior superior alveolar artery 14, 15
- posterior superior alveolar nerve 14, 15
- postextraction procedures 74, 75
- postoperative complications 102–3
- postoperative management 98, 99
- postoperative patient instructions 99, 122–3
- postoperative patient records 49, 120–1
- precision, surgical template 45
- preoperative checklist 49, **49**
- preoperative patient preparation 69
- prescriptions 96, 97
- pretreatment phase 50, 51
- primary stability 19, 35
 - absent/poor, management 102
 - defined 108
 - immediate implantation 74, 75
 - immediate loading 57
 - risk factors for poor **103**
 - split osteotomy technique 87
- probing depth (PD) 107
- prosthetic-driven implant dentistry 53
- prosthetic evaluation 51
- prosthetic failure 25, 108
- prosthetic survival 25
- provisional restoration 54, 55
 - computer-guided surgery 76, 77
 - fixed solutions 54, 55
 - removable solutions 54, 55
 - soft tissue modeling 58, 59
- quotes, dental 49

- radiographic template 44, 45
 - computer-guided surgery 76, 77
- radiography 46, **46**, 47
 - monitoring of implants 46, 47, 106, 107
 - preoperative 47, **47**
- radiopacity, surgical template 44, 45
- radiotherapy 30, 33
- ramus bone harvesting 84, 85, **85**, 99
- records, patient 48, 49
- removable dentures, postoperative use 98, 99
- removable prostheses, implant-retained
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients 62, 63, **124–5**
 - see also* overdentures
- removable prosthesis, defined 108
- removable provisional restorations 54, 55
- resin-bonded cast metal bridge 54, 55
- Resolut® membranes 80, 81
- respiratory disease 31
- ridge splitting technique *see* split osteotomy
- risk assessment, preoperative 29
- root fracture 37
- rotational flap **92**, 93
- rough implant surfaces 22, 23, 53

- screw-retained restorations
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients **125**
 - implant-supported FDPs 61, **61**
 - single-tooth implants 59
 - see also* abutment screw
- secondary stability 108
- selection, implant 52, 53, **53**
- short implants 19, **19**, 52, 53
- single-tooth replacement (ISC) 58, 59
 - anterior 58, 59
 - complications 24, 25
 - contraindications 59
 - indications 59
 - interdental distance 52, 53
 - posterior 59
 - provisional restoration 54, 55
 - split osteotomy 86
 - survival 24, 25, **61**
- sinus floor elevation 15, 88, 89
 - lateral approach 88, 89
 - postoperative care 99
 - risk of complications **79**
 - transalveolar approach 88, 89
- SLActive™ surface 23
- SLA™ surface 22
- smile line, evaluation 40, 41
- smoking 32, 33, 39, 89
- smooth machined implant surfaces 22, 23
- socket preservation 70, 71
- soft tissue
 - augmentation 39, 41, 92, 93
 - biotype *see* biotype, tissue
 - complications 24, 25
 - keratinized *see* keratinized mucosa
 - modeling, provisional restoration and 58, 59
 - peri-implant 10, 11
 - position 41
 - thickness 34, 35, 40, 41
- splinting, implant 61
- split osteotomy (split ridge technique) **79**, 86, 87
- stability, implant 35
 - assessment 35
 - evolution over time 56, 57
 - primary *see* primary stability
 - secondary 108
- stability, surgical template 45
- staged approach, provisional restoration 55
- standard dental implant protocol 72, 73
- sterile team, preparation 111
- sterility, surgical 69
- Steri-Oss HA-coated surface 23
- steroids 31, 97
- stress reduction **31**, 31
- subepithelial connective tissue graft (SECTG) **92**, 93
- sublingual artery 13, 101
- submental artery 13, 101
- success, implant 24, 25, **25**
- superior labial artery 14, 15
- surface amplitude (S_a) 23
- surfaces, implant 22, 23
 - chemical modifications 22, 23
 - topography 22, 23
- surgery
 - patients at risk 30–1
 - preoperative evaluation 42, 43, **43**
- surgical accessibility 42, 43
- surgical complications 102–3
 - life threatening 101, **101**
 - peroperative 102
 - postoperative 102–3
 - prevention **103**
 - rare 103
 - risk assessment 29
- surgical environment 68, 69
- surgical evaluation 51
- surgical guides 44, 45
- surgical planning form 48, 49
- surgical table, preparation 69, 110
- surgical team 69
 - preparation 69, 111
- surgical techniques 70–93
 - bone augmentation *see* bone augmentation
 - computer-guided surgery 76, 76–7
 - implants in postextraction sites 74, 75
 - socket preservation 70, 71
 - standard protocol 72, 73
- surgical template 44, 45
 - computer-guided surgery 76, 77
- survival *see* implant survival rate; prosthetic survival

- tapered implants 19
- team *see* implant team; surgical team
- teeth-retained prosthesis 108
 - see also* tooth-supported fixed partial dentures
- temporary partial denture 54, 55
- temporary restoration *see* provisional restoration
- tetracycline hydrochloride **107**, 108
- thin implants *see* narrow diameter implants

- thin tissue biotype
 - esthetic risk 40, 41
 - mucosal recession risk 34, 35
 - soft tissue augmentation 92, 93
- thread designs, implant 18, 19
- three-dimensional jaw reconstruction 76, 77
- three-dimensional positioning of implant, esthetic zone 40, 41
- TiOblast™ surface 23
- tissue biotype *see* biotype, tissue
- titanium 23
- titanium-reinforced e-PTFE membranes 80, 81
- TiUnite™ surface 22, 23
- tomography 47
 - conventional 46, **46**, 47
 - preoperative examination 47, **47**
 - see also* computed tomography
- tooth agenesis 32, 33, 95
- tooth brushing 99, 104, 105
- tooth extraction
 - anticoagulated patients 30
 - periodontally compromised patients 39
 - postextraction implantation 74, 75
 - socket preservation after 70, 71
 - timing of bone augmentation after 75, 79
 - timing of implant placement after 79
 - tissue modification after 40, 41
- tooth–implant distance 35, 53
- tooth loss
 - history of 37
 - see also* edentulism
- tooth migration 37, 42, 43
- tooth-supported fixed partial dentures (FDPs)
 - advantages/disadvantages 59
 - survival 24, 25, **61**
 - see also* bridge(s)
- tooth-supported provisional restoration 54, 55
- topography, implant surface 22, 23
- traceability, dental implants 49
- transitional implants 55
- transplant recipients 30–1
- traumatic tooth loss 36, 37
- treatment plan 50, 51
 - edentulous mandible 64, 65
 - edentulous maxilla 66, 67
 - fully edentulous patients 62, 63, **124–5**
 - immediate, early and delayed loading 56, 57
 - implant selection 52, 53, **53**
 - implant-supported fixed partial denture 60, 60–1
 - periodontally compromised patients 38, 39
 - provisional phase 54, 55
 - records required 49
 - single-tooth replacement 58, 59
- tripod configuration 52, 53
- two-component implants 20, 21
- two-stage implantation
 - block bone grafts 85
 - fully edentulous patients 63
 - sinus floor elevation 88, 89
 - soft tissue augmentation 93
 - standard protocol 72, 73
- two-stage/staged approach, bone augmentation 78, 79

- vertical bone augmentation
 - block bone grafts 85
 - distraction osteogenesis 90, 91
 - esthetic limitations 41
 - guided bone regeneration 81
 - periodontal disease 39
- vertical bone resorption 16, 17
- vertical dimension, collapsed 62, 63
- vertigo, benign positional 87
- vestibule, shallow 92, 93
- virtual surgery 76, 77
- vital signs **28**
 - monitor 100, 101
- wide diameter implants 18, 19, **19**, 53
- wound closure 72, 73
- wound dehiscence 102–3
- wound healing *see* healing
- woven bone, formation 8, 9
- xenografts
 - bone 83, 89
 - defined 108
- X-rays *see* radiography