Stefan Wolfart
Bilal Al-Nawas



International Team for Implantology

# Managing Fully Edentulous Patients

**EDITORS**
Daniel Wismeijer
Stephen Barter
Nikolaos Donos

QUINTESSENCE PUBLISHING

Berlin | Chicago | Tokyo
Barcelona | London | Milan | Paris | Prague | Seoul | Warsaw
*Beijing | Istanbul | Sao Paulo | Sydney | Zagreb*

The German National Library has listed this publication in the German National Bibliography. Detailed bibliographical data are available at https://dnb.ddb.de.

A CIP record for this book is available from the British Library.
ISBN 978-1-78698-132-5

QUINTESSENCE PUBLISHING DEUTSCHLAND


Ifenpfad 2–4
12107 Berlin
Germany
www.quintessence-publishing.com

Quintessence Publishing Co Ltd
Grafton Road, New Malden
Surrey KT3 3AB
United Kingdom
www.quintessence-publishing.com



| | |
|---|---|
| Illustrations: | Ute Drewes, Basel (CH), www.drewes.ch |
| Copyediting: | Triacom Dental, Barendorf (DE), www.triacom.com |
| Layout \| Production: | Janina Kuhn, Berlin (DE) |
| Printer: | Grafički zavod Hrvatske<br>Mičevečka ulica 7<br>HR-10000 Zagreb, Croatia<br>www.gzh.hr |

Printed in Croatia
ISBN 978-1-78698-132-5

The materials offered in the ITI Treatment Guide are for educational purposes only and intended as a step-by-step guide to the treatment of a particular case and patient situation. These recommendations are based on the conclusions of the ITI Consensus Conferences and, as such, are in line with the ITI treatment philosophy. These recommendations, nevertheless, represent the opinions of the authors. Neither the ITI nor the authors, editors, or publishers make any representation or warranty for the completeness or accuracy of the published materials and as a consequence do not accept any liability for damages (including, without limitation, direct, indirect, special, consequential, or incidental damages or loss of profits) caused by the use of the information contained in the ITI Treatment Guide. The information contained in the ITI Treatment Guide cannot replace an individual assessment by a clinician and its use for the treatment of patients is therefore the sole responsibility of the clinician.

The inclusion of or reference to a particular product, method, technique or material relating to such products, methods, or techniques in the ITI Treatment Guide does not represent a recommendation or an endorsement of the values, features, or claims made by its respective manufacturers.



The tooth identification system used in this ITI Treatment Guide is that of the FDI World Dental Federation.

# The ITI Mission is …

"… to empower dental professionals globally through a collaborative network, cutting-edge education, innovative research, and to cultivate leaders committed to evidence-based practices."

# Acknowledgement

The authors would like to express their gratitude to Dr. Kati Benthaus for her excellent support in the preparation and coordination of this Treatment Guide. We would also like to thank Ms. Ute Drewes for the professional illustrations, Ms. Janina Kuhn (Quintessence Publishing) for the typesetting and Ms. Änne Kappeler (Quintessence Publishing) for the coordination of the production workflow and Mr. Per N. Döhler (Triacom Dental) for the language editing.

# Preface

The use of dental implants to provide edentulous patients with better function, comfort, and appearance, can also result in considerable improvements in the confidence and self-esteem of this patient group. When such treatment is carefully planned and executed, the resulting psychosocial benefit could be truly life changing. This makes the successful treatment of the edentulous patient one of the most satisfying treatment options for both patient and clinician.

The possibilities for treatment range from the simplest to highly complex. Since the McGill Consensus Conference 2002, the implant-supported overdenture has been accepted as the basic treatment of choice for edentulous patients. As both experience and research have shown us, we are not limited to standard implants; short, narrow, tilted/angled, or even zygoma implants can all be used when treating the edentulous patient to provide complete fixed reconstructions.

The challenges in all such treatments are often substantial; the changes in volume and morphology of both hard and soft tissues, as well as facial appearance, present with a number of factors to be considered. Treatment planning is as important as ever, but equally important is the need to explain to and decide with the patient how best their needs and expectations can be fulfilled.

To help the clinician in the decision-making process, this Volume 15 of the ITI Treatment Guide series introduces the “Patient Profile”: a tool that can be used in finding the best option for each individual patient.

In addition, as we move further into an increasingly digital therapeutic environment, technologies that can be used to improve the quality of treatment, with potential reductions in complexity, risk, cost, and morbidity, are also discussed.

Successful treatment is not produced at the delivery of the final prosthesis; the benefits described, together with potential overall health benefits from improved function and a better diet, are measured over years and decades. How the outcomes of treatment will endure as the patient ages and becomes less able to manage the essential home-performed maintenance, will be key considerations if we are to prevent dental disability later in life.

Based on the clinical recommendations of the 6th and 7th ITI Consensus Conferences in Amsterdam (2018) and Lisbon (2023), in this Volume 15 of the ITI Treatment Guide series the reader will find step-by-step clinical cases based on the available evidence, performed by experts in the field, focussing on the various up-to-date treatment options in order to successfully treat edentulous patients.

D. Wismeijer

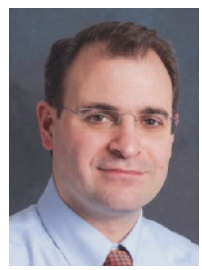
S. Barter

N. Donos

# Editors and Authors

## EDITORS

**Daniel Wismeijer, Prof, DMD, PhD**
Referral Practice for Oral Implantology and Prosthetic Dentistry
De Veluwezoom
p/a Zutphensestraatweg 26
6955 AH Ellecom
The Netherlands
danwismeijer@gmail.com

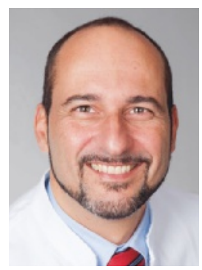


**Nikolaos Donos, DDS, MS, FHEA, FDSRCSEngl, PhD**
Director of Research
Professor and Chair of Periodontology and Implant Dentistry
Head of Clinical Research
Centre for Oral Clinical Research
Institute of Dentistry
Faculty of Medicine and Dentistry
Turner Street
London E1 2AD
United Kingdom
n.donos@qmul.ac.uk

**Stephen Barter, BDS, MSurgDent, RCS**
Specialist in Oral Surgery
Honorary Senior Clinical Lecturer / Consultant Oral Surgeon
Centre for Oral Clinical Research
Institute of Dentistry
Faculty of Medicine and Dentistry
Turner Street
London E1 2AD
United Kingdom
s.barter@gmx.com

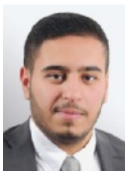
## AUTHORS

**Stefan Wolfart, Univ-Prof, Dr med dent**
Head and Chair of the Clinic of Prosthodontics and Biomaterials
Center for Implantology
University Hospital Aachen
Pauwelsstrasse 30
52074 Aachen
Germany
swolfart@ukaachen.de



**Bilal Al-Nawas, Univ-Prof, Dr med, Dr med dent**
Medical Director, Department of Oral, Maxillofacial and Plastic Surgery
University Medical Center of Johannes Gutenberg University
Augustusplatz 2
55131 Mainz
Germany
al-nawas@uni-mainz.de

# Contributors



**Abdullah Ali A. Alehaideb, DMD, MS, FRCDC**
Department of Prosthodontics
Security Forces Hospital
Riyadh
Saudi Arabia
abdullah.alehaideb@gmail.com

**Carlos Aparicio, MD, DDS, MSc, MSc, DLT, PhD**
Visiting Research Professor
Indiana University School of Dentistry
Indianapolis, IN 46202
USA

Director of the Zygomatic Unit at Hepler
Bone Clinic, ZAGA Center Barcelona
Roman Macaya 22-24
08022 Barcelona
Spain
carlos.aparicio@zygomaticimplants.org

**Arne F. Boeckler, Prof Dr med dent habil, DMD, PhD**
Zahnzentrum Halle
Lafontainestraße 20
06114 Halle (Saale)
Germany
arne.boeckler@zahnzentrum-halle.de

**João Caramês, DMD, PhD**
Full Professor
Dean of the Faculty of Dental Medicine
Lisbon University
1649-003 Lisbon
Portugal
carames@campus.ul.pt

Implantology Institute
Av. Columbano Bordalo Pinheiro, nº 50
1070-064 Lisbon
Portugal

**Paolo Casentini, DDS, Dr med dent**
Private practice
Studio Dr Paolo Casentini
(Implantology, Oral Surgery, Periodontology, Esthetic Dentistry)
Via Anco Marzio 2
20123 Milan
Italy
paolocasentini@fastwebnet.it

**Matteo Chiapasco, MD**
Professor, Unit of Oral Surgery
Department of Biomedical, Surgical and Dental Sciences
University of Milan
Via della Commenda 10
20122 Milan
Italy
matteo.chiapasco@unimi.it

**Tommaso Ghedini, DDS, MClinDent Oral Surgery**
Adjunct Professor MED School — Humanitas University
Department of Oral Surgery
Humanitas Dental Center
via Rita Levi Montalcini 4
20072 Pieve Emanuele (Milan)
Italy
tommaso.ghedini@hunimed.eu

**Pauline Gutmann, Dr med dent**
Associate Professor
Department of Prosthodontics
Center for Oral Medicine (Carolinum)
Faculty of Medicine at Goethe-University
Theodor-Stern-Kai 7, building # 29
60596 Frankfurt am Main
Germany
gutmann@med.uni-frankfurt.de

**Matthias Kern[†],**
**Prof Dr med dent habil, FADM**

**Henny J.A. Meijer, Prof Dr**
Department of Oral and Maxillofacial Surgery
and Department of Restorative Dentistry
University Medical Center Groningen
University of Groningen
Hanzeplein 1
9713 GZ Groningen
The Netherlands
h.j.a.meijer@umcg.nl

**Dean Morton, BDS, MS, FACP**
Indiana Dental Association Endowed
Professor, Department of Prosthodontics
Director, Center for Implant, Esthetic and
Innovative Dentistry
Indiana University School of Dentistry
1121 W Michigan Street, DS-S408
Indianapolis, IN 46202
USA
deamorto@iu.edu

**Puria Parvini, Prof Dr med dent habil,**
**MSc, MSc**
Assistant Director
Department of Oral Surgery & Implantology
Center for Oral Medicine (Carolinum)
Faculty of Medicine at Goethe-University
Theodor-Stern-Kai 7, building # 29
60596 Frankfurt am Main
Germany
parvini@med.uni-frankfurt.de

**Thorsten Peter, MSc of Dental Technology,**
**MDT**
Head of Department of Dental Technology
Center for Oral Medicine (Carolinum)
Faculty of Medicine at Goethe-University
Theodor-Stern-Kai 7, building # 29
60596 Frankfurt am Main
Germany
t.peter@med.uni-frankfurt.de

**Waldemar D. Polido, DDS, MS, PhD**
Clinical Professor, Department of Oral and
Maxillofacial Surgery and Hospital Dentistry
Co-Director, Center for Implant, Esthetic and
Innovative Dentistry
Indiana University School of Dentistry
1121 W Michigan Street, DS 109
Indianapolis, IN 46202
USA
wdpolido@iu.edu

**Clemens Raabe, Dr med dent, MAS**
Senior Oral Surgeon and Lecturer
Department of Oral Surgery and Stomatology
School of Dental Medicine
University of Bern
Freiburgstrasse 7
3010 Bern
Switzerland
clemens.raabe@unibe.ch

**Gerry M. Raghoebar, DMD, MD, PhD**
Department of Oral and Maxillofacial Surgery
University of Groningen
University Medical Center Groningen
Hanzeplein 1
9713 GZ Groningen
The Netherlands
g.m.raghoebar@umcg.nl

**Said Arturo Sánchez, DDS**
Specialty in Prosthodontics and Implant Surgery
Private Practice, ProstoPerio Grupo Dental
37130 León
Mexico

Clinical Professor and lecturer
La Salle Bajío University
3602 Juan Alonso de Torres
37458 León
Mexico
said.arturo.sz@gmail.com

**Nicole Schenk, Dr med dent, MAS**
Department of Reconstructive Dentistry and Gerodontology
School of Dental Medicine
University of Bern
Freiburgstrasse 7
3010 Bern
Switzerland
nicole.schenk@unibe.ch

**Martin Schimmel, Prof Dr med dent, MAS Oral Biol**
Chairman, Department of Reconstructive Dentistry and Gerodontology
School of Dental Medicine
University of Bern
Freiburgstrasse 7
3010 Bern
Switzerland
martin.schimmel@unibe.ch

**Wim Slot, DMD, PhD**
University Medical Center Groningen
Oral Surgery and Implantology
Center for Dentistry and Oral Hygiene
Antonius Deusinglaan 1
9713 AV Groningen
The Netherlands
j.w.a.slot@umcg.nl

**Paul Weigl, Dr med dent, PhD**
Head of Department of Postgraduate Education
Head of Department of Medical Technology Research
Center for Oral Medicine (Carolinum)
Faculty of Medicine at Goethe-University
Theodor-Stern-Kai 7, building # 29
60596 Frankfurt am Main
Germany
weigl@em.uni-frankfurt.de

# Table of Contents

# 1 Introduction

S. Wolfart, B. Al-Nawas

The dental health of the population has improved continuously over the past decades. Global disparities in dental health are shaped by access to care, socioeconomic status, public health policies, and cultural factors. While high-income countries have made considerable progress in reducing dental diseases and improving care, many low- and middle-income countries still face serious challenges. In Germany, for example, the proportion of completely edentulous patients in the 65–74 age group decreased from 23% in 2005 to 12% in 2014 and to 5% in 2025 (Micheelis and Schiffner 2006; Jordan and Micheelis 2016; Jordan and coworkers 2025).

In contrast to this, in middle and low-income countries the disease burden of edentulism is high. The World Health Organization (WHO) has estimated that the global prevalence of edentulous adults aged ≥ 60 is 23% (WHO 2023). Many of the factors that contribute to edentulism are preventable and unequally distributed. Globally, patient demand for dental restorations and a good oral health-related quality of life has increased significantly.

Implant treatment options for the edentulous jaw range from implant-supported overdentures to implant-supported fixed restorations. The surgical, prosthetic, and laboratory effort required to place an implant-supported prosthesis varies considerably, depending on the initial clinical/anatomical situation. Extensive augmentation techniques in conjunction with standard implants can be as justified today as the conscious avoidance of augmentation. Short or narrow implants, tilted/angled implants, or zygomatic implants can all be used.

The current surgical and prosthetic treatment options are supported by scientific evidence, resulting in a wide "corridor" for the treatment of the edentulous jaw. Therefore, it is clearly inadequate to consider only the long-term performance and complication rates of different treatment modalities. Instead, patient-related parameters such as the patient's oral health-related quality of life, desires, abilities, and resources must be considered to determine the most appropriate treatment for the individual patient. In high-income countries, the desire for a certain "comfort level" for the patient, i.e., a specific treatment approach, is associated with different levels of invasiveness, treatment time, and cost. The patient's manual dexterity and ability to maintain adequate oral hygiene and care must also be considered. This complex decision-making process is supported in this Treatment Guide by the "patient profile" concept. The decision tree is visually structured by assigning "patient types" to appropriate surgical and prosthetic treatment concepts.

Modern digital technologies, such as CBCT combined with superimposed STL surface data from intraoral scanners, improve the planning accuracy and predictability of surgical and prosthetic treatments. Many contemporary treatment concepts, such as the combination of immediate implant placement and immediate loading, are made more predictable by these technologies. In addition, statically guided implant placement typically reduces surgical time significantly, which can have a positive impact on postoperative discomfort. Three-dimensional planning of the surgical procedure can also make patient education more effective. Last but not least, digital technologies open up new possibilities in dental technology, which can improve the quality of the treatment.

The follow-up and maintenance period begins with the delivery of the implant-supported restoration. Follow-up is often restoration-specific. The clinician should become familiar with the respective maintenance regimen early and communicate it to the patient. In this way, the patient will know what to expect after treatment, and the time and cost involved.

This ITI Treatment Guide aims to systematically discuss the surgical and prosthetic rehabilitation of edentulous patients with dental implants on the basis of currently available scientific evidence, with a consistent focus on patient-related outcomes. The necessary differential diagnoses, implant prosthetic planning, and treatment procedures are presented in detail by internationally renowned clinicians as exemplified by actual cases.

The clinical recommendations of the 6th and 7th ITI Consensus Conferences in Amsterdam (2018) and Lisbon (2023) on the edentulous patient have also been incorporated into this Treatment Guide and play a key role in shaping the structure and recommendations of this book.

# 2 Basic Principles

S. Wolfart, B. Al-Nawas

# 2.1 Patient Selection

S. Wolfart

## 2.1.1 Incidence of Edentulism

The global prevalence of edentulism has decreased over the past few decades due to improvements in dental care and preventive measures. However, it is still estimated that approximately 7–20% of the world's adult population is edentulous, with much higher rates among older adults (GBD 2017). At the same time, patient demand for dental restorations and good oral health-related quality of life has increased significantly. Today, complete dentures are associated with unsatisfactory chewing ability, speech problems, psychological distress, and social impairment (Albaker 2013).

There are large regional differences. In wealthier countries, such as the United States, Canada, and Western Europe, the prevalence of edentulism has declined significantly in recent decades. Improved access to preventive dental care, public health initiatives such as fluoridation, and advances in dental treatments have contributed to this decline. For example, in the United States, the prevalence of complete tooth loss among adults aged 65 and older declined from 50% in the early 1960s to approximately 13–15% by the 2010s (CDC 2015). Similar trends have been observed in Australia and New Zealand, where public health interventions, improved oral hygiene, and access to dental services have led to reductions in edentulism rates (AIHW 2016). Norway, Sweden, and Denmark have some of the lowest edentulism rates in the world, due to strong public health systems and access to high-quality dental care. In these countries, edentulism among older adults has declined to 5–10% in recent decades (Pitts and coworkers 2011).

However, in many low-income regions, such as sub-Saharan Africa and parts of South Asia, edentulism is still a significant problem due to limited access to dental care and preventive services. Rural areas and low-income populations are particularly vulnerable, with edentulism rates often exceeding 20–40% among older adults. Countries such as Brazil, despite significant advances in public health and dental care, still report relatively high rates of edentulism among older adults, with rates as high as 20–30% in certain regions.

In Southeast Asian countries such as India, Indonesia, and the Philippines, edentulism remains prevalent, particularly among older adults and low-income populations. Limited access to dental care as well as high rates of dental caries and periodontal disease contribute to higher rates of tooth loss.

The global prevalence of edentulism is steadily declining in high-income countries due to improved access to dental care, preventive measures, and public health interventions. However, edentulism remains a significant problem in low- and middle-income countries, particularly among older adults, rural populations, and low-income groups. Efforts to improve access to dental care, oral-health education, and preventive public-health measures will be critical in reducing global disparities in edentulism.

## 2.1.2 Patient-Related Metrics and Patient-Related Outcomes

**INTRODUCTORY REMARKS**

Given the wide range of clinical options, from complete dentures to implant-supported overdentures and implant-supported fixed dental prostheses, it is essential to consider patient-related factors such as quality of life and comfort. In addition, the degree of invasiveness, cost, and time required for each treatment option must be taken into account. Only by considering these aspects can clinical decisions be effectively tailored to meet the unique needs of each individual patient.

Patient-reported outcomes (PROs) are commonly used for such patient-centered outcome analyses. In the medical field, PROs describe health outcomes that come directly from patients without interpretation by another person. These PROs are collected using various patient-reported outcome measures (PROMs), which are the tools used to collect PROs. In dentistry, specific dental patient-reported outcome measures (dPROMs) are used to measure the patient-reported outcomes of dental care (dPROs). However, the terms "dPROs" and “dPROMs” are often used interchangeably (Schimmel and coworkers 2023).

These patient-related measures include satisfaction with oral health or treatment status as well as other non-clinical assessments, such as satisfaction with treatment esthetics, speech, and masticatory function (Lang and Zitzmann 2012; McGrath and coworkers 2012),

### METRICS REPORTED IN CLINICAL TRIALS

Messias and coworkers (2022) used the example of the edentulous jaw with removable or fixed restorations to examine how often these metrics have been used in clinical trials since the definition of dPROMs. Implant failure or survival was the most frequently reported outcome (270 studies). Marginal bone levels, technical complications, and clinical parameters (e.g., assessment of peri-implant soft-tissue and implant stability) were also frequently reported. By contrast, patient-related data were evaluated in only 145 studies and function-based assessments in only 40 studies. While quality of life was assessed using validated instruments, patient satisfaction was assessed using a “common-sense” concept of satisfaction. Economic outcomes were least frequently reported (13 studies) (Messias and coworkers 2022).

To gain a better understanding of the impact of different treatment options on patients, the currently available scientific evidence is presented here, organized by treatment options. Due to the anatomical differences, the maxilla and mandible will be considered separately.

### COMPLETE DENTURE

In terms of oral health-related quality of life, patients with complete dentures in both jaws are generally less satisfied than patients with only one complete denture in the maxilla or mandible. Difficulty in biting or chewing food was reported by 79% of study participants, a large proportion of whom were embarrassed to eat in front of others. 45% of study participants reported difficulty speaking with the denture (Albaker 2013).

Most studies on the edentulous mandible show significantly better patient satisfaction and better oral health-related quality of life with implant overdentures compared with complete dentures (Assunção and coworkers 2010). In contrast, complete dentures in the maxilla tend to be well accepted by patients (Thomason and coworkers 2007). A systematic review showed that in patients who are generally comfortable with their complete dentures and have a suitable alveolar ridge, an implant overdenture does not significantly improve function, stability, or patient comfort (Andreiotelli and coworkers 2010). This is contradicted by the findings of Zembic and Wismeijer (2014), who demonstrated an improvement in oral health-related quality of life between newly fabricated complete dentures when these were retained via two Locators in the maxilla. In addition, overall satisfaction with the restoration, chewing function, speech, and denture stability improved (Zembic and Wismeijer 2014).

In summary, a complete denture can be considered a reasonable option in the maxilla when anatomic conditions are favorable, but it is usually not an adequate solution in the mandible. Ultimately, financial aspects and resilience factors also influence a patient’s decision for or against an implant-supported overdenture as an alternative to a complete denture (Sharka and coworkers 2019).

### MANDIBULAR IMPLANT OVERDENTURE

Already in the 1990s, Wismeijer and co-workers (1995, 1997 and 1999) demonstrated that implants improve the support, retention, and stability of mandibular dentures in edentulous patients and improve patient satisfaction. There is now ample evidence that mandibular implant-supported overdentures can result in higher satisfaction, improved quality of life, or other improved dPROs compared to conventional complete dentures (De Bruyn and coworkers 2015). Specifically, an overdenture supported by two interforaminal implants shows improvements regarding comfort, speech, stability, and masticatory function. In terms of esthetic appearance, there was no improvement over the complete denture. There was even a subjective deterioration in oral hygiene (Egido Moreno and coworkers 2021).

Based on existing studies, an overdenture on two implants is considered the first choice for the treatment of the completely edentulous mandible (Feine and coworkers 2002).

To evaluate the appropriate number of implants to support the overdenture in the edentulous mandible, several studies have investigated overdentures supported by no, one, two, or three implants, assessing masticatory function and oral health-related quality of life. Masticatory performance and oral health-related quality of life improved regardless of the number of implants (one, two, three, or four) (Wismeijer 1996). The best masticatory performance was achieved with two implants (Passia and coworkers 2022). A multicenter study with more than 150 patients also showed a significant improvement in both prosthetic satisfaction and masticatory function for the mandible with a single midline implant and a ball attachment (Passia and coworkers 2017a; Passia and coworkers 2017b).

These results are supported by a recent meta-analysis. Support by a single implant results in better oral health-related quality of life and satisfaction compared with a complete denture. Mandibular prostheses supported by either one or two implants showed no significant differences in terms of satisfaction with speech, comfort, esthetics, and social life. However, prostheses supported by two implants showed better masticatory performance (Fu and coworkers 2021).

In an early crossover clinical trial first reported in 2000, 18 edentulous subjects with complaints about their mandibular dentures received two implants and a new denture with magnet, ball, or bar/clip attachments that were placed in random order. At the end of the study, the attachment type of their choice was placed in the overdenture. After 10 years, 7 subjects with a ball and 7 subjects with a bar/clip attachment were available for evaluation. Four subjects were lost to follow up. There was no significant difference in satisfaction between subjects with ball-attachment and bar/clip-retained mandibular overdentures at initial evaluation and after 10 years of function. Patient appreciation of implant-supported dentures was high and remained high over time (Cune and coworkers 2010).

In another crossover study, 30 patients received three different overdentures for 1 year each. Support was provided by either four implants splinted with a bar, two implants splinted with a bar, or two ball attachments. Restorations with two ball attachments were rated equal to or better than bar restorations for most metrics, with the bar on four implants showing the highest retention. After wearing all options, patients reported the highest satisfaction with ball attachments (Burns and coworkers 2011).

### MANDIBULAR IMPLANT-SUPPORTED FIXED DENTAL PROSTHESIS

Fixed mandibular restorations were rated better than overdentures in three quality-of-life subscales: functional limitations, physical disability, and physical pain. Fixed restorations also improved satisfaction in terms of comfort, mastication, retention, and stability compared to overdentures. The same was true for overall oral health-related quality of life and patient satisfaction. Only satisfaction with cleanability was better for overdentures (Borges and coworkers 2022). In clinical cases where both options are considered, patient expectations and cost should be the determining factors in deciding which treatment option to choose (Tsigarida and coworkers 2021).

### MAXILLARY IMPLANT OVERDENTURE

Removable restorations in the maxilla can be supported on implants using either ball attachments, bar attachments, or telescopic crowns. In situations where only two Locators are used for support, good oral health-related quality of life scores were achieved, but functional limitations can be expected. This may be due to the linear axis of rotation around the two fixtures, which has a detrimental impact on function (Zembic and coworkers 2019). This linear axis primarily causes the denture to tilt during biting with the anterior teeth, which are typically positioned anterior to the alveolar ridge. The more the denture tilts, the more likely it is that the attachments will loosen at the same time.

However, even with an overdenture supported on four implants with Locators, inconsistent results were seen. Within a 5-year observation period, a significant number of implant losses (19%), prosthetic complications (44%), and refabrications (15%) occurred. After 5 years, oral health-related quality of life deteriorated as a result and returned to the baseline levels achieved with complete dentures (Bouhy and coworkers 2023).

Other studies collected dPROs using only unvalidated patient satisfaction questionnaires. For example, Zou and coworkers (2013) tested different anchorage systems (telescopes, bars, and Locators) supported by four implants each in the maxilla over a 3-year observation period. Patients reported being "completely satisfied" with their restorations in terms of comfort, speech, and function.

Patients treated with bar-supported overdentures on four or six implants reported a significant improvement in terms of prosthetic satisfaction and chewing ability compared with complete dentures (Boven and coworkers 2017; Slot and coworkers 2016; Slot and coworkers 2019).

Anchoring maxillary overdentures on six implants with implant-supported telescopic crowns also resulted in a significant improvement in patient satisfaction compared to baseline with a complete denture. This high level of satisfaction remained stable over the 5-year observation period (Eerdekens and coworkers 2014).

### MAXILLARY IMPLANT-SUPPORTED FIXED DENTAL PROSTHESIS

The data for the edentulous maxilla are not as conclusive as for the edentulous mandible. However, there are isolated studies that do not measure oral health-related quality of life but measure patient satisfaction through questionnaires. For example, patients with fixed restorations on six to eight implants for more than 8 years in function reported high overall satisfaction with function, esthetics, speech, and restorations (Mertens and Steveling 2011). Zhang and coworkers (2016) also found excellent patient satisfaction with multi-unit FDPs, 10 years after loading, in terms of esthetics, comfort, masticatory ability, and overall satisfaction.

In the field of immediate restorations, a recent systematic review analyzed the treatment of edentulous patients using the all-on-four concept. The 693 patients included in the review demonstrated high levels of oral health-related quality of life and patient satisfaction (Gonçalves and coworkers 2022).

### PALATE-FREE DESIGN FOR REMOVABLE PROSTHESIS

When a patient receives a removable prosthesis, the question arises as to whether the prosthesis should be designed to cover the palate or leave the palate exposed. A covered palate has advantages in terms of inherent and positional stability of the prosthesis. In contrast, a palate-free design supports improved patient articulation, especially for "S"-type sounds

(Fonteyne and coworkers 2019). Taste perception is also rated better by patients (Zembic and coworkers 2015). The clinical implementation of the palate-free design has been successfully implemented with four to six implants and a supporting polygonal framework in some clinical studies (Sadowsky and Zitzmann 2016).

In terms of improved speech function (articulation) and taste perception, a palate-free design is recommended, based on scientific evidence, when four to six well-distributed implants are available to support a removable prosthesis.

### REMOVABLE VS. FIXED RESTORATIONS

A recent systematic review compared dPROs regarding implant-supported overdentures and implant-supported fixed restorations from 8 prospective and 5 retrospective studies. In general, the two types of restorations showed no significant differences when comparing dPROs, with a slight trend toward the superiority for fixed restorations. However, conflicting results were observed for aspects such as chewing function, speech function, overall satisfaction, and esthetics (Yao and coworkers 2018). For example, most patients preferred the maxillary removable overdenture to the fixed restoration. This was due to was better speech function and ease of cleaning (Heydecke and coworkers 2003).

In summary, the absolute advantage of fixed or removable implant-supported restorations is not evident from patient-reported metrics, especially since factors such as patient preferences and expectations play a key role (Yao and coworkers 2018).

### PATIENT FACTORS AND TREATMENT DECISIONS

The attitude of the edentulous patient is important in the decision for or against an implant-supported restoration. Patients are more likely to choose implant-supported restorations if they explicitly request implant therapy or are unable to adapt to or tolerate a complete denture. Financial aspects and adaptability also influence patient tolerance of both treatment modalities (Sharka and coworkers 2019). Education, income, and patient-perceived quality of life are potential predictors of edentulous patients' preferences for implant rehabilitation. These factors may be important for clinicians to consider when planning treatment for edentulous patients (Leles and coworkers 2019).

### LEVEL OF INVASIVENESS TOLERATED BY EDENTULOUS PATIENTS

Particularly in the implant treatment of the edentulous jaw, more invasive augmentation techniques should be weighed against minimally invasive placement techniques, depending on the patient type. In this context, a review article included 37 studies reporting on minimally invasive implant treatment. Patient satisfaction averaged 91% with flapless implant placement, 89% with short implants, 87% with narrow-diameter implants, 90% with a reduced number of implants, 94% with tilted implant placement, and 83% with zygomatic fixtures.

An indirect comparison showed that patients tended to prefer tilted implant placement to a reduced number of implants or to zygomatic implants. Although this comparison did not provide direct evidence of patient preference for minimally invasive treatment alternatives over surgical bone augmentation, it can be concluded that patient satisfaction with non-graft solutions is generally high (Pommer and coworkers 2014).

This underscores the need to balance the use of less invasive treatment approaches with more complex augmentation procedures, often involving extraoral grafts. Three-dimensional radiographs, combined with a prosthesis-oriented set-up, can be valuable in this complex decision-making process (see Chapter 3.1 for details).

### CLINICAL RECOMMENDATIONS BASED ON DPROS

In summary, the current data on dPROs in edentulous patients are good, allowing important clinical recommendations to be derived, which were formulated at the 7th ITI Consensus Conference (2023) as follows:

**Clinical recommendation 1**

In fully edentulous patients, based on dPROs, both complete implant-supported fixed dental prostheses and implant overdentures result in an improvement in stability and comfort compared to complete dentures. For the highest levels of stability, retention, and comfort, complete implant-supported fixed dental prostheses may be recommended over implant overdentures whenever clinically indicated. Clinical decisions should also consider other relevant factors including speech, esthetic concerns, prosthetic space requirements, costs, stability, retention, maintenance requirements, and manual dexterity. Continuous assessment of the patient's ability to manage the prosthesis and maintain plaque control should be performed (Schimmel and coworkers 2023).

**Clinical recommendation 2**

In fully edentulous patients, both splinted and unsplinted attachments are equally effective from a patient's perspective and can be recommended (Schimmel and coworkers 2023).

**Clinical recommendation 3**

In fully edentulous patients, mandibular implant overdentures retained by one or two implants show positive effects on dPROs compared to a mandibular complete denture, with two implants being the optimal number. Additional implants do not offer further improvements in dPROs. Based on expert opinion, if the opposing maxilla is dentate or restored with a fully implant-supported prosthesis, more than two standard-diameter implants in strategic positions are recommended to support mandibular implant overdentures to avoid complications and fractures of the implants and prosthetic components. More than two implants are also recommended to enable implant support over mucosal support in compromised anatomical situations (e.g., highly resorbed posterior mandible) and/or compromised mucosal conditions (e.g., hyposalivation) (Schimmel and coworkers 2023).

**Clinical recommendation 4**

Oral function significantly improves in completely edentulous patients when the mandible is restored using a complete implant-supported fixed dental prosthesis or implant overdenture compared to complete dentures. Therefore, these can be recommended as the best treatment options. The availability of these treatment modalities should be actively promoted in all edentulous communities, including those with limited means or limited access to medical care (Schimmel and coworkers 2023).

Use this code to download the Proceedings of the 7th ITI Consensus Conference (2023)

### 2.1.3 Patient Profiles

**INTRODUCTORY REMARKS**

The decision of whether to rehabilitate a patient with fixed or removable implant prostheses cannot be based solely on dPROMs (see Chapter 2.1.2). Such decisions should be guided by the specific anatomy and clinical parameters of the individual case, as well as the patient's needs and wishes. In cases where either treatment is feasible, a proper assessment of the patient's pre-treatment expectations and desires is critical before deciding on a fixed or a removable prosthesis (Feine and coworkers 2018).

To make this assessment, it is necessary to have a comprehensive understanding of the patient, beyond clinical findings and diagnoses. In this context, education, income, and the patient's perceived quality of life are the potential predictors for edentulous patients' preference for implant rehabilitation (Leles and coworkers 2019). In addition, a patient is more likely to choose an implant restoration if he or she explicitly requests implant therapy or cannot adapt to or tolerate a complete denture (Sharka and coworkers 2019).

The sum of these individually weighted patient factors results in the patient profile (Wolfart 2023). It considers the patient's wishes and expectations on the one hand and essential anatomical and general medical factors on the other. The patient profile helps the clinician to guide and moderate this complex decision-making process together with the patient.

The individual components considered in the patient profile are:

**Patient wishes and expectations:**

1. Resilience (and willingness to undergo invasive procedures, while considering the patient's general health)
2. Function (expectations of the restoration)
3. Retention
4. Esthetics

**Patient-related baseline factors:**

5. Tissue loss (vertical and horizontal)
6. Financial resources
7. Individual risk of implant loss

When evaluating the patient profile, it is important to also assess the esthetic, surgical, and prosthetic risks using the SAC classification for edentulous patients in implant dentistry (Dawson and coworkers 2022). To fully inform the patient, it is necessary to consider their wishes and options as well as the SAC risk assessment and the level of surgical and prosthetic difficulty. Based on this information, a joint decision can be made regarding the most suitable treatment plan. The SAC classification can help determine whether the clinician can meet the surgical and prosthetic demands or whether specialist intervention may be required. See Table 1 for more information.

**MAIN ASPECTS OF THE PATIENT PROFILE**

**Resilience:** Since patients usually have limited knowledge of the surgical procedures involved in oral implantology, they should be provided with a clear description of the duration and invasiveness of the procedure, and of the expected degree and duration of postoperative discomfort. A subjective evaluation of this factor should also include the patient's age, morbidity, and any additional measures associated with the procedure, such as endocarditis prophylaxis or anticoagulant therapy (Wolfart 2023). Measures to reduce exogenous stress, e.g., by providing a quiet surgical environment, good planning, and empathic perioperative care are important, especially since the patients concerned are often elderly. Targeted sedation, the use of anti-inflammatory medications, and preventive pain management have also been shown to be effective in reducing stress. By incorporating flapless implantation techniques, the use of short, narrow, or angled implants, or zygomatic implants, augmentation can be avoided, and patient distress may be reduced. Similarly, the treatment burden can be reduced by providing fewer implants and an implant-supported overdenture.

**Function:** Functional aspects in edentulous patients mainly relate to the question of whether they can accept a removable implant-supported overdenture or whether they prefer an implant-supported fixed restoration. In the case of removable restorations, the number of implants and the retention element used are important, because both have a direct influence on the stability of the prosthesis and are therefore relevant to the functionality of the prosthesis. In the case of fixed restorations, the question is whether a shortened dental arch up to the second premolar is advisable, or whether the masticatory function must be maintained up to the first molar.

**Retention:** A distinction must be made here between supportive function and fixed support without mobility, which in part determines the type of retention element(s) used. Bar attachments and telescopic crowns can achieve very rigid anchorage, giving the patient the feeling of having "fixed teeth again." Stud attachments such as ball, Locator or Novaloc attachments, on the other hand, usually exhibit a certain amount of movement, which gives the patient the feeling of a "fixed prosthesis," but not the feeling of having fixed teeth. In addition to this patient preference, the required vertical height of the prosthesis and the parallelism of the implants also influence the choice of the retention element. The smaller the vertical distance to be bridged and the more parallel the implants are placed, the more suitable the stud attachments systems are for the restoration. In the other case, bar attachments or telescopic crowns are more appropriate.

**Esthetics:** In edentulous patients, esthetic considerations may influence the decision to use a fixed or removable restoration. Three examples are given in the following:

- For example, if a patient insists on maximum dental and (artificial) gingival esthetics, ceramic restorations will be required, but these can only be achieved with fixed full-arch restorations.
- On the other hand, if the vertical tissue loss is extensive, the missing soft and hard tissues can be esthetically reconstructed with pink acrylics using removable overdentures. Improved lip support is also easier to achieve with overdentures.
- Another important aspect is the visibility of the transition between the natural soft tissue and the artificial gingiva. If this transition is visible while laughing, it can reveal the restoration as artificial. This can be concealed with a removable prosthesis that includes a labial pink plastic saddle, for example. Alternatively, during implant placement, reducing the alveolar ridge in an inconspicuous area is a possible approach for fixed restorations; however, this procedure is questionable due to its high invasiveness.

**Tissue loss:** The extent of the vertical tissue loss determines whether vertical bone augmentation is necessary or whether the existing tissue loss can be prosthetically compensated (see Chapter 3.5). The latter may be a strong indication for an implant overdenture, which can compensate for any tissue loss much more easily than a fixed prosthesis.

**Financial aspects:** The financial aspects depend on the patient's social situation, insurance coverage, and specific choices. Especially in the case of edentulous patients, planning implant overdentures rather than complete implant-supported fixed dental prostheses provides a wide margin of maneuver in terms of treatment costs.

**Risk:** To assess the individual risk of implant loss, it is necessary to analyze the patient's medical history regarding certain concomitant general medical factors (see Chapter 2.2). In addition, factors such as smoking, a history of periodontitis, and patient resilience (oral hygiene) are considered here.

## PRESENTATION OF THE PATIENT PROFILE

The seven factors of the patient profile are each presented as a scale with a low and high endpoint (see Fig 3). Each of the seven scales has four levels (low, moderate, moderately high and high). This effectively consolidates all the data for parameters important for treatment planning, making them easily assessable and readable at a glance.

## PATIENT PROFILE AND PROSTHETIC APPROACH

An individual patient profile can be created for each patient. This profile can be used to make different recommendations regarding surgical procedures and the number of implants. Most importantly the profile largely determines the most appropriate prosthetic approach (see Table 3, Chapter 3.6). It thus supports the clinical recommendation of the 6th ITI Consensus Conference (2018) that the planned final prosthesis should be considered when determining the surgical treatment of the edentulous jaw (Morton and coworkers 2018).

At the same time, the concept of the patient profile makes it clear in principle that as soon as individual parameters in the evaluated profile change significantly, the most suitable dental prosthesis for this patient will also change (see Table 3, Chapter 3.6).

## THE SAC CLASSIFICATION IN THE EDENTULOUS JAW

The patient profile provides an initial assessment of the individual prosthetic restoration concept (see Chapter 3.6). The degree of esthetic, surgical, and prosthetic difficulty associated with the clinical situation should be recorded in parallel (see Chapters 5.3, 5.7, and 5.9 for detailed patient examples).

**Table 1** Edentulous esthetic risk assessment (EERA) (The SAC Classification in Implant Dentistry; Dawson and coworkers 2022).

| Esthetic risk factors - Edentulous | Level of risk | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **Arch** | Mandible | | Maxilla |
| **Facial support (fixed)** | Alveolar process provides adequate facial support | Minimal changes tolerated by the patient | Flange required for adequate facial support |
| **Facial support (removable)** | Flange provides adequate facial support | Minimal changes tolerated by the patient | Insufficient space for a flange |
| **Labial support** | Designed tooth position provides satisfactory labial support | Minimal changes tolerated by the patient | Designed tooth position causes unsatisfactory labial support |
| **Upper lip length** | Long upper lip (> 20 mm) | | Short upper lip (< 20 mm) |
| **Buccal corridor* (atrophic ridge)** | Removable prosthesis | | Fixed prosthesis |
| **Smile line** | No display of the ridge(s) at full smile (maxilla or mandible) | | Display of the ridge(s) at full smile (maxilla or mandible) |
| **Maxillomandibular relationship** | Class I | Class II | Class III |

*Desired narrow corridor in definitive prosthesis.

The introduction of the SAC classification for edentulous patients in implant dentistry (Dawson and coworkers 2022) has provided a valuable tool for this purpose. It encompasses both a general risk assessment and a specific esthetic risk assessment. As an illustration of the intricacy of the assessment, the individual decision criteria and categorization of esthetic risk levels in edentulous patients are presented in Table 1.

Furthermore, the case is classified as straightforward (S), advanced (A), or complex (C) based on anatomical and specific surgical and prosthetic factors. This classification is made separately for surgery and prosthetics. The use of the SAC classification is exemplified in the case presentation in Chapter 5.9. In general, the risk for each clinical case can be assessed using the ITI's online SAC Assessment Tool.

Use this code to access the online SAC Assessment Tool.
The online SAC Assessment Tool takes you through each step necessary to identify the degree of complexity and potential risk involved in individual clinical cases.

**Fig 1** Initial situation: Residual mandibular dentition.

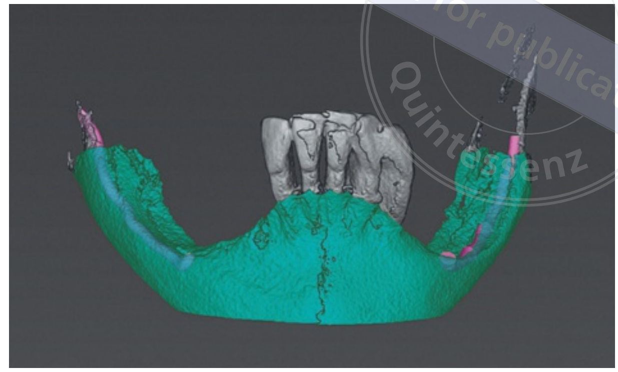


**Fig 2** Initial situation: CBCT analysis of the mandible. The CBCT showed a significant difference in bone height between the highly atrophic posterior region and the mandibular residual dentition.

## CLINICAL EXAMPLE: PRACTICAL APPLICATION OF A PATIENT PROFILE

A 67-year-old female patient had no teeth left in the maxilla and was wearing a complete denture, which she tolerated very well. A few periodontally compromised residual teeth were present in the anterior mandible. The difference in the vertical dimension between this region and the very severely atrophied posterior region was considerable (Figs 1 and 2). Due to this difficult anatomical situation, the patient was very dissatisfied with her current mandibular prosthesis with its cast-metal framework. The prosthesis was unstable during chewing. The patient complained of “stabbing nerve pain” in the posterior region when chewing. This was immediately attributed to impaction of the mental nerve, as the mental foramina were located almost directly on the severely atrophied alveolar ridge.

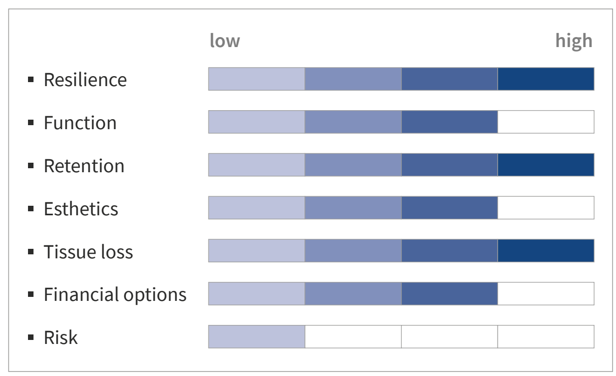



**Fig 3** Patient profile of the 67-year-old patient.

The patient was a retiree who reported that she had saved a considerable amount of money in her life: she said that financial considerations “should only play a subordinate role in treatment planning for now.” She wanted a restoration that provided a significant functional improvement, was free of phonetic restrictions and was esthetically pleasing and in harmony with her youthful appearance. She stated emphatically that she was willing to go to great lengths to try and improve her quality of life, which had been severely compromised by her difficult oral situation.

There were no general medical conditions that would have increased the risk of implant loss. The patient did not smoke. Her oral hygiene was good. Only the presence of periodontitis indicated an increased risk of implant loss.

The initial consultation provided the clinician with the information needed to establish the patient profile (Fig 3).

**Resilience:** Based on her very good general health, the patient’s athletic appearance, her assertion that she was ready to make a great effort to achieve her goal, and her unremarkable general medical history, her resilience was rated as high (level 4).

**Function:** Based on the patient’s comments and the fact that she was satisfied with the function of her maxillary complete denture and did not want any other type of restoration, it was clear that the patient would be satisfied with a significant improvement in the function and esthetics of her mandibular prosthesis. Her functional expectations were rated as moderately high (level 3).

**Retention:** The patient had been dissatisfied with the retention of the mandibular partial denture for years. She wanted a significant improvement in this area. At the same time, the new prosthesis should not exert any pressure on the severely atrophied posterior region in order to prevent the associated nerve pain. Since a secure anchorage of the mandibular prosthesis was therefore an essential wish of the patient, her expectations regarding the retention of the prosthesis were rated as high (level 4).

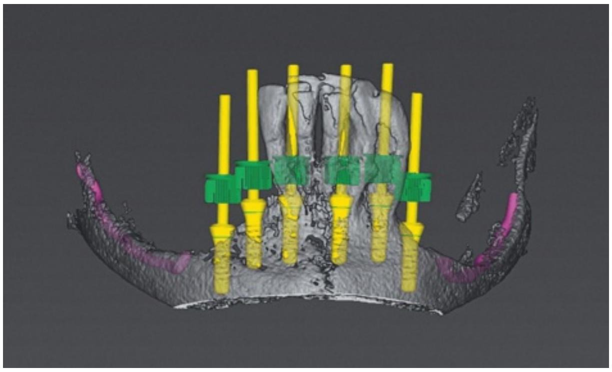


**Fig 4** Implant planning, taking into account the narrow alveolar ridge and reducing the large height difference between the anterior and posterior alveolar bone.

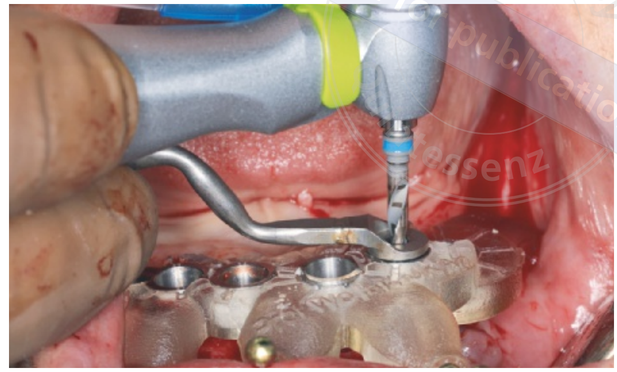


**Fig 5** Surgical guide in place. Execution of the drilling protocol with appropriate drill keys and shaping drills.

**Esthetics:** The patient wanted an esthetic improvement but was not really dissatisfied with her current appearance. In relation to the current situation, the patient's esthetic expectations for her prosthetic restoration were rated as moderately high (level 3).

**Tissue loss:** The CBCT confirmed a very severe loss of vertical dimension in the posterior mandible (level 4).

**Financial aspects:** Based on the patient's statement that financial considerations "should only play a subordinate role in treatment planning" and the fact that she had private dental insurance, no major limitations were expected (level 3).

### TREATMENT PLAN AS DERIVED FROM THE PATIENT PROFILE

The patient profile shown in Figure 3 was derived from these considerations. Based on this profile, the complete maxillary denture was replaced and a mandibular overdenture supported by six interforaminal implants was fabricated (Figs 4 to 14). In this case, six implants were planned instead of four because the patient wanted absolute assurance that no pressure would be exerted on the posterior region during mastication and that this would be ensured even in the event of implant loss.

In addition to the severe periodontal destruction, the narrow alveolar process in the anterior mandible was unfavorable for the planned implant restoration. The buccal and lingual bone plates were extremely thin, especially in the root area. The vertical bone level needed to be adjusted to ensure a favorable implant distribution while maintaining a clinically acceptable height difference between the implants. For this purpose, the implants were ideally positioned in the CBCT dataset (Fig 4).

After extraction of the remaining mandibular teeth and adjustment of the vertical height of the alveolar ridge, immediate implant placement was performed using a surgical guide (Figs 5 and 6).

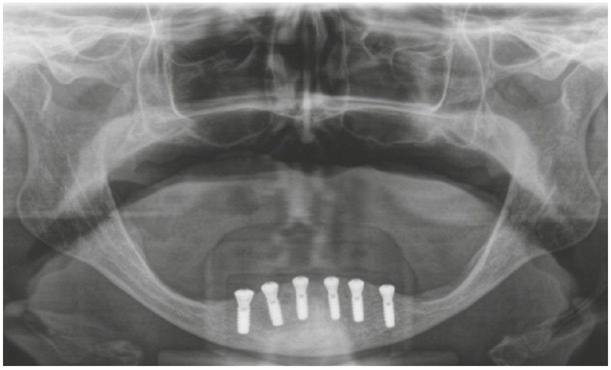


**Fig 6** Postoperative panoramic radiograph.

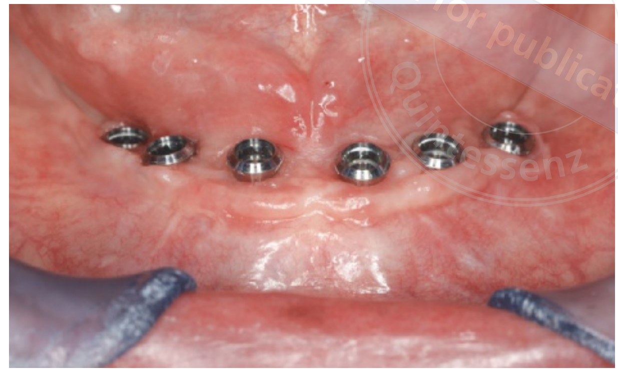


**Fig 7** Reentry 3 months after implant placement.

**Fig 8** CAD/CAM titanium abutments (milled primary telescopes) before placement.

**Fig 9** Primary telescopes in place with sealed screw access channels.

**Fig 10** Basal view of the overdenture.

**Fig 11** Lateral view of the overdenture.

Re-entry surgery was performed 3 months after implant placement (Fig 7). The implants were restored with a removable overdenture on telescopic crowns (Figs 8 to 12). This restorative concept ensured that the severe vertical tissue loss was compensated in an anatomically appropriate manner. The implants were easy to clean, and the restoration would remain functional even in the event of implant loss, without the need to modify the overdenture.

**Fig 12** Treatment outcome 3 months after delivery. The maxillary complete denture was also new.

Fig 13 The patient's smile.

Fig 14 Portrait of a satisfied patient at the 1-year follow up.

At 1 year after delivery, the patient was still very satisfied with the restoration, both with the function of the prostheses and their esthetic appearance (Fig 14).

# 2.2 Edentulous Patients and Restorative Risks

B. Al-Nawas

The numerical age of a patient does not necessarily correlate with the perioperative risks associated with a given procedure. Similarly, the process of osseointegration is not affected by age (Boboeva and coworkers 2021). Conversely, the number of risk factors increases with age. For example, patients with a mean age of 40 years and older often have more than one risk factor, and patients 70 years and above often have more than two and a half risk factors (Turrentine and coworkers 2006; Barnett and coworkers 2012) (Fig 15).

The most significant risk factor is cardiovascular risk. It is of the utmost importance to objectively assess and document the patient's physical status, in particular his or her exercise capacity, and the ASA classification or metabolic equivalent is an appropriate and practical way to do this. These are validated scores that assess perioperative risk (Table 2) (Abouleish and coworkers 2020). Such a score allows the dentist to objectively assess the patient's physical resilience, facilitating the identification of the most appropriate level of invasiveness for a given dental treatment.

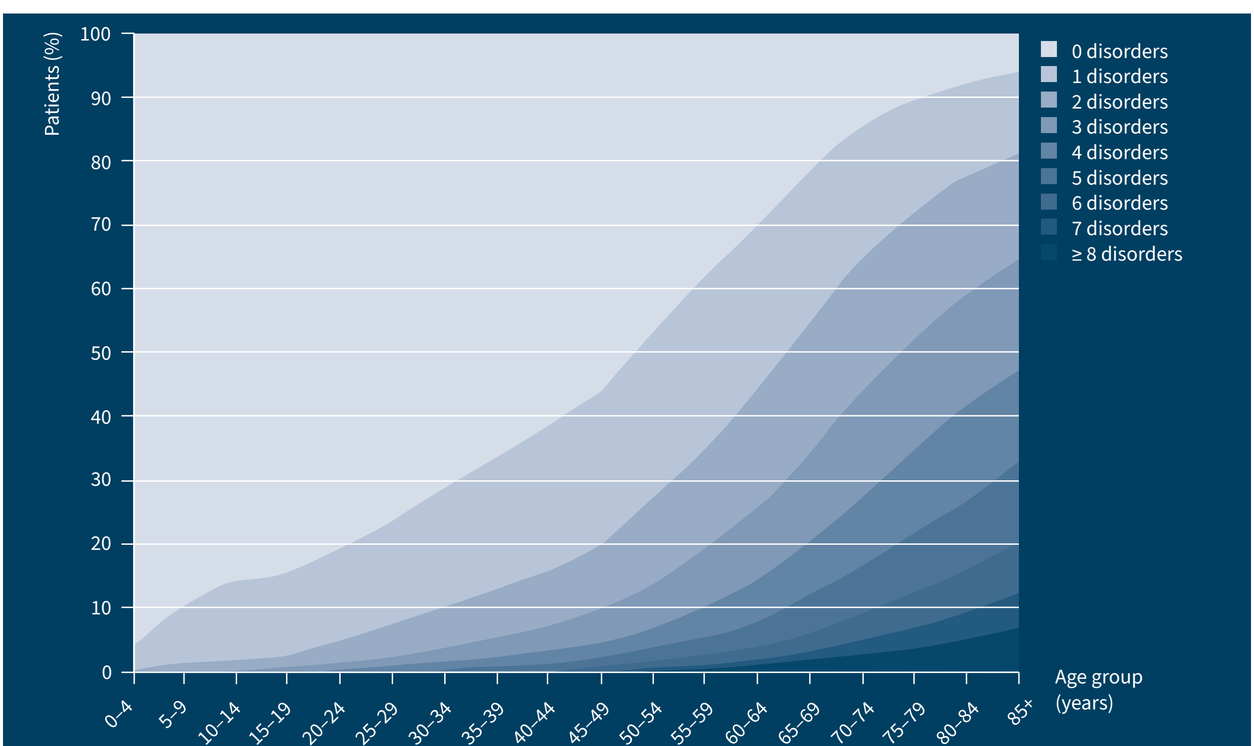



**Fig 15** Average number of risk factors as a function of patient age (Barnett and coworkers 2012. In: ITI Treatment Guide, Vol. 9. Implant Therapy in the Geriatric Patient. Müller and Barter 2016).

**Table 2** Surgical risk classification for outpatient surgery according to the American Society for Anesthesiology, including patient examples (Abouleish and coworkers 2020).

| ASA Classification | Definition | Adult examples, including, but not limited to |
|---|---|---|
| ASA I | A normal healthy patient | Healthy, non-smoking, no or minimal alcohol use. |
| ASA II | A patient with mild systemic disease | Mild diseases only without substantive functional limitations. Current smoker, social alcohol drinker, pregnancy, obesity (Body Mass Index BMI 30–40), well-controlled diabetes, mild lung disease. |
| ASA III | A patient with severe systemic disease | Substantive functional limitations: One or more moderate to severe diseases. Poorly controlled diabetes, COPD, morbid obesity (BMI ≥ 40), active hepatitis, alcohol dependence or abuse, implanted pacemakers, moderate reduction of ejection fraction, history (> 3 months) of myocardial infarction, TIA, or stents. |
| ASA IV | A patient with severe systemic disease that is a constant threat to life | Recent (< 3 months) myocardial infarction, TIA, or stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction. |

**Table 3** Overview of medical risk factors and their relevance to the risk of implant surgery.

| | Low risk | Intermediate risk | High risk |
|---|---|---|---|
| **Anticoagulants** | Aspirin | Coumarins,<br>direct oral anticoagulants | New stent (last 12 months)<br>Cardiac infarction |
| **Immunosuppression** | Healthy or well controlled diabetes<br>HIV under treatment | Diabetes uncontrolled or with inadequate control | Immunosuppression (chronic polyarthritis, organ graft) |
| **Radiation therapy** | None or < 50 Gy | Radiation > 50 Gy | Radiation (last 12 months) |
| **Bone physiology** | Osteoporosis | Antiresorptives in osteoporosis (low dose)<br>Low vitamin D level | Antiresorptives in oncology (high dose) |

Another aspect related to cardiovascular risks is the frequently used medical anticoagulation or antiplatelet therapy. It is rarely possible to interrupt or modify the procedure without additional risks. It may be advisable to contact to the prescribing physician, but this does not absolve the dentist of the responsibility for the procedure.

This assessment of the medical background results in subjective risk categories that are not always related to the chronological age of the patient. Table 3 helps facilitate decision-making. For instance, recent myocardial infarction (within the previous 12 months) is a relative contraindication for elective interventions (red category). However, the commonly prescribed aspirin is usually not restricted, even for extensive augmentative procedures (green category). Patients taking on coumarins or direct oral anticoagulants can often discontinue them for short periods. This makes them suitable for simple local bone procedures and circumscribed augmentation. There are more frequent indications for dimensionally reduced implants (yellow category) (Römer and coworkers 2022).

A similar system, which is subjective but practical, can be used for patients under immunosuppression with disturbances in bone physiology, or with similar effects after radiotherapy. In patients with high doses of antiresorptive drugs, e.g., in oncological indications, the decision for an implant-supported restoration or even augmentation must be made with great caution (red category). In contrast, in low-dose therapy, in osteoporosis, implant-supported measures and circumscribed augmentation can be planned successfully (yellow category) (Al-Nawas and coworkers 2023) (Fig 16).

There is limited scientific information on patients with compromised mucosa, such as those with oral lichen planus or those with post-irradiation xerostomia. In these cases, there may be a clear relative contraindication to tissue-supported dentures. The question must therefore be raised to what extent purely tissue-supported full dentures can still be considered as a therapeutic option for certain patient groups, e.g., after radiotherapy in the head and neck region or difficult mechanical or immunological soft-tissue conditions (e.g., oral lichen planus) (Pawlowski and coworkers 2023).

The general medical situation must be taken into account when deciding how to restore the edentulous jaw, as it can affect the load-bearing capacity of the soft tissue and bone. This refers not only to the reduced physical resilience and perioperative risks, but also to the bone and soft-tissue physiology.

**Fig 16** Patient with “lichen-like” mucosal inflammation due to graft-versus-host disease. Implant-supported prostheses may reduce mechanical irritation to the mucosa.

# 2.3 Anatomical Conditions and Changes over Time

B. Al-Nawas

## 2.3.1 Morphology and Atrophy

The anatomy of the edentulous jaw is well-described, with special attention to the peculiarities of its morphology.

One aggravating factor is the physiological loss of the alveolar process after tooth extraction. Another factor is the wearing of tissue-supported dentures for many years (Tallgren 1975; Cawood and Howell 1988) (Fig 17). The different trajectory of atrophy in the maxilla compared to the mandible leads to typical incongruence of the upper and lower tooth positions relative to the available bone (Fig 18). It is therefore essential to consider the relative position of the jaws when planning fixed or removable restorations (Figs 19 to 21).

The maxillary sinuses also become increasingly pneumatized. Elevation of the maxillary sinus floor is a common requirement for implant placement. This is a form of "internal atrophy" (Figs 22a-b). Typical horizontal and vertical bone loss is expected to occur in the maxillary anterior and premolar regions after tooth extraction. This makes single-stage implant placement difficult and results in typical loss of facial soft-tissue support.

A history of periodontitis will also exacerbate the vertical loss of alveolar bone. A number of clinical classifications can assist in accurate pre-implant analysis (Cawood and Howell 1988) (Fig 18). The complexity of the anatomical situation and the challenges of the prosthetic restoration require the analysis of 3D image data in many cases, especially for fixed restorations.

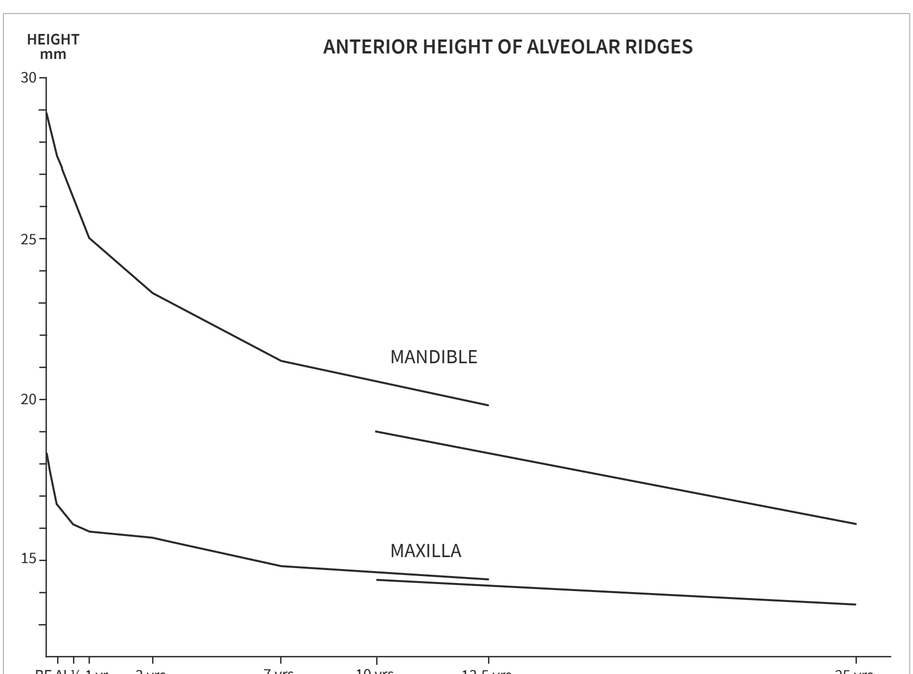



**Fig 17** Continuous reduction of the residual alveolar ridges in complete-denture wearers over 25 years (based on Tallgren 1972).

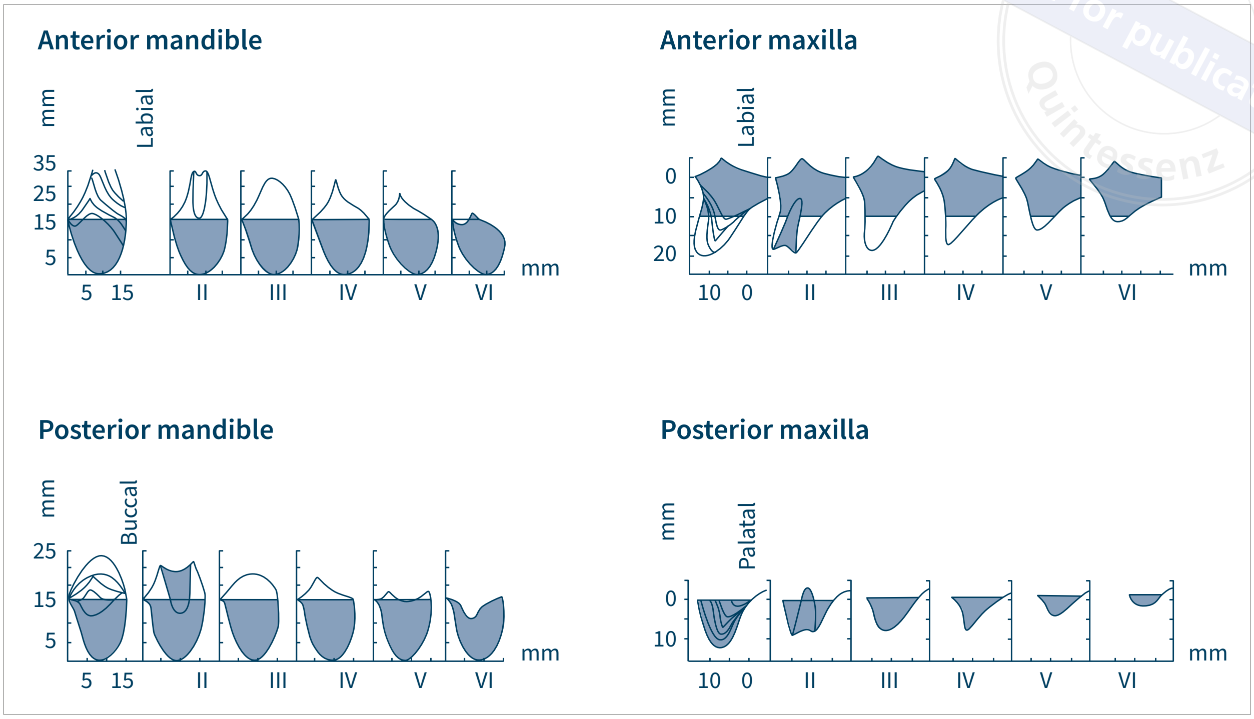



**Fig 18** Classification of alveolar ridge morphology according to Cawood and Howell (1988). Class I: Dentate ridge. Class II: Ridge immediately after extraction. Class III: Broad and rounded ridge with adequate height and width. Class IV: Knife-edge ridge with sufficient height but inadequate width. Class V: Flat ridge with insufficient height and width. Class VI: Depressed ridge with a cup-shaped surface. (Blue: Basal bone. White: Alveolar bone.)

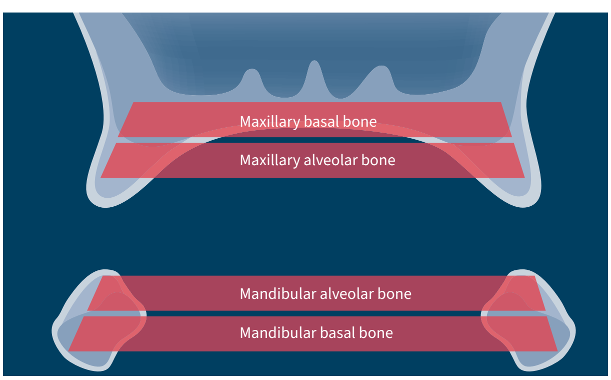



**Fig 19** Atrophy developing in different directions in the maxilla and mandible (ITI Treatment Guide, Vol. 7. Ridge Augmentation Procedures in Implant Patients: A Staged Approach. Cordaro and Terheyden 2014).

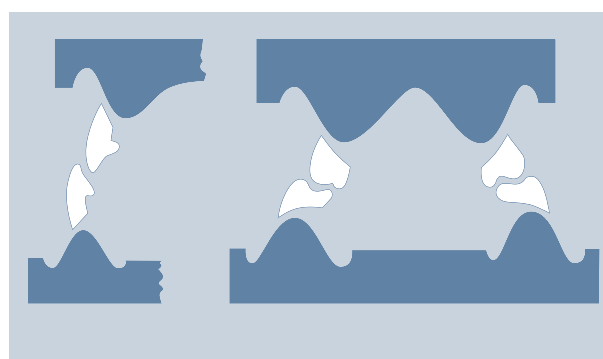


**Fig 20** Crossbite in relation to different directions of atrophy in the mandible and maxilla.

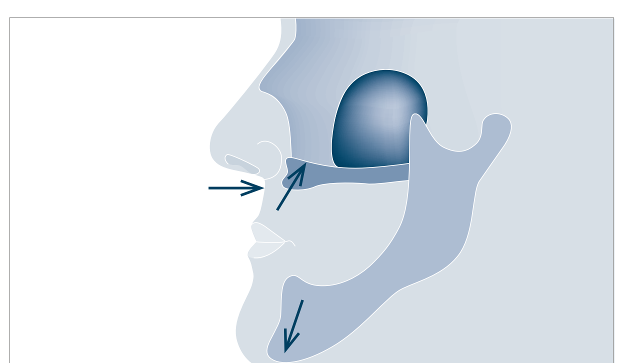
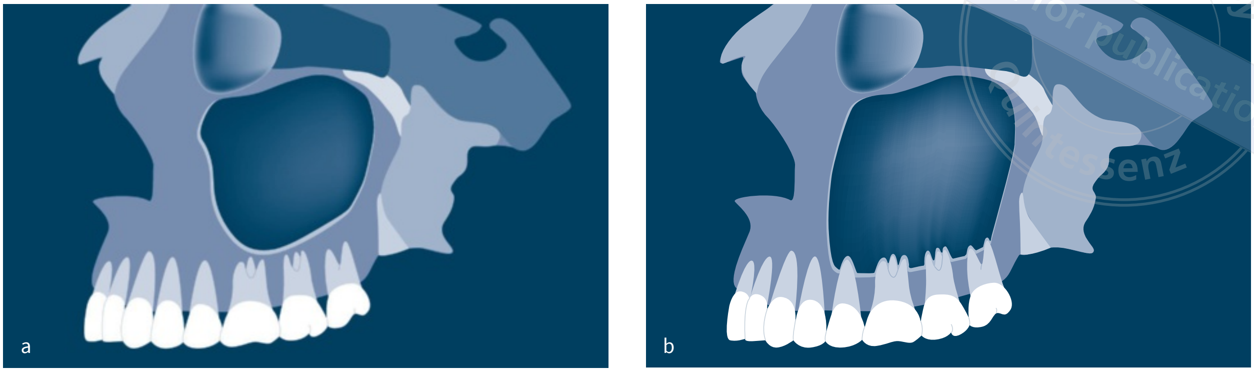


**Fig 21** Loss of lip support and establishment of a class III jaw relationship in relation to different directions atrophy in the mandible and maxilla.




**Figs 22a-b** "Internal atrophy" of the maxilla due to pneumatization of the sinus floor with indication for elevation of the maxillary sinus floor (ITI Treatment Guide, Vol. 5. Sinus Floor Elevation Procedures. Katsuyama and Storgård Jensen 2011).

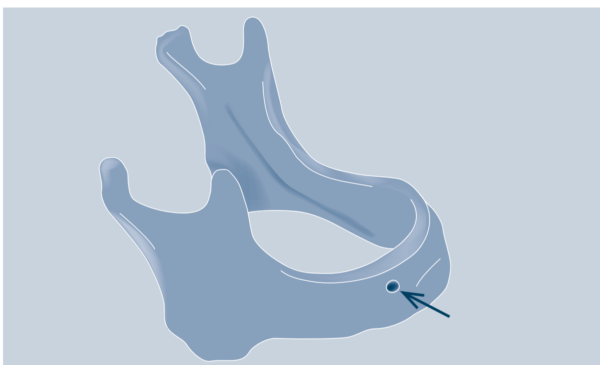


**Fig 23a** Typical lateral position of the mental foramen.

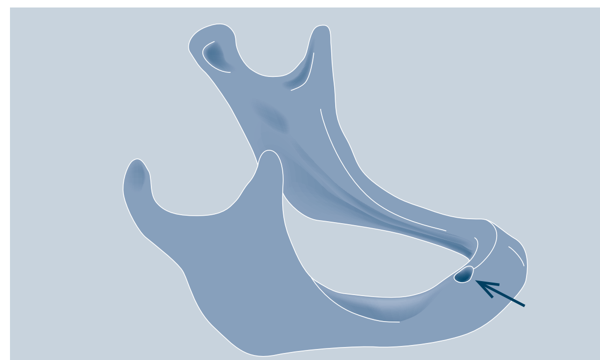


**Fig 23b** Crestal position of the mental foramen in severe mandibular atrophy.

In the mandible, the inferior alveolar nerve is a typical limitation. From an implant surgical perspective, the position of the so-called anterior loop is of particular interest, as this site is crucial for interforaminal implant placement. The combination of physiological loss of the alveolar process after tooth extraction and pressure atrophy due to tissue-supported dentures worn for many years also plays a role.

Sharp knife-edge ridges are a significant clinical challenge. They often require the use of reduced-diameter implants or bone augmentation. In cases of extreme atrophy, the loss of crestal bone ultimately places the nerve exit point on the alveolar ridge. This can cause chronic pain and is a clear indication for ridge augmentation or implant-supported dentures. In the posterior region, on the other hand, the vertical dimension will undoubtedly be a challenge, often requiring the use of short implants or complex augmentation procedures. Typical undercuts below the mylohyoid line (submandibular fossa) or in the lingual region of the chin (sublingual space) must be considered. Perforations into the floor of the mouth can be a critical complication (Figs 23a-b).

Severe atrophy of the mandible can even lead to pathological fractures (Fig 24).

### 2.3.2 Bone Physiology: Osteoporosis and Osteoimmunology

Bone physiology has received limited attention in recent years. Implants heal successfully, even in the "oldest old" patients. However, there is a clear need for more research into the success of complex augmentation procedures (such as vertical augmentations) in older patients. The role of long-term inflammation in bone and the possible consequences, such as the impact on osteoimmunology and in the risk of osteonecrosis, are also controversial topics. In the mandible, for example, histological signs of osteomyelitis and osteonecrosis can still be seen 1 year after tooth extraction (Kassolis and coworkers 2010).

Reduced cortical plate thickness and increased trabeculation are often observed in the maxilla compared to the mandible. Therefore, the development of osteoporosis is particularly relevant in the maxilla. In some cases, it might be difficult to achieve sufficient primary stability of dental implants in this situation, which is particularly relevant for immediate loading. Modern implant systems with high primary (mechanical) stability are currently popular solutions to this problem. This is particularly relevant for immediate loading concepts. And

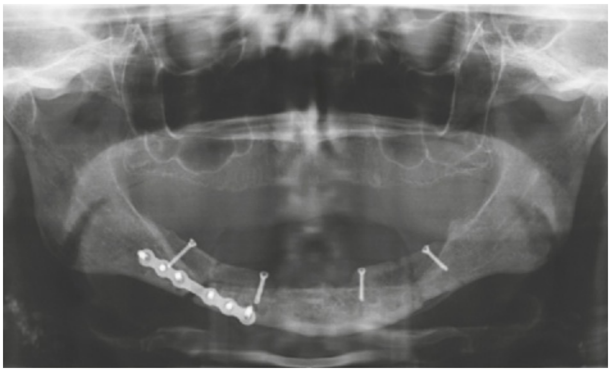


**Fig 24** Pathological fracture due to atrophy treated with a mini-plate and iliac crest grafting.

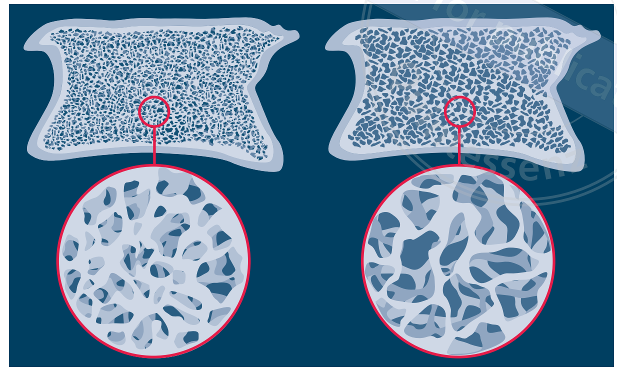


**Fig 25** Bone density changes in osteoporosis in men (left) and women (right) (here: vertebral bone) (ITI Treatment Guide, Vol. 9. Implant Therapy in the Geriatric Patient. Müller and Barter 2016).

while bone density values (Hounsfield units) can provide an indication of bone density on a CT, a CBCT is much less reliable for such an analysis (Flanagan and coworkers 2021). Drilling protocols must be adapted to the clinical situation. It is therefore likely that difficulties with distal implants in bone with reduced cortical thickness are underreported, especially with immediate loading.

In the mandible, however, the very dense cortical bone can also be a significant challenge requiring precise and sensitive preparation of the implant cavity.

In addition, it is critical to evaluate medications and their effects on bone physiology. Low-dose antiresorptive agents, such as those used in osteoporosis (Fig 25), decrease the rate of bone remodeling and may even cause implant-associated bone necrosis. Immediate loading is not recommended here under any circumstances (Al-Nawas and coworkers 2023). However, other drugs such as steroids also slow down bone healing and lead to osteoporosis. These must be taken into account when designing the treatment concept.

### 2.3.3 Mechanical Aspects: Mandibular Torsion

While the maxilla allows rigid splinting of multiple implants, mandibular torsion during opening and closing of the mouth is a well-known problem. Clinical work has demonstrated a change in the distance and angle between the mandibular posterior teeth during jaw movement (Richter 1999; Thongpuong and coworkers 2022; Raymond and coworkers 2016) (Fig 26). There is considerable individual variation. However, the relevance for prosthetic restorations is still controversial. Historically, the interforaminal implant position in the mandible has been proven for fixed restorations. Most clinicians avoid splinting into the molar region and prefer to employ modular restorations rather than a single cross-arch mandibular restoration.

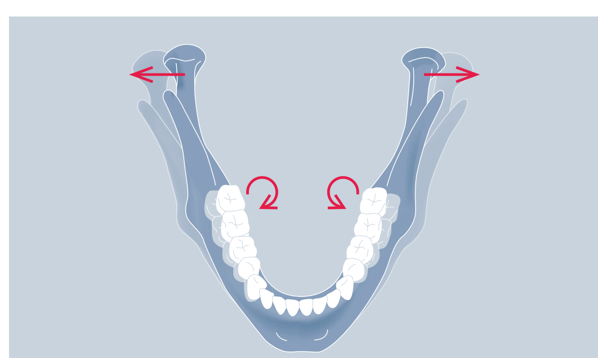


**Fig 26** Mandibular deformity during mouth opening and chewing.

# 2.4 Implant Designs and the Edentulous Patient

B. Al-Nawas, C. Aparicio

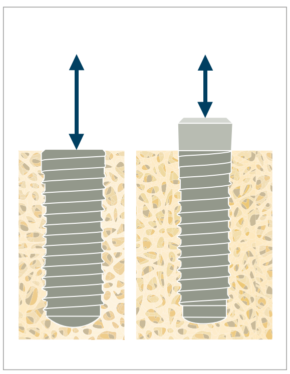


**Fig 27a** Reduced vertical bone dimension with long crown: soft-tissue level implants offer shorter technical crown lengths.

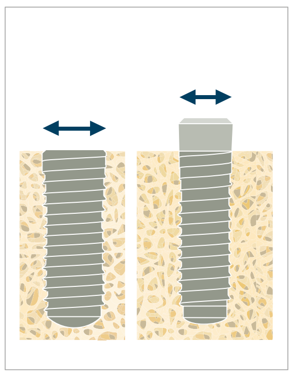


**Fig 27b** Reduced horizontal bone dimension with narrow-diameter implant: soft-tissue level implants offer wider and stronger neck designs.

The rapid development of implant designs in recent years has also led to clinical changes and indication expansion. The scientific rationale for short implants is well established in randomized studies, compared to vertical ridge augmentation and longer implants (Jung and coworkers 2018). Even 4-mm implants have been documented in studies. Today, 8-mm implants are no longer considered short. In the future, 6- and 7-mm implants will be in the focus of clinical and scientific work.

In contrast to implant length, reduced-diameter implants have rarely been the subject of comparative studies. Fractures of these implants have been documented, particularly in the molar region. The incidence is unclear, and the importance of splinting has not been sufficiently investigated. Current implant designs feature highly stable crestal structures, and it is clear that reduced-diameter implants are increasingly being used in the edentulous jaw. One-piece mini-implants are a special variant that has been scientifically established in larger study cohorts.

Biomechanical forces and cantilever play a limiting role, especially with short implants, but also in the case of reduced-diameter implants. The renaissance of the soft-tissue level concept has also allowed for a more stable neck design and shorter vertical cantilever arms (Figs 27a-b). Overall, the reduction in implant dimensions allows for less insertion morbidity and a reduced need for bone augmentation.

Almost all modern implant systems are designed with the explicit goal of increasing primary stability (Heimes and coworkers 2023; Jokstad and coworkers 2018) (Figs 28 and 29). This is achieved in part by slightly tapered implant shapes, but more importantly by cutting rather than compressing thread geometries. This not only provides stability even in less dense osteoporotic bone, but also frequently allows for immediate loading.

Implants are now available that can be placed in the atrophic maxilla without the need for major bone augmentation. For example, zygomatic implants have been on the market for over 20 years and are scientifically well documented. Implants placed at the junction of the maxillary tuberosity and the pterygoid process have also been documented in case series and are helpful in truly exceptional situations (Figs 30a-b).

Recently, additively manufactured subperiosteal implants (Fig 31) that are placed over a large area of the bone and fixed with screws ("osseofixation") have also been used. This is an understudied technique that needs to be rigorously evaluated (Van den Borre and coworkers 2022). It is important to evaluate explantation morbidity and bone loss in the event of inflammation/infection following the use of bulky implants. Taken together, these specific implant designs may allow for augmentation-free restorations even in difficult situations.

Implant design strategies (Table 4) follow a clear trend toward fewer augmentations. Digital planning allows the use of the available bone volume; smaller implant dimensions or angulated implants may also allow the use of a limited bone bed. Together with the focus on primary stability, this explains the trend toward more immediate restorations.

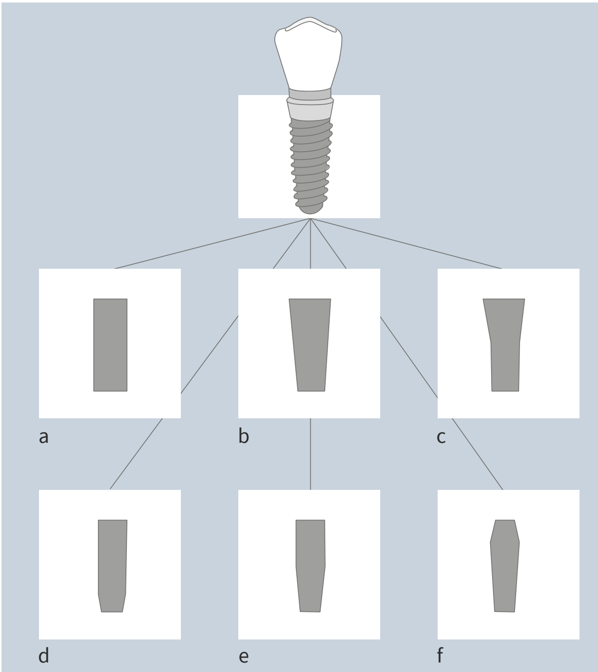



Fig 28 Implant body designs. Cylindrical design (a). Conical design (b). Hybrid design (apically cylindrical and crestally conical) (c). Cylindrical design with apical taper (d). Hybrid design (apically conical and crestally cylindrical) (e). Conical design with crestal back taper (f).

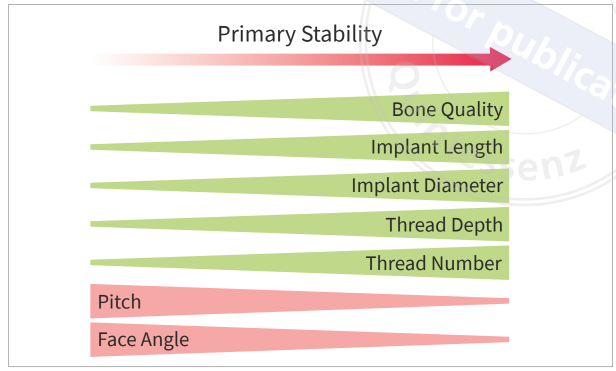
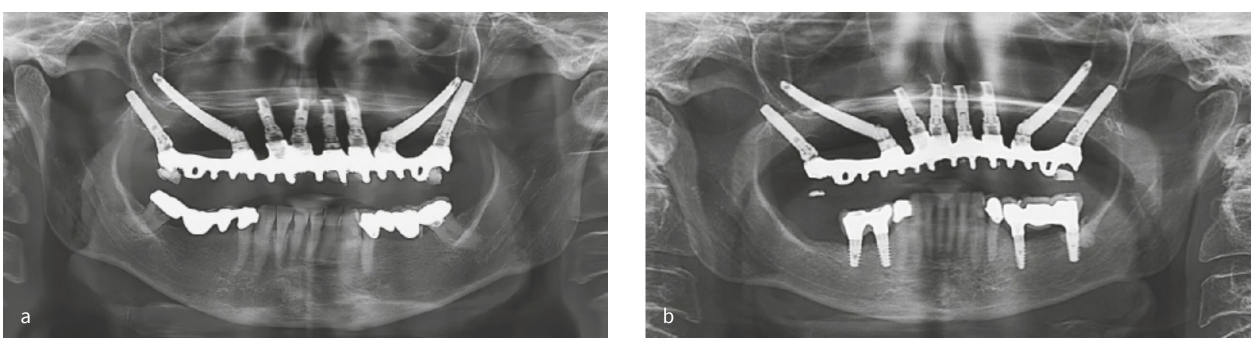



**Fig 29** Characteristics of the implant macro design. Thread helix angle: angle between the horizontal of the thread helix to the longitudinal axis of the implant. Apical face angle: angle between the horizontal of the thread face to the longitudinal axis of the implant. Pitch: distance between the center of a thread to the next thread in the longitudinal axis of the implant or implant length divided by the number of threads. Thread depth: distance between the outer contour of the thread and the implant base body. Thread width: distance between the most coronal and the most apical portion of the same thread.




**Figs 30a-b** Pterygoid, zygomatic, and regular implants 10 years after placement (a). The same patient after 20 years (b).

**Table 4** Implant design strategies that allow augmentation-free restorations and therefore immediate restorations.

| |
|---|
| Short implants |
| Reduced-diameter implants |
| Tilted implants |
| Zygomatic implants |
| Pterygoid implants (Fig 30) |
| Subperiosteal implants (Fig 31) |

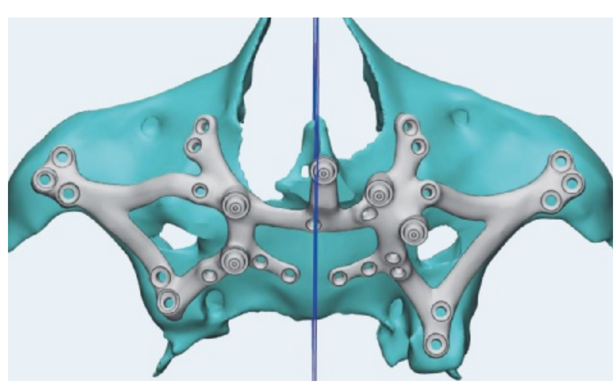


**Fig 31** Subperiostal implant planned for a discontinuous maxillary bone by Dr9 Taras Yurov, ZAGA Center Saint Petersburg.

### 2.4.1 Zygomatic Implants

Zygomatic implants were originally developed to rehabilitate patients with severe mid facial alveolar bone defects. They play a critical role in the prosthetic rehabilitation of severely resorbed maxillae, whether the patient is fully or partially edentulous. While we often assume that non-specialist clinicians have a basic understanding of "what zygomatic implants are and what they are used for," the reality is quite different. Due to limited usage and restrictive indications, most clinicians remain unfamiliar with the various placement techniques, the differences in implant design, and the impact these factors can have on long-term outcomes and the development of complications.

The placement of zygomatic implants should be regarded as a major surgical intervention—complex in nature and, in many cases, representing the final opportunity to restore fixed dentition in patients with extreme maxillary atrophy. Adequate and specialized training is, therefore, essential. These implants are indicated only in cases of severe maxillary bone loss, with the "king indication" being the complete absence of both anterior and posterior maxillary bone. As a result, the number of suitable cases in an average dental practice will be very limited, leading to a steep and prolonged learning curve for clinicians.

Moreover, in recent decades, a range of placement protocols and implant designs have been introduced—many without long-term clinical validation. This situation is further complicated by the aggressive marketing strategies of some companies, which often promote the technique as simple and accessible following just a short weekend course. Such oversimplification risks clinicians adopting unproven techniques or using implants designed without sufficient consideration for biological principles, potentially leading to suboptimal outcomes and an increased incidence of complications.

This introductory chapter aims to encourage the responsible and evidence-based use of zygomatic implants. We also wish to highlight the value of employing a well-documented and protocol-driven approach tailored to the specific anatomy of each patient and physiology based: the zygoma anatomy-guided approach (ZAGA).

When planning the osteotomy for a zygomatic implant, it is important to understand that a zygomatic implant may follow different trajectories depending on the anatomical situation. Consequently, adapting the treatment strategy to each patient's situation is a key factor in the evolution of zygomatic treatment concepts. From this critical perspective, a site-specific implant design that can adapt to the patient-specific anatomy appears to be crucial.

The original Brånemark protocol, known as the original surgical technique (OST), included one implant in each zygoma, traversing the sinus, combined with two to four conventional anterior implants (Parel and coworkers 2001; Brånemark and coworkers 2004). In subsequent years, the original technique has been refined with respect to sinus position and crestal emergence to allow for better individual anatomical and prosthetic adaptations. The sinus-slot technique (Stella and Warner 2000) reduces the size of the first osteotomy, decreases inflammation by elevating a less extensive flap and after a second osteotomy achieves a prosthetically guided crestal position of the implant platform. To avoid bulky prostheses and at the same time respect the integrity of the sinus membrane, Aparicio and coworkers (2008), Ouazzani and coworkers (2006), and Miglioranza and coworkers (2006) proposed the exteriorized technique for the placement of zygomatic implants in patients with extreme buccal concavities in the anterior maxillary wall. Later, an extramaxillary approach was advocated by Malo and coworkers (2008) eliminating the alveolar bone to anchor the implant exclusively in the zygomatic bone.

In 2010, the ZAGA concept was described by Aparicio based on a cross-sectional study of 200 human clinical and radiographic sites (Aparicio 2011). This approach was organically introduced as a refinement of his exteriorized technique for different anatomical situations from the flat maxillary wall to the concave or atrophic maxilla. By following specific prosthetic, biomechanical, and anatomical factors, the determination of the entry point and final implant path depends on the vertical and horizontal resorption of the alveolar/basal process and the anterior maxillary wall curvature. The differences between OST and the ZAGA concept when it comes to placing implants in an atrophic maxilla are shown in Fig 32. This figure illustrates, in a two-dimensional view, the length of the implant's contact areas with the bone. L-1 is the length of the implant-bone contact in its dorsal area. We can see that when we apply OST to an atrophic maxilla (Fig 32, left), contact L-1 occurs in a narrow area, limited only to the neck of the implant with the thin bone of the palatal area. When the ZAGA concept is applied to an atrophic maxilla, such as the one shown in Fig 32, right, no early "window" osteotomy is made in the maxillary wall. Instead, a channel is carved into the maxillary wall and the implant pathway is externalized using both the remaining alveolar bone and the maxillary wall as support. This lengthens the L-1 segment, which also occupies a large part of the maxillary wall. L-2 and L-3 represent the implant contact areas at the level of the zygomatic bone. The intrasinus path of the original procedure (OST) forces the entry of the implant through the palatal area. When a functional force is applied to the implant, a concentration of forces occurs on the palatal alveolar segment L-1 which, over time, can lead to bone destruction, micromovements of the implant under load, and end up in orosinusal communication. When we analyze the right-hand side of Fig 32, we

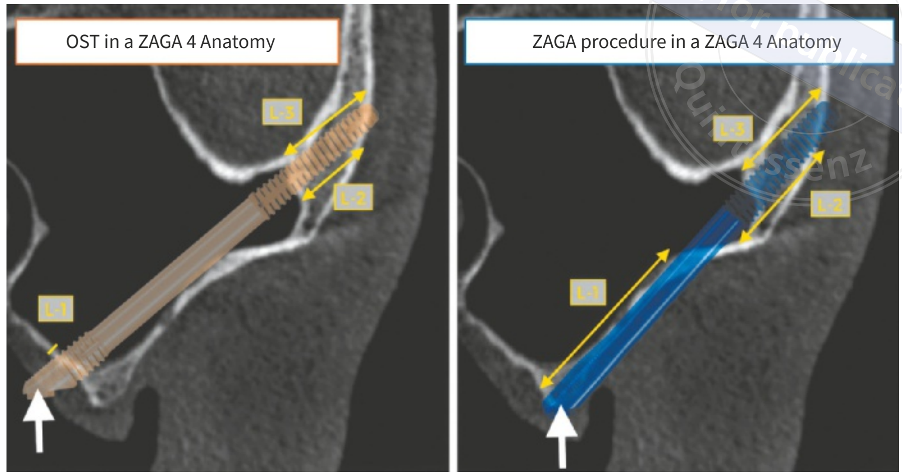



**Fig 32** The left-hand side of this figure shows an image of the OST being used on a patient with posterior atrophy of the ZAGA 4, which represents approximately 60% of cases. Due to its intrasinus path, the functional force represented by the white arrow is concentrated in the L-1 alveolar segment, which can cause its destruction, micromovements, and OAC. On the right-hand side, the ZAGA concept is illustrated in the same situation. Here, a single minimally invasive osteotomy is applied, externalizing the implant and significantly increasing the L-1 segment for the same masticatory force. The total BICA, represented by the sum of the L-1, L-2, and L-3 segments, in the ZAGA protocol is clearly superior. The possibility of sinus infection is reduced in the ZAGA protocol, and the implant platform is located on the bone crest.

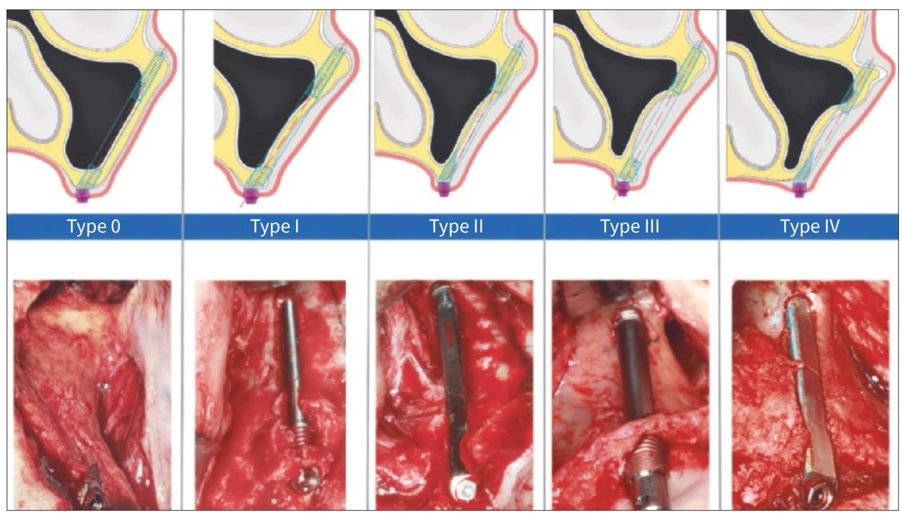



**Fig 33** The simulation at the top represents the ZAGA classification, while the simulation at the bottom represents the different paths that the implant can take depending on the residual anatomy. Within the ZAGA concept, the trajectories can be intrasinus, parasinus, or externalized. In addition, the design of the implant will also be chosen according to the nature of the osteotomy used.

understand that under the ZAGA protocol, the functional load is distributed performed over a much longer L-1 segment, and therefore the distribution is much improved. The ZAGA concept has been used for years in teaching and clinical decision making (Aparicio and coworkers 2021). Fig 33 shows the ZAGA classification for posterior areas. The most frequent anatomies are ZAGA types 4 and 3, with 57.4% and 18.7%, respectively (Aparicio and coworkers 2021). The reader can observe in the same figure that the implant design is chosen according to the residual anatomy. According to the ZAGA protocol, the oral rehabilitation of extreme maxillary atrophy shown in Figs 34 to 39 illustrates the importance of adapting the planning of the type of osteotomy, implant path, and implant design to the patient's anatomy to obtain a tailored, predictable, long-lasting result similar to the original prosthodontic situation.

A scheme of criteria for evaluating the outcome of zygomatic implants proposed by Aparicio and coworkers (2020) is shown in Table 5.

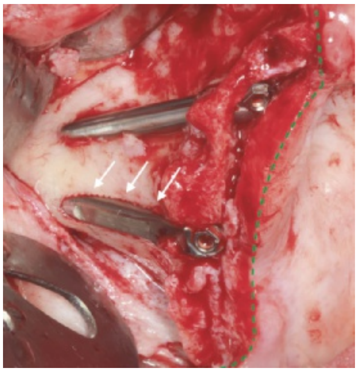


**Fig 34** The two zygomatic implants (Institut Straumann AG, Basel, Switzerland) in situ. The anterior one has a mixed path: intraalveolar (ZAGA tunnel osteotomy); then extramaxillary; finally, intrazygomatic. The anterior osteotomy was closed with a ZAGA Round implant. The posterior implant (ZAGA Flat) has an externalized path from the crest (ZAGA channel osteotomy). The white arrows indicate the precision of the osteotomy. No previous window or slot osteotomy was performed prior to implant placement. The dashed green line indicates the edge of the palatal incision which will easily prevent soft-tissue dehiscence by displacing keratinized tissue buccally (ZAGA: zygoma anatomy-guided approach).

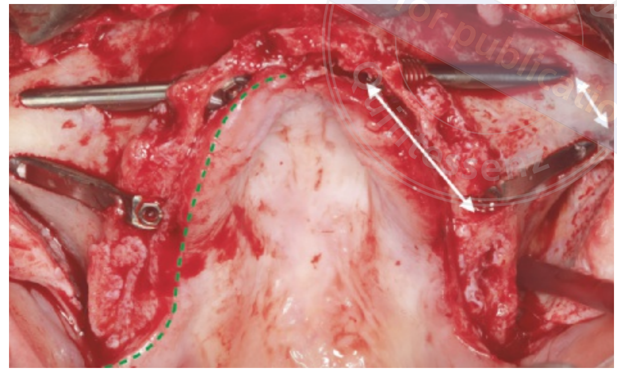


**Fig 35** Occlusal view of the four zygomatic implants in their final position. The anterior implants (ZAGA Round) were placed with preservation of the remaining alveolar bone. The two posterior implants (ZAGA Flat) were placed in an externalized position. The green dashed line indicates the perimeter of the incision. The double white arrows show that thanks to the reduced diameter of the implants (3.4 mm diameter in the first 10 mm of their apical part), an excellent anterior-posterior distribution of the masticatory load was achieved.

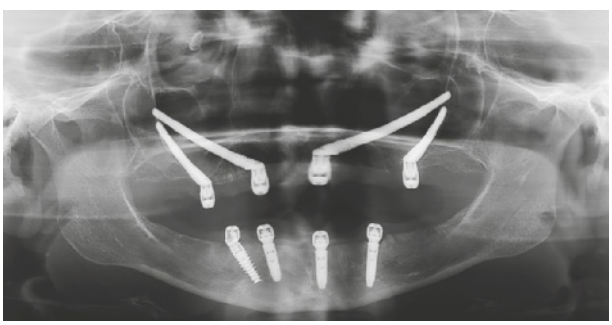


**Fig 36** Panoramic radiograph immediately after surgery.

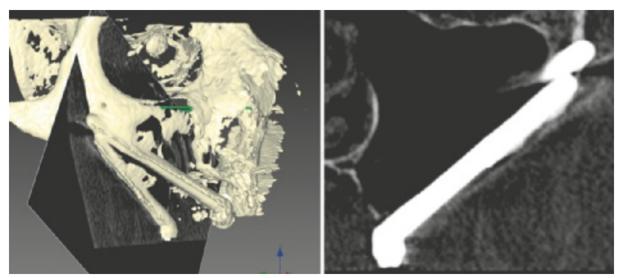


**Fig 37** Radiographic situation of the implant at site 15/16 after the first year of loading.

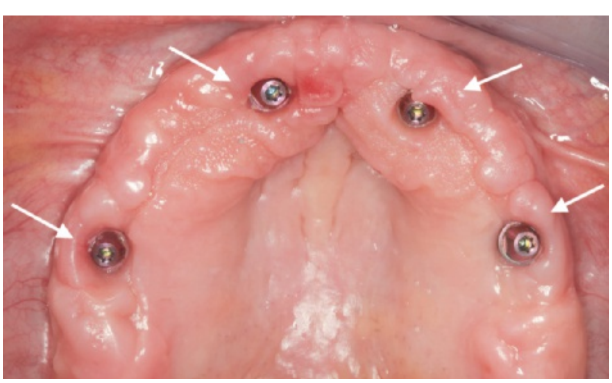


**Fig 38** Clinical image taken at the follow-up visit 1 year after immediate loading. The white arrows indicate the quality and quantity of the soft tissue. Thanks to the palatal incision, an additional thickness of keratinized tissue was transported from the palatal area of the alveolar ridge. As a consequence to the ZAGA palatal rolled flap, the keratinized tissue has increased in thickness and will be further strengthened because the connective pedicle has the genetic capacity to transform into keratinized tissue.

**Fig 39** Frontal view of the oral rehabilitation performed by Dr Peter Simon and Dr Madalina Simon (ZAGA Center Stuttgart, Germany). The white arrows indicate how the prosthesis should ideally relate to the soft tissue to facilitate hygiene and good maintenance.

**Table 5** Description of the specific criteria (ORIS) that classify zygomatic implants (Aparicio and coworkers 2020) as successful in grades I, II, and III (conditions I to III); survival (condition IV); or failed (condition V). The condition of the four ORIS criteria (i.e., O-1/R-3/I-2 /S-4 would be classified as survival). L-K: Lanza and Kennedy task force on rhinosinusitis criteria for the diagnosis of rhinosinusitis. Prosthetic offset: distance from the center of palate to the center of residual alveolar ridge minus distance from the center of palate to the implant head. Positive values correspond to zygomatic implants placed palatally, while negative values correspond to zygomatic implants placed buccally to the alveolar crest.

| **Zygomatic implant condition** | | | | | |
|---|---|---|---|---|---|
| | **I** | **II** | **III** | **IV** | **V** |
| **ORIS* criteria** | **Success** | | | **Survival** | **Failure** |
| O Prosthetic offset (mm) | 0 ≤ d ≤ 6<br>−3 ≤ d ≤ 0 | 6 ≤ d ≤ 10<br>−4 ≤ d ≤ −3 | 10 ≤ d ≤ 15<br>−5 ≤ d ≤ −4 | Implant not tested following ORIS criteria | d > 15<br>d < −5 |
| R Rhinosinus-associated pathology | L-K (−)<br>No increased opacity between pretsurgical and post surgical CBCT | L-K (+) or increased opacity between pretsurgical and post surgical CBCT | Occasional rhinosinusitis responding positively to medical or surgical treatment | | Persistent or recurrent rhinosinusitis refractory to treatment |
| I Peri-implant soft-tissue condition | No recession<br>No signs of inflammation or infection | Stable recession<br>No signs of inflammation or infection | Progressive recession<br>Occasional signs of inflammation or infection responding positively to treatment | | Recession + Permanent or recurrent signs of soft tissue inflammation or infection refractory to treatment or no esthetic acceptance |
| S Stability (individually tested) | No mobility<br>No pain<br>No rotation | Light mobility<br>No pain<br>No rotation | Clear mobility (no evidence of disintegration of the apex of the implant)<br>No pain<br>No rotation | | Clear mobility (evidence of disintegration of the apex of the implant)<br>Rotation and/or pain |

In 2023, the ITI Consensus Workshop on Zygomatic Implants evaluated the current literature to reach consensus and provide evidence-based recommendations for the safe use of zygomatic implants. The Proceedings of the First ITI Consensus Workshop on Zygomatic Implants are available for download below.

Use this code to download the Proceedings of the First ITI Consensus Workshop on Zygomatic Implants (2023).

The clinical recommendations below were derived from the First ITI Consensus Workshop on Zygomatic Implants (2023).

To download the full Proceedings of the First ITI Consensus Workshop on Zygomatic Implants, which also include the consensus statements derived, please scan the code or click on the link on this page.

## PLANNING

**Clinical recommendation 1**
Who should perform zygomatic implant treatment? Zygomatic implants are considered a complex treatment. The success of the treatment is highly dependent on the clinician skill and experience. There is a need for surgical and restorative expertise to address all potential difficulties and complications. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

**Clinical recommendation 2**
Who is a candidate for zygomatic implants? Zygomatic implants are an evidence-based alternative to support fixed or removable prostheses to restore partially or completely edentulous maxillae, allowing high survival rates when splinted to other implants. Zygomatic implants are an alternative when the maxillary bone is completely or partially absent, secondary to resection, trauma or congenital defects. Zygomatic implants are an alternative when the maxillary bone is completely or partially absent, secondary to failure of previously placed implants and/or bone grafts. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

**Clinical recommendation 3**
What diagnostic tools are recommended to assess the surgical field? A CT/CBCT including the midface, allowing for 3D assessment of the maxillary and zygomatic bone volume and sinus health should be obtained. Preoperative evaluation for a lack of existing sinus pathologies is recommended. The use of specific software for planning, including the image of the planned prostheses and 3D anatomic models is an option. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

**Clinical recommendation 4**
What is the degree of maxillary atrophy to consider zygomatic implants? Objective criteria should be utilized to determine the amount of bone atrophy. A 3D assessment of the maxillary and zygomatic bone volume is recommended. The most cited anatomical classification is Cawood and Howell (1988), with class IV, V and VI. Each site should be individually analyzed, and treatment options should be discussed with the patients, considering the risks, benefits, the final prosthetic outcome, total treatment time, long-term outcomes and patients preference and conditions. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

**Clinical recommendation 5**
Can I consider zygomatic implants for maxillofacial defects? Zygomatic implants in maxillofacial rehabilitation cases have additional complexity and considerations. Factors such as surveillance of malignant disease, radiation, bone and soft tissues quality and quantity, patient compliance should be considered. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

## SURGERY

**Clinical recommendation 6**
Can I place zygomatic implant at the same time as dental extractions? Factors such as presence of infection, hard and soft-tissue quality and quantity, clinician experience and patient preference should be considered. Risks may be increased when performing zygomatic implants at the same time as tooth extractions. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

What is the role of guided surgery or dynamic navigation for inertion of zkygomatic implants? Direct visualization of the surgical field is paramount to avoid disorientation and anatomical complications (e.g.. to the orbital cavity or the infra-temporal fossa). This clinical recommendation is based on expert opinion.

**Clinical recommendation 7**
Should the sinus membrane be elevated (“preserved”) for insertion of zygomatic implants? Neither the literature nor expert consensus on preserving the sinus membrane for zygomatic implant placement exists. This clinical recommendation is based on expert opinion.

## RESTORATION

**Clinical recommendation 8**
Do specific loading protocols have an influence on the long-term outcomes of zygomatic implant therapy? Zygomatic implant survival rates appear to be slightly higher for immediate over delayed loading protocols subject to adequate primary implant stability. Immediate loading also confers benefits to the patient through immediate functional rehabilitation. However, delayed loading techniques are also clinically acceptable. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

**Clinical recommendation 9**
When zygomatic implants are used, what type of prosthesis can be utilized? Once generally accepted restorative concepts for implant-supported-prosthesis are followed, removable or fixed restorations can be considered, provided that all implants are splinted. Factors to be considered include prosthetic material, esthetic factors (e.g., lip support, smile line), condition of the opposing dentition, available space for the prosthesis, planned implant distribution, presence and length of cantilever, space available for hygiene and maintenance, proper abutment selection and timing of implant

platform position, patient preference and compliance. This clinical recommendation is based on the systematic review from Polido and coworkers (2023).

## OUTCOMES

### Clinical recommendation 10

What are the long-term therapeutic advantages of zygomatic implants? Current survival data support the use of zygomatic implants as a long-term therapeutic option. Zygomatic implants present an opportunity to rehabilitate patients who either lack the desire to undergo extensive augmentation procedures, or lack the anatomical structures required to deliver conventional implant therapy in the maxilla. Zygomatic implants may confer treatment time benefits to patients due to the possibility of immediacy in reconstruction. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

### Clinical recommendation 11

How does zygomatic implant survival perform long-term when compared to conventional implants? Survival of zygomatic implants appear to be comparable to conventional implants when used for reconstruction of the atrophic maxilla. This includes techniques such as short implants, tilted implants, and implants placed in grafted sinuses. With this in mind, zygomatic implants may be considered as an option to support maxillary reconstructions. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

### Clinical recommendation 12

What is the long-term performance of zygomatic implant-supported reconstructions? Within the context of long-term data survival analyses, zygomatic implant reconstructions are comparable to, and have similar survival characteristics to reconstructions supported by conventional implants. They are subject to similar mechanical complications. Although no additional technical considerations are required, zygomatic implant reconstruction should be considered as a complex procedure. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

### Clinical recommendation 13

What are the long-term mechanical complications associated with zygomatic implants? The most common mechanical complications include zygomatic implant prosthesis abutment or screw fracture, abutment or screw loosening, and chipping or loss of the veneering acrylic or ceramic materials. These complications may occur whether the zygomatic implant reconstructions are splinted to conventional implants or supported by zygomatic implants alone, through a Quad Zygomatic implant approach. Zygomatic implant fracture or reconstruction framework fracture have been reported as rare complications. In light of these findings, conventional prosthetic techniques to mitigate such factors are recommended. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

### Clinical recommendation 14

What are the long-term biological risks associated with zygomatic implants? The most reported long-term biological complication was sinusitis. This may be successfully treated through antibiotic and/or surgical interventions. If these therapies are unsuccessful, the zygomatic implant may be lost. Oro-antral communications, peri-implant infection of the soft tissues, peri-implant mucositis, bleeding on probing and increased probing pocket depths have also been reported. Patient education in oral hygiene maintenance is paramount. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

### Clinical recommendation 15

How should sinus infections in relation to zygomatic implants be treated? Sinus infections are generally treated with antibiotics with a satisfactory resolution. In the absence of resolution, refractory maxillary sinus infections may need exploration of the patency of the osteo-meatal complex and other paranasal sinuses. This clinical recommendation is based on expert opinion.

## PATIENT'S PERSPECTIVE

### Clinical recommendation 16

Do patients perceive a long-term benefit from the zygomatic implant treatment experience? Most patients report an increase in oral health-related quality of life and satisfaction with the treatment outcome. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

### Clinical recommendation 17

Are unique challenges faced by patients receiving zygomatic implants and their reconstructions? Zygomatic implants and their reconstructions may require a higher level of professional maintenance. There are also limitations on the range of acceptable masticatory loads. Patients' expectations need to be managed in line with the biological and technical complexities faced by zygomatic implant therapies. This clinical recommendation is based on the systematic review by Brennand Roper and coworkers (2023).

3

# Clinical Aspects

S. Wolfart, B. Al-Nawas

# 3.1 Radiographic Analysis, Augmentation Requirements, Implant Planning, and Surgical Guide

S. Wolfart

A basic distinction is made between two-dimensional implant planning using a panoramic radiograph and three-dimensional planning using a CBCT scan. In both cases, the radiograph of the edentulous jaw is ideally taken in situ with an individualized radiographic template. Elements of the clinical recommendations from the 6th ITI Consensus Conference 2018 (Wismeijer and coworkers 2018) are a good starting point for a state-of-the-art radiographic analysis, implant planning, and implant placement.

Use this code to download the Proceedings of the 6th ITI Consensus Conference (2018)

- Static computer-aided implant surgery (s-CAIS) should be considered as an additional tool for comprehensive diagnosis, treatment planning, and surgical procedures (see Chapter 3.1.3).
- s-CAIS should be prosthetically driven (see Chapter 3.1.1).
- Surgical experience and general comprehensive training are desirable to achieve an accurate and favorable outcome for implants placed using s-CAIS.
- While recent studies indicate improved accuracy when using s-CAIS in partially edentulous cases, a safety margin of 2 mm from critical anatomical structures should be maintained.
- The alignment of surface scans, including the prosthetic planning, with 3D volumetric imaging data is recommended to improve the accuracy of the anatomical position of the implant (see Chapter 3.1.3).
- Surgical guides should be digitally designed on surface scan files that have been aligned with DICOM data, which is more accurate than using DICOM data alone (see Chapter 3.1.3).
- Flapless s-CAIS may be beneficial in fully edentulous cases in relation to postoperative pain intensity compared with open-flap procedures.
- Flapless s-CAIS may lead to implant placement outside the zone of keratinized mucosa; therefore, the quality and quantity of the keratinized mucosa must be assessed before planning s-CAIS to avoid this or determine the need for keratinized soft-tissue grafting.

## 3.1.1 Prosthetically Guided Implant Planning

### FROM SET-UP TO RADIOGRAPHIC TEMPLATE

Implant planning should be prosthetically guided in all cases. For this purpose, the prospective tooth set-up must be known in all dimensions prior to implant planning and must meet the patient's functional and esthetic requirements. If a suitable complete denture is available, it can be used as the basis for further planning. If there is no appropriate complete denture that reflects the appropriate vertical, horizontal, and sagittal alignment of the future restoration, it is strongly recommended that an adequate final prosthetic set-up be fabricated first and used as a diagnostic try-in. For this purpose, the occlusal plane and the vertical dimension of occlusion (VDO) are determined using maxillary and mandibular bite blocks.

The required radiographic template is then created based on the appropriate prosthesis, or on the clinically tested and approved set-up.

### THE RADIOGRAPHIC TEMPLATE AS A MEASURE OF ATROPHY

The radiographic template consists of a clear plastic base with white barium sulfate teeth and should clearly show the cementoenamel junction and the adjacent roots of the teeth on the proposed prosthesis. When the radiographic template is inserted, the alveolar ridge should be visible through the template and the vertical and horizontal degree of atrophy of the soft and hard tissues can be assessed (Fig 1). The

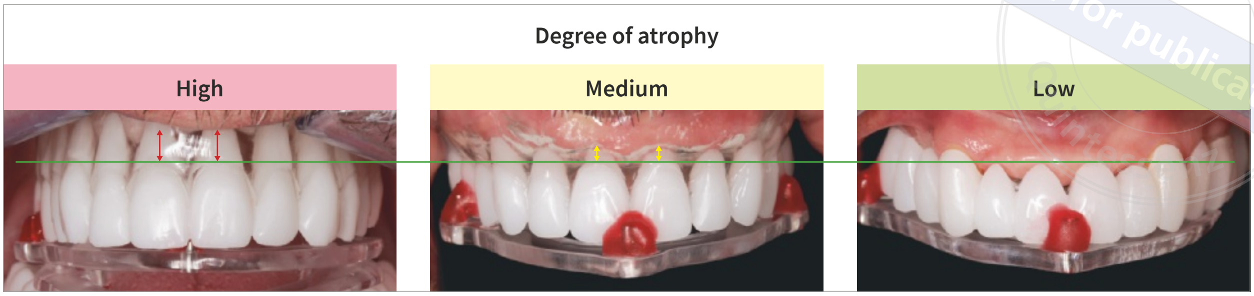



**Fig 1** Degree of atrophy: The alveolar ridge can be seen through the radiographic template and the vertical (arrows) and horizontal degrees of soft- and hard-tissue atrophy can be estimated.

degree of atrophy has a direct impact on possible prosthetic treatment approaches and the associated degree of difficulty (see Chapter 3.5). Accordingly, the degree of atrophy present determines whether a clinical case is classified as Advanced or Complex according to the SAC classification for edentulous patients in implant dentistry (Dawson and coworkers 2022).

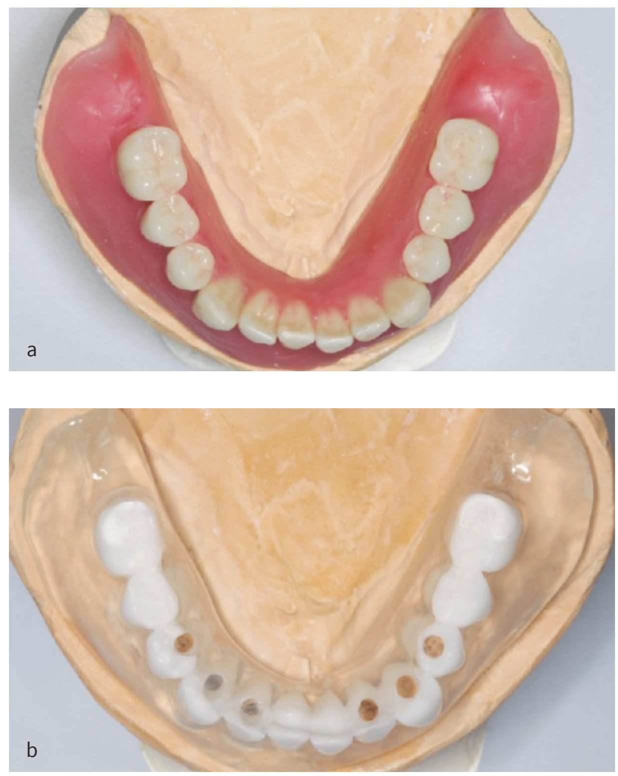
### 3.1.2 2D Radiographic Analysis for Orientation-Based Implant Planning

In orientation-based implant planning, metal spheres or sleeves (fiducial markers) are attached to the radiographic template above the regions of the planned implants. These cues broadly represent the planned position of the implants as radiopaque shadows during the radiographic measurements. Another function of the metal spheres is certainly to determine the magnification factor of the plain radiograph to be taken.

Based on the resulting (usually panoramic) radiograph, the template is converted into a surgical guide. There is no direct relationship between the drill hole defined by the template and the radiographic image. In other words, the indicated drilling direction is only a rough guide; the template does not define the drilling depth or implant angulation. However, since any implant rehabilitation of the edentulous jaw must be considered Advanced or Complex according to the SAC classification, static computer-guided implant placement with 3D radiographic analysis is preferable to orientation-based implant planning.

### 3.1.3 Static Computer-Assisted Implant Surgery (s-CAIS) with 3D Radiographic Analysis

In the edentulous jaw, the fabrication of a guide template is mandatory for static computer-assisted implant surgery (s-CAIS). This requires a CBCT scan with a barium sulfate (radiopaque) template inserted. Axis-centered holes corresponding to the tooth set-up are created to indicate implant positions in the radiographic template (Figs 2a-b).




**Figs 2a-b** Radiographic template (classical method): The set-up as tried on intraorally is transferred to a radiographic template with teeth containing barium sulfate. The reference holes in the teeth reflect the ideal prosthetic implant axis.

A surgical guide is then digitally designed through a complex planning process and manufactured by CAM. The surgical guide allows precise placement of the implants in terms of position, angulation, and insertion depth via integrated guide sleeves using defined drilling sequences. This requires secure anchoring of the surgical guide, which is not possible in an edentulous jaw without the use of specific accessories, provided that the implant is also inserted using the template. Additional retention pins ensure positive fixation of the guide.

**Fig 3** Panoramic radiograph of the edentulous jaw with pronounced mandibular atrophy. The mental foramina are located almost at the level of the alveolar ridges.

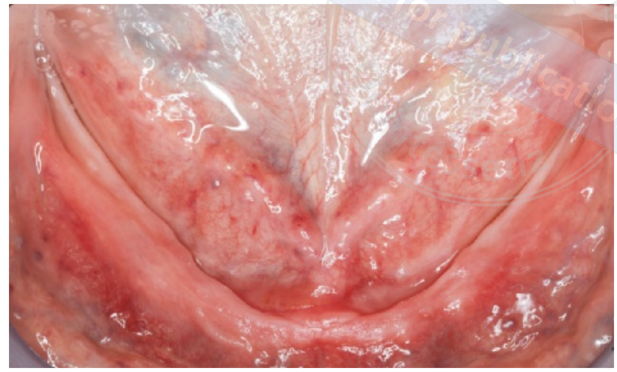


**Fig 4** Initial situation: Occlusal view with severely atrophied alveolar ridges.

**Fig 5** Radiographic template (using the existing complete denture): Relining of the denture for optimal congruency between the denture base and the alveolar ridge. Radiopaque cues (zirconia measuring spheres) are placed on the denture base at regular intervals. Sufficient distance from the denture is required for the spheres to be fully visible in subsequent scans.

**Fig 6** Basal view of the denture after relining.


**Fig 7** A stone cast of the denture base is made. Reference markers are incorporated (yellow circles) and the cast is scanned with an intraoral scanner.

## CAD/CAM SURGICAL GUIDES IN THE EDENTULOUS JAW

In the clinical case presented in this chapter (Figs 3 and 4), a functional and esthetic analysis of the existing complete dentures concluded that it met all the projected requirements and could be used directly as a radiographic template. The radiographic measurements were taken with the existing prosthesis, followed by the CAD/CAM fabrication of the surgical guide. The procedure consists of the following steps (Tuna and coworkers 2024):

1. The denture is relined to ensure maximum congruence between the denture base and the alveolar ridge (Figs 5 and 6).
2. A stone cast of the denture base is made (Fig 7).
3. Since the denture itself has no radiopaque structures, fiducial markers (e.g., zirconia measuring spheres) are regularly spaced and attached to the denture base (Fig 5). These markers must not visually overlap with the prosthesis but should maintain a sufficient distance from the acrylic denture teeth and metallic framework structures within the denture.
4. Reference markers are placed on the outer surfaces of the cast (Fig 7).
5. Four datasets are created:
   a. STL dataset: The cast alone is scanned with an intraoral scanner (*cast-only* scan, Fig 7).
   b. STL dataset: The complete denture with the radiopaque measuring spheres is scanned with an intraoral scanner (*denture-only* scan).
   c. STL dataset: The complete denture with the radiopaque measuring spheres is scanned on the cast with an intraoral scanner (*denture-on-cast* scan, Fig 8).

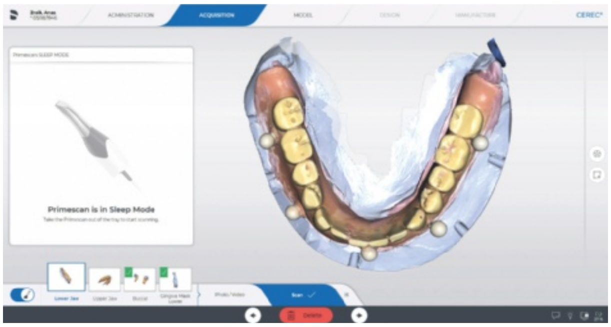


**Fig 8** The denture is returned to the cast and scanned with it. Another scan is made of the denture only.

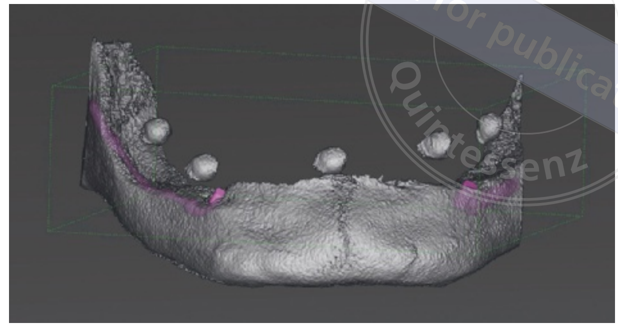


**Fig 9** CBCT with the mandibular complete denture inserted. Only the reference bodies are visible.

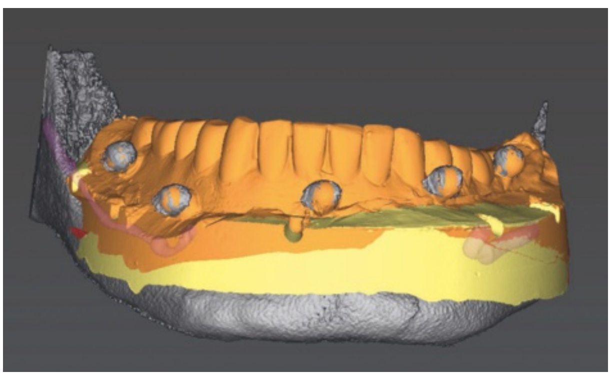


**Fig 10** The measuring sphere is used to match the CBCT with the denture-on-cast STL dataset.

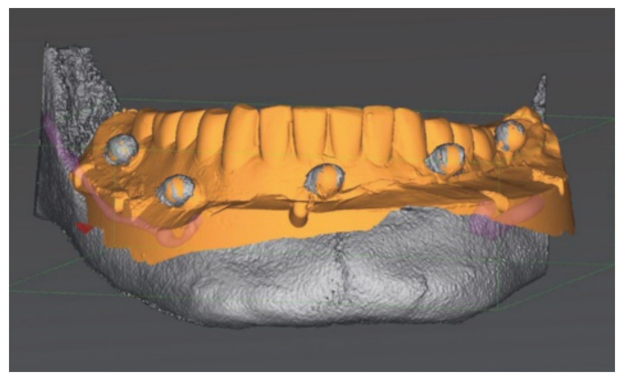


**Fig 11** The measuring sphere is used to match the denture-on-cast STL dataset with the denture-only STL dataset.

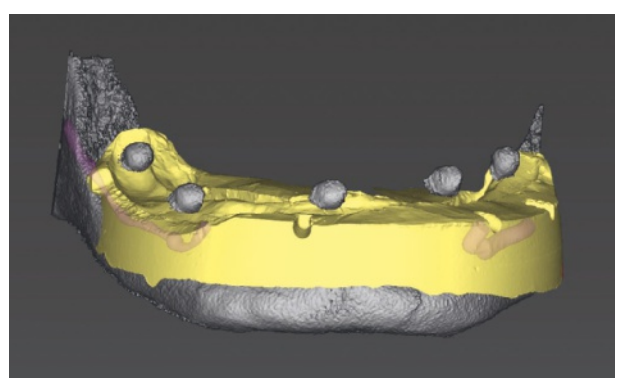


**Fig 12** The reference marks on the cast are used to match the denture-on-cast STL dataset with the cast-only STL dataset.

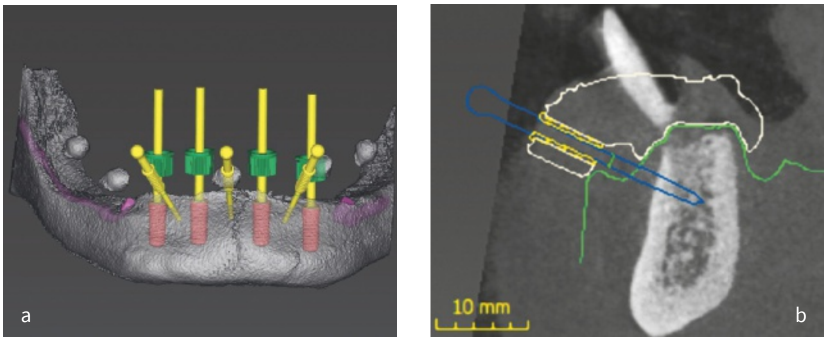
   d. DICOM dataset: A CBCT scan is made with the complete denture (including the measuring spheres) in place (*CBCT-with-denture*, Fig 9).

6. Finally, the measuring spheres and the temporary relining impression are removed from the denture.

The different datasets are superimposed and merged using the different reference structures (measuring spheres and markers in the dental stone):

In the first step, the *CBCT-with-denture* dataset is matched with the *denture-on-cast* dataset using fiducial markers (Fig 10). Next, the *denture-only* dataset is matched with the *denture-on-cast* dataset, again using the **fiducial markers** (Fig 11). Subsequently, the *denture-on-cast* dataset is matched with the *cast-only* dataset using the **reference markers** on the cast (Fig 12). The merged datasets can be individually added or subtracted as needed in the following steps.

The implants are assigned prosthetic positions in the DICOM dataset (Figs 13 and 14) for the subsequent design of the surgical guide. The guide is supported by the alveolar ridge over as large an area as possible so that it can be clearly positioned in the mouth (Figs 15 and 16). The design of the basal surface of the guide (the surface that contacts the alveolar ridge) is created according to the surface textures of the *cast-only* scan. This results in maximum congruence between the surgical guide and the alveolar ridge (Fig 17).




**Figs 13a-b** Implant planning and design of the three additional pin channels with precision guide inserts (a). The pins are adequately anchored in the jawbone (b).

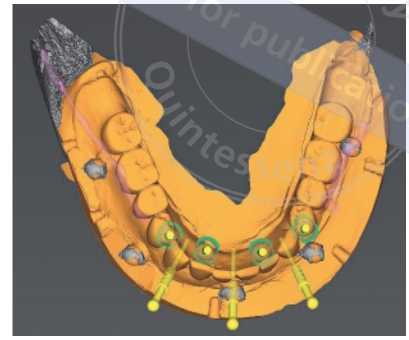


**Fig 14** The implants are positioned as prosthetically guided.

**Fig 15** Finished printed surgical guide with bonded guide sleeves for the implants and guide inserts for the retention pins (basal surface constructed from the STL surface structures of the cast-only scan).

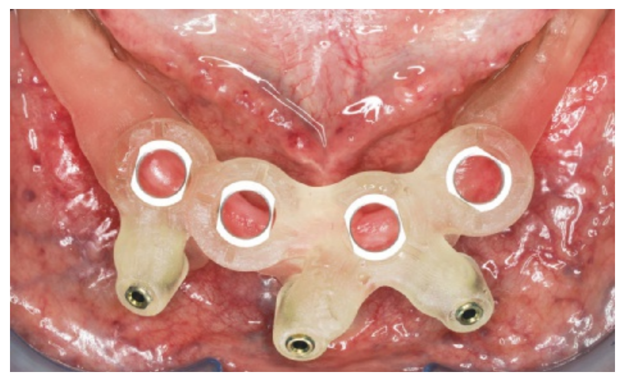


**Fig 16** The characteristic saddle areas allow the surgical guide to be clearly positioned on the alveolar ridges.

**Fig 17** A visible thin line of flow silicone confirms that the surgical guide is fully seated.

## 3.1.4 Guided Implant Placement with Fixation Pins

To increase the accuracy of guided implant placement in the edentulous jaw, the guide should be attached to the alveolar ridge with additional fixation pins (e.g., Neodent Guided Surgery). For this purpose, the position and penetration depth of the pins are planned at the time the surgical guide is fabricated (Figs 13a-b). In addition to the implant guide sleeves, the finished guide has three pin channels with precision guide inserts (Fig 15). The holes for the retaining pins are drilled through the mucosa. All three retaining pins are then inserted and the guide is secured (Figs 18 to 20). The flap is then reflected. After exposing the alveolar ridge, the guide is reattached with the pins. At this point, it would no longer be possible to use anatomical structures alone for clear positioning (Fig 21).

With the surgical guide in place, the implants are inserted according to the drilling protocol. The drill keys reduce the diameters of the guide sleeves to different internal diameters, so that the pilot drills of different diameters are always precisely guided. A drilling protocol also specifies the drill bit length to be used and the height of the drill keys. The drill keys have a height of either 1 mm or 3 mm. This clearly defines both the drilling axis and the drilling depth (Figs 22 to 24). The implants can also be inserted through the surgical guide to prevent angulation changes during placement (Figs 25 to 29).

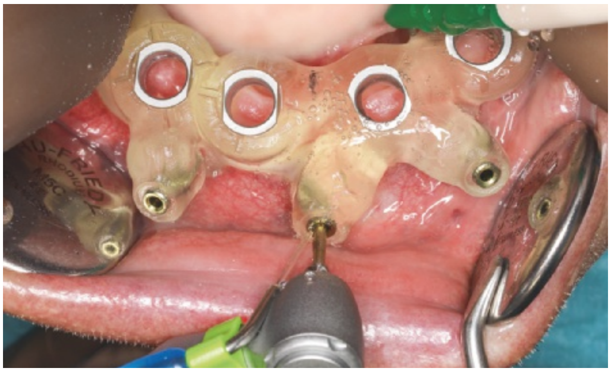


**Fig 18** The pre-drills were guided through the pin channels and drilled through the mucosa into the bone with the guide in its optimal position. No flap should be reflected at this time.

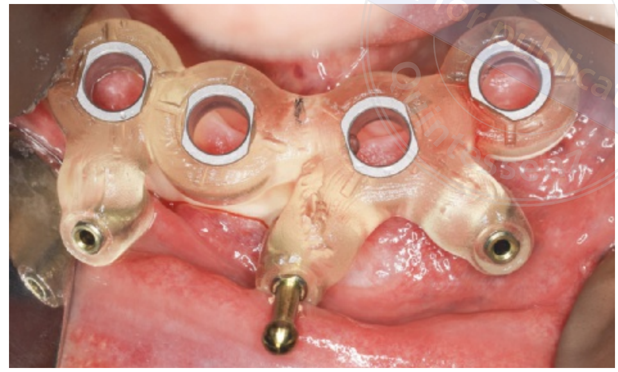


**Fig 19** The first pin is inserted through the guide into the bone. The retention of the surgical guide has already improved before drilling the remaining pin channels.

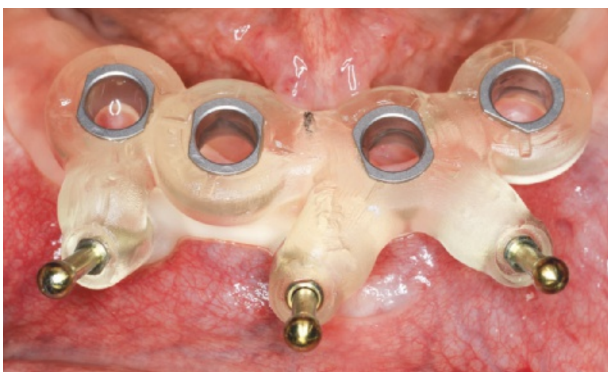


**Fig 20** After drilling the remaining pin channels, all three pins are inserted as far as they will go.

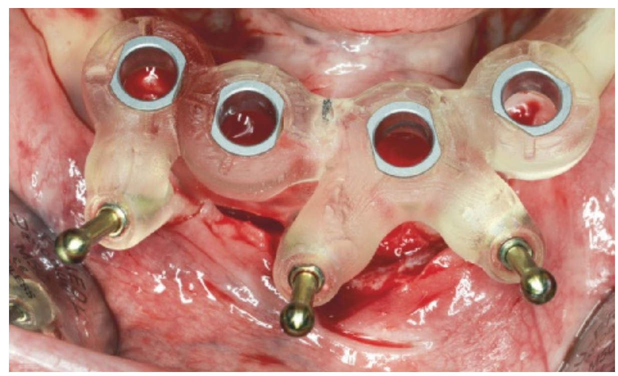


**Fig 21** Flap reflection and insertion of the surgical guide with pins. The guide is now firmly anchored and securely fixed by the pins. The pin inserts aid in lip retraction and improve the view of the surgical field.

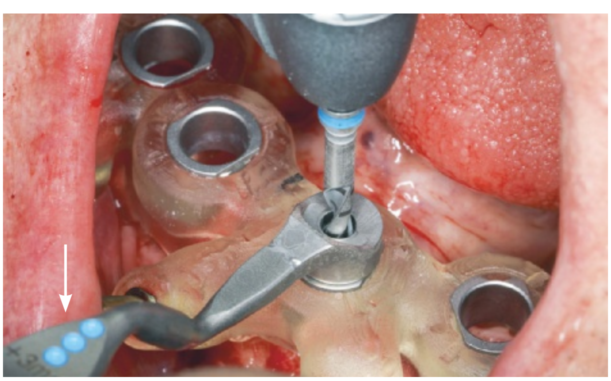


**Fig 22** The drill keys reduce the diameters of the guide sleeves to different internal diameters, so that the pilot drills of different diameters are always precisely guided. A drilling protocol also specifies the drill bit length to be used and the height of the drill keys. The drill keys have a height of either 1 mm (one dot) or 3 mm (three dots, see arrow). This clearly defines both the drilling axis and the drilling depth.

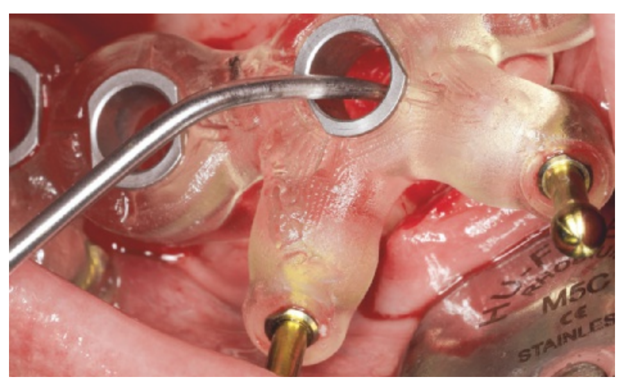


**Fig 23** The cloverleaf probe can be used to probe the implant site through the surgical guide.

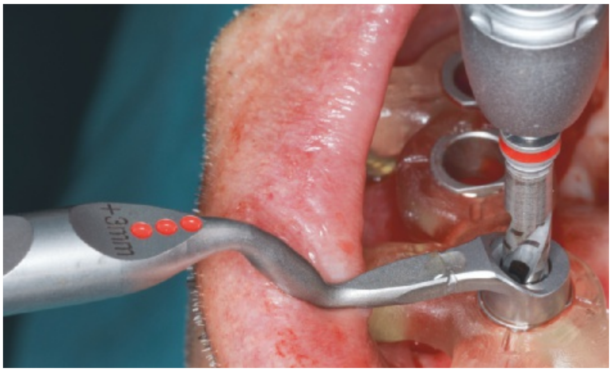



**Fig 24** Final shaping drill with corresponding drill key.

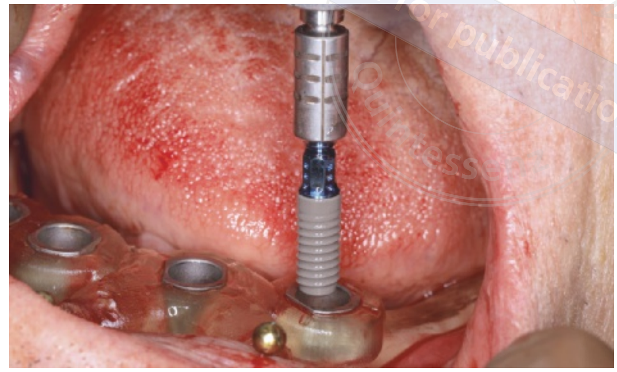


**Fig 25** The implants can also be inserted through the surgical guide.

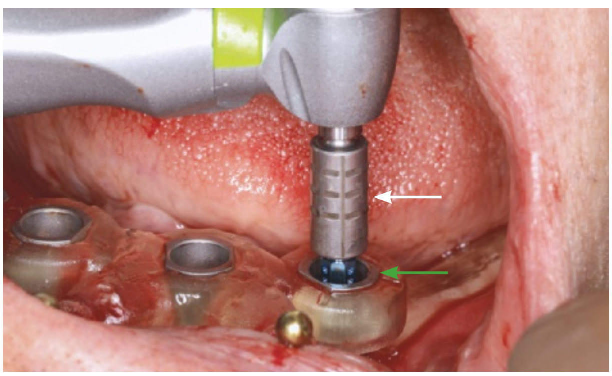


**Fig 26** The insertion depth is determined by the horizontal markings on the insertion tool. When finished, the mark (white arrow) specified by the drilling protocol must be flush with the surgical guide (green arrow).

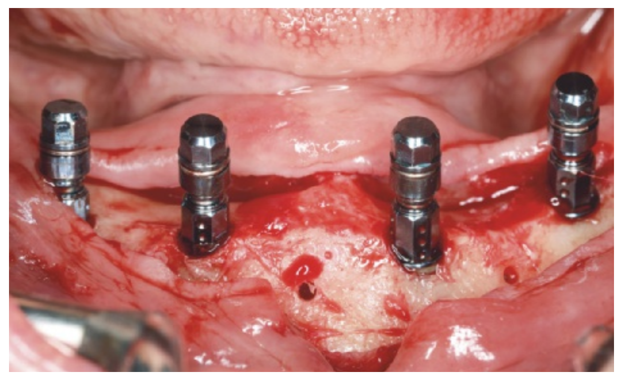


**Fig 27** The implants are positioned in parallel with each other.

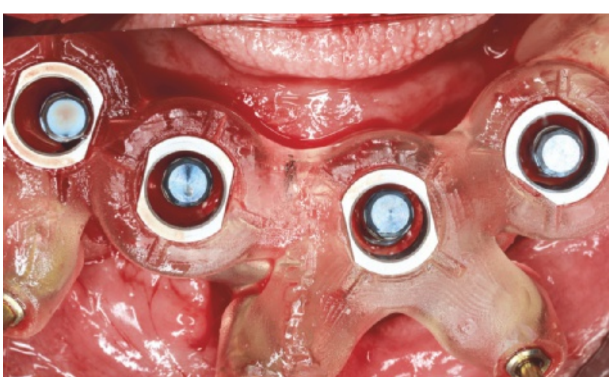


**Fig 28** Verification of implant positions (with insertion posts) in relation to the surgical guide.

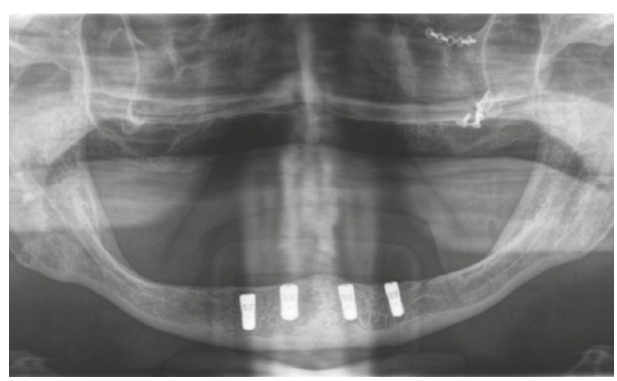


**Fig 29** Postoperative panoramic radiograph.

### 3.1.5 Implant Planning/Placement and dPROs

Patients generally prefer digital technologies for implant planning and placement. However, no difference in intraoperative or postoperative comfort was observed whether implant placement was performed freehand, orientation-based, or with a surgical guide. Only flapless procedures were associated with improved dPROs (Bishti and coworkers 2021).

Three-dimensional planning allows the clinician to predict the course of surgery and the necessary surgical techniques much more accurately (Wismeijer and coworkers 2018; Dawson and coworkers 2022). Based on this accurate planning, it also allows for more sophisticated patient education, which becomes much more vivid and easier to understand when three-dimensional imaging techniques are available. This, better illustrated, patient education suggests an easier understanding of the patient regarding the upcoming surgical procedure. This can further strengthen the dentist-patient relationship (Gross 2012). In addition, the use of a surgical guide typically significantly reduces the surgical time, which in turn can have a positive impact on postoperative (dis)comfort (Wismeijer and coworkers 2018).