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       Acknowledgments
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Removable and Fixed Implant/Prosthodontic Options for the Edentulous Maxilla

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Removable and Fixed Implant/Prosthodontic Options for the
Edentulous Maxilla
The ITI Mission is...

“... to promote and disseminate knowledge on all aspects of implant dentistry and related tissue regeneration through research, development and education to the benefit of the patient.”
Preface

Since the introduction of implant dentistry some 40 years ago, much has changed. The development of implant materials and implant design, the evolution of prosthetic materials and prosthetic design, and the optimization of surgical and prosthetic treatment protocols have opened this field of dentistry to a large group of treatment providers and patients. Oral implantology has provided edentulous patients with denture retention, immensely improving their quality of life. Based on research in the field and increased practical knowledge, a treatment involving two implants has now been described as the standard of care for retaining an overdenture in the edentulous patient.

Innovation, knowledge, and experience have led to improved implant designs and optimized treatment protocols. Research and treatment evaluations have shown us how to optimize the biomechanical design of the superstructures and taught us how to select patients for the different treatment protocols, making oral implantology an ever more predictable treatment option. Over the past 40 years, we have gone from 6 months of healing in the edentulous maxilla and 3 months in the edentulous mandible to immediate loading protocols for a large group of patients and many treatment indications.

Computer technology and CAD/CAM are playing a more dominant role in oral implantology. Guiding systems and computer-assisted superstructure manufacturing have given clinicians the tools required to develop an entire treatment plan in a virtual environment. This is the direction in which oral implantology is rapidly developing.

In August of 2008, the ITI met at the 4th ITI Consensus Conference in Stuttgart to discuss a large number of topics, including loading protocols for edentulous patients and computer technology and CAD/CAM for edentulous patients. The proceedings of this conference were published in a supplement to the International Journal of Oral and Maxillofacial Implants in 2009.

This Treatment Guide provides a summary of the findings and statements of the 4th Consensus Conference, completed with the underlying scientific evidence. Based on these statements, guidelines and recommendations are
provided for the various treatment options for edentulous patients, illustrated with detailed case reports.

The authors hope that this fourth volume in the series of ITI Treatment Guides will provide clinicians with a sound resource to turn to when developing treatment plans for their edentulous patients.

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Daniel Buser
Urs C. Belser
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1 Introduction

D. Wismeijer

The mission of the ITI is to promote and disseminate knowledge about all aspects of implant dentistry and related tissue regeneration through research, development, and education. During the first decade of the 21st century, the leading role of the ITI in informing the dental community as well as its patients was highlighted by various relevant endeavors coordinated by the ITI Education Committee:

- The ITI Consensus Conferences periodically update the body of evidence on which many clinical approaches in implant surgery and implant prosthodontics are based. These conferences lead the way for clinicians in the field to provide their patients with evidence-based care.
- The ITI Treatments Guides provide clinicians with objective recommendations for implant treatment. These recommendations and treatment concepts based on the outcomes and recommendations of the ITI Consensus Conferences and are supported and illustrated by experienced clinicians.
- The Glossary of Oral and Maxillofacial Implants is another tool for professionals in the field of implant dentistry. With its more than 2000 terms in various areas, it is the standard work in the field.
- The SAC Classification in Implant Dentistry (2009) is a reference tool for practitioners when selecting treatment approaches for individual patients. It allows them to assess the degree of complexity, the risks involved when treating the individual patient, and the skills required to provide the necessary treatment. This publication is based on an ITI conference on this subject held in March 2007.

The 4th ITI Consensus Conference was held in August of 2008, discussing various topics in implant dentistry, including loading protocols and applications of computer technology. The proceedings of this conference were published in a supplement to the International Journal of Oral and Maxillofacial Implants (JOMI) in 2009.
This Treatment Guide, the fourth in the series, focuses on the treatment of the edentulous patient. Based on the body of literature that was studied for the 4th ITI Consensus Conference and the ensuing recommendations and results, an evidence-based approach is presented and supported by detailed case reports. We hope that this fourth Treatment Guide—like the previous three—will once again be a useful tool for clinicians in achieving their treatment goals.
2 Proceedings of the 4th ITI Consensus Conference: Loading Protocols in Implant Dentistry


Group 3 of the 4th ITI Consensus Conference held in Stuttgart reviewed the current scientific evidence for loading protocols in implant dentistry. The group was composed of three teams:

- Partially edentulous patients, anterior region
- Partially edentulous patients, posterior region
- Edentulous patients

The participants were:

*Group leader:* Hans-Peter Weber

*Reviewers:* German O. Gallucci
Linda Grütter
Mario Roccuzzo

*Secretary:* Dean Morton

*Co-Reviewers:* Urs Belser
Luca Cordaro

*Participants:* Gil Alcoforado
Juan Blanco
Roberto Cornellini
Tony Dawson
Andreas Feloutzis
Siegfried M. Heckmann
Frank L. Higginbottom
Haldun Iplikçıoğlu
The group addressing edentulous patients was to present well-structured scientific and clinical evidence related to maxillary and mandibular implant-supported rehabilitations. The specific aim was to assess the survival outcome of various loading protocols according to treatment sequence and selected prosthodontic design.

The electronic search yielded 2,371 publications, of which 61 articles met the inclusion criteria. Only studies reporting on implants with “rough surfaces” were selected for this review. The reported data covered 2,278 patients and 9,701 implants. Studies were grouped according to treatment protocols and prosthodontic designs, and results on conventional, early, and immediate loading were assessed separately for fixed and removable dental prostheses (Table 1).

Although several randomized controlled trials (RCT) and reviews have demonstrated clinical efficiency in shortening the time to loading for edentulous patients, the related scientific evidence is mostly presented from the perspective of implant survival or success, with only limited information about the prosthodontic treatment outcome. To assess the impact of modified loading protocols in edentulous patients accurately, data was analyzed separately for: (1) maxillary and mandibular protocols; (2) fixed and removable rehabilitations; (3) rough-surfaced implants; and (4) implant placement into healed sites or extraction sockets not yet healed. These factors have often been presented as having a direct influence on the implant and prosthodontic survival rate.

Table 1 Number of selected publications by loading protocol and prosthodontic treatment modality.

<table>
<thead>
<tr>
<th>Removable</th>
<th>Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading Type</td>
<td>Maxilla</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>(Conventional) loading</td>
<td>3 studies 0 (RCTs) 2 (prospective) 1 (retrospective) 110 pats/530 imps 94.8%-97.7% OH+</td>
</tr>
<tr>
<td>Early loading</td>
<td>2 studies 0 (RCTs) 2 (prospective) 0 (retrospective) 49 pats/185 imps 87.2%-95% OH-</td>
</tr>
<tr>
<td>Immediate loading</td>
<td>1 study 0 (RCTs) 1 (prospective) 0 (retrospective) 12 pats/48 imps 95.6% OH N/A</td>
</tr>
<tr>
<td>Immediate loading of immediately</td>
<td>N/A</td>
</tr>
</tbody>
</table>
2.1 Recommended Clinical Procedures Regarding Loading Protocols for Endosseous Implants in Edentulous Patients

Several factors have been identified as playing a key role in successfully achieving osseointegration with modified loading protocols: initial implant stability, implant surface characteristics, anatomical conditions, bone metabolism, interim prosthesis design, and occlusion pattern during the healing phase. Ideally, they should be considered in the selection of an appropriate loading protocol for the edentulous patient (see Chapter 5).

According to the 4th ITI Consensus Conference, clinical recommendations for implant loading protocols in different indications were presented using a novel validation protocol (JOMI Supplement, 2009). This validation was based on parameters presented in Table 1. In order to propose clinical recommendations for various loading protocols, study design, sample size, and outcome homogeneity (OH) were considered the fundamental parameters. Outcome homogeneity was considered positive (OH+) when the variation of implant survival rates for the treatment protocol was 10% or less, and negative (OH-) when the variation was greater than 10% (Table 1).

Using these criteria, scientific and/or clinical validation was categorized according to the following four groups:

- **SCV**: scientifically and clinically validated
- **CWD**: clinically well documented
- **CD**: clinically documented

---

<table>
<thead>
<tr>
<th>placed implants</th>
<th>Total main groups</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>149 pats/1194 imps 87.5%- 98.4% OH-</td>
<td>27</td>
<td>61</td>
</tr>
<tr>
<td>15 pats/97 imps 97.7%-100% OH+</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

**RCTs**: randomized controlled trials, **pats**: patients, **imps**: implants, **OH**: outcome homogeneity, + (less than 10% variation), - (more than 10% variation)
The highest level of scientific and clinical validation was found for conventional loading with mandibular overdentures and maxillary fixed dental prostheses. Insufficient scientific or clinical documentation/validation was found for immediate loading of maxillary overdentures as well as for immediate loading of immediately placed implants combined with fixed or removable dental prostheses in either jaw. All other loading protocols for edentulous arches showed different degrees of clinical documentation without proper scientific validation (Table 2).

Table 2 Validation of loading protocols for different prosthodontic treatments in the edentulous mandible or maxilla.

<table>
<thead>
<tr>
<th>Removable</th>
<th>Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxilla</td>
<td>Mandible</td>
</tr>
<tr>
<td>Conventional loading</td>
<td>CWD</td>
</tr>
<tr>
<td>Early loading</td>
<td>CD</td>
</tr>
<tr>
<td>Immediate loading</td>
<td>CID</td>
</tr>
<tr>
<td>Immediate loading of immediately placed implants</td>
<td>CID</td>
</tr>
</tbody>
</table>

SCV: scientifically and clinically validated - dark green; CWD: clinically well-documented - light green; CD: clinically documented - yellow; CID: clinically insufficiently documented - red

Table 2 represents a simplified method for selecting a loading protocol based on the scientific evidence available for each clinical situation. The dark and light green loading protocols have been at least clinically well documented with proven homogenous outcomes in several publications. The yellow group indicates clinically documented loading protocols with a small number of publications or a limited sample size. In the red group, all the protocols presented an important variation on their outcome homogeneity when survival rates were assessed. These protocols can be considered to be technique-sensitive, where careful patient selection, operator skills, and risk benefit for the patient should be taken into consideration before selecting a
red-group loading protocol.

This description, however, does not refer to the level of complexity for the procedures that, in some cases, are still considered advanced or complex according to the SAC classification.

### 2.1.1 Definition of Terms

The group revisited the conclusions and consensus statements from the previous ITI Consensus Conference as published by Cochran and coworkers, as well as the various definitions for loading protocols from other organizations. Table 3 summarizes those different proposed definitions of terms.

Loading protocols were considered as part of a Congress Consensus meeting in Barcelona, Spain, in 2002. The following definitions for implant loading were agreed on by Aparicio and coworkers:

- **Immediate loading.** The prosthesis is attached to the implants the same day the implants are placed.
- **Early loading.** The prosthesis is attached during a second procedure, earlier than the conventional healing period of 3 to 6 months. The time of loading should be stated in terms of days/weeks.

**Table 3 Summary of loading protocol definitions and clarifying terms.**

<table>
<thead>
<tr>
<th></th>
<th>Immediate loading</th>
<th>Early loading</th>
<th>Conventional loading</th>
<th>Delayed loading</th>
<th>Clarifying terms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barcelona Consensus 2002</strong></td>
<td>&lt; 24 hours</td>
<td>&gt; 24 hours &lt; 3-6 months</td>
<td>3-6 months</td>
<td>&gt; 3-6 months</td>
<td>Non-occlusal loading: restoration not in contact in centric occlusion</td>
</tr>
<tr>
<td><strong>ITI Consensus 2003</strong></td>
<td>&lt; 48 hours</td>
<td>&gt; 48 hours &lt; 3 months</td>
<td>3-6 months</td>
<td>&gt; 3-6 months</td>
<td>Immediate restoration: immediate loading without occlusal</td>
</tr>
<tr>
<td>European Association of Osseointegration 2006</td>
<td>&lt; 72 hours</td>
<td>&gt; 3 months (mandible)</td>
<td>&gt; 3-6 months</td>
<td>Immediate restoration or non-functional immediate loading defined as restoration within &lt; 72 hours without occlusal contact</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Cochran Systematic Reviews 2007</td>
<td>&lt; 1 week</td>
<td>&gt; 1 week &lt; 2 months</td>
<td>&gt; 2 months</td>
<td>Immediate loading with or without occlusal contact</td>
<td></td>
</tr>
</tbody>
</table>

- **Conventional loading.** The prosthesis is attached to the implants during a second procedure 3 to 6 months after the implants are placed.
- **Delayed loading.** The prosthesis is attached during a second procedure, later than the conventional healing period of 3 to 6 months.

The 3rd ITI Consensus Conference in 2003 in Gstaad, Switzerland, modified the definitions as follows (Cochran and coworkers, 2004):

- **Immediate loading.** A restoration is placed in occlusion with the opposing dentition within 48 hours of implant placement.
- **Early loading.** A restoration is in contact with the opposing dentition and placed at least 48 hours after implant placement but no later than 3 months afterwards.
- **Conventional loading.** The prosthesis is attached during a second procedure after a healing period of 3 to 6 months.
- **Delayed loading.** The prosthesis is attached during a second procedure that takes place sometime later than the conventional healing period of 3 to 6 months.
• **Immediate restoration.** A restoration is inserted within 48 hours of implant placement but is not in occlusion with the opposing dentition.

For a Consensus Conference of the European Association for Osseointegration (EAO) in Zurich in 2006, Switzerland, a review was presented by Nkenke and Fenner. The group accepted the following definitions:

• **Immediate loading.** A situation where the superstructure is attached to the implants in occlusion with the opposing dentition within 72 hours.

• **Conventional loading.** A situation where the prosthesis is attached to the implants after an unloaded healing period of at least 3 months in the mandible and 6 months in the maxilla, respectively.

• **Non-functional immediate loading and immediate restoration.** Used when prostheses are fixed to the implants within 72 hours without achieving full occlusal contact with the opposing dentition.

Esposito and coworkers published an updated version of their systematic review regarding different times for loading dental implants, and based it on the following definitions:

• **Immediate loading.** This means placing implants in function within 1 week after placement. No distinction was made between occlusal and non-occlusal loading.

• **Early loading.** This means placing implants in function between 1 week and 2 months after placement.

• **Conventional loading.** This means placing implants in function after 2 months.

Based on these definitions and considering the Cochrane Report (Esposito and coworkers, 2007) and the 4th ITI Consensus Conference, group 3 on loading protocols for the edentulous patient recommends the following ITI definitions for dental implant loading:

• **Conventional loading.** Dental implants not connected to prostheses are allowed a healing period of more than 2 months after implant placement.

• **Early loading.** Dental implants are connected to the prostheses between
1 week and 2 months subsequent to implant placement.

- **Immediate loading.** Dental implants are connected to the prostheses within 1 week subsequent to implant placement.

In addition, the group recommended abandoning the separate definition for delayed loading, since it will be included under the definition of conventional loading.

### 2.2 Consensus Statements

**Statement 1**
For the edentulous mandible and maxilla, the existing literature supports the loading of microrough implants between 6 and 8 weeks after implant placement with fixed or removable prostheses in the mandible, and fixed prostheses in the maxilla. Therefore, for the majority of patients, loading of dental implants for these indications and within this timeframe should be considered routine.

**Statement 2**
A lower level of evidence exists to support loading of dental implants with maxillary overdentures for this timeframe (6 to 8 weeks). Similarly, scientific evidence supporting loading of dental implants in the edentulous arches between 2 and 6 weeks remains limited at this time.

**Statement 3**
In the case of the edentulous mandible, the literature supports immediate loading of microrough implants with fixed prostheses or overdentures. This consensus statement is made with the understanding that the treatment is complex. Treatment within this protocol, for the above indications, can be considered a valid treatment option for clinicians with the appropriate education, experience, and skills.

**Statement 4**
In the case of the edentulous maxilla, the literature supports immediate loading of microrough implants with fixed prostheses. This consensus statement is made with the understanding that the treatment is complex. Treatment within this protocol, for the above indications, can be considered a valid treatment option for clinicians with the appropriate education, experience, and skills.

**Statement 5**

For the edentulous maxilla, insufficient data exists to support immediate loading of dental implants with overdenture prostheses.

**Statement 6**

For the edentulous maxilla and mandible, conventional loading (more than 2 months after placement) is recommended under specific conditions. These conditions include, but may not be limited to, alveolar ridge augmentation, sinus floor elevation, and the presence of parafunction, maxillary overdentures, and compromised host status.

### 2.3 Consensus Statements on Computer Technology and CAD/CAM for Edentulous Patients

Group 2 of the 4th ITI Consensus Conference reviewed the emerging techniques and technologies in implant dentistry. The participants were:

*Group leader:* Christoph Hämmerle

*Reviewers:* Ronald Jung  
David W. Paquette  
Daniel Wismeijer

*Co-Reviewers:* Linah Ashy  
Nadine Brodala  
Jeffrey Ganeles  
Theodoras Kapos  
David Schneider  
Ali Tahmaseb
The scientific evidence was divided into two main topics: the application of computer technology in surgical implant dentistry and CAD/CAM used for the fabrication of frameworks and abutments in implant dentistry.

2.3.1 Application of Computer Technology in Surgical Implant Dentistry

**Computer-guided (static) surgery.** The use of a static surgical template that reproduces the virtual implant position directly from computerized tomographic data without allowing the intraoperative modification of implant position.

**Computer-navigated (dynamic) surgery.** The use of a surgical navigation system that reproduces the virtual implant position directly from computerized tomography and allows intraoperative changes in implant position.

The group recommended that, with appropriate training, experience, and pre-surgical planning, these systems might be clinically beneficial in the following clinical situations:

- Complex anatomy
- Minimally invasive surgery
- Optimization of implant placement in critical esthetic cases
- Immediate loading
Statement 1
The reviewed computer technology applications are sufficiently accurate to justify use in selected situations.

Statement 2
There are no long-term data to support an assumption of similarity between implant and prosthetic survival and success with computer-guided and computer-navigated surgical techniques compared to traditional surgical intervention.

Statement 3
The rapid development of undocumented technology in commercially driven processes has led to unrealistic expectations regarding the efficacy and ease of use of current technologies.

2.3.2 Computer-Assisted Design and Computer-Assisted Manufacturing in Implant Dentistry

Computer-assisted design (CAD) and computer-assisted manufacturing (CAM) have been applied in implant dentistry to the design and fabrication of prosthetic frameworks and prosthetic abutments. The advantages of this technology include: improvements in quality, better process control, the reduction of dependence upon conventional dental laboratory technology, and a reduction in cost. The following specific advantages are cited:

- Improved quality
- Reduced cost
- Individualized treatment concept
- Improved precision
- Diminished need for traditional laboratory technology
- Consistency
- Homogenous material
- Minimized inventory
- Individual processes are now industrialized
• Software determines minimal dimensions based on material properties

Disadvantages of CAD/CAM technology include: the cost of equipment and maintenance, the time and education necessary to operate equipment, and insufficient clinician control over specific technical outcomes. The following disadvantages are cited:

• Set-up cost
• Learning curve
• Short lifespan of technique
• Industry controlled
• Material incompatibility
• Software upgrades
• Materials subject to inconsistency

Statement 4
While preliminary evidence appears promising, a systematic review of the literature concerning the use of CAD/CAM for the fabrication of frameworks and abutments fails to deliver meaningful clinical evidence of safety and effectiveness associated with the routine use of this technology. The information currently available is insufficient in terms of long-term documentation.

2.4 Conclusions
The statements resulting from the 4th ITI Consensus Conference represent a thorough examination of the current clinical and scientific evidence in loading protocols for edentulous patients. This information can be used for selecting the most suitable loading protocol based on each clinical situation. The cases presented in this book are selected based on these statements. Chapter 5 details the selection of loading protocols according to the prevailing clinical situation.
3 Pre-Operative Assessment and Prosthetic Planning: The Edentulous Patient

D. Wismeijer, P. Casentini, M. Chiapasco

The estimated percentage of denture wearers who are dissatisfied with their denture is between 10% and 30%, depending on the method used (van Waas, 1990; Kent and Johns, 1994). Their principal complaints are: loosening of the lower denture, pain during function, problems with speech, esthetics, and problems while eating.

Most of these complaints can be imputed to the loss of retention and stability of the lower denture. This in turn is primarily caused by resorption of the denture-bearing area. During the first 1 to 3 years after tooth extraction, bone resorption is at its strongest. The resorption process slows down after this initial period but never stops completely. In the long term, the mandible will still decline in height at an average rate of about 0.2 mm per year (Tallgren, 1972). In some cases, the resorption is so severe that it is impossible to make a complete denture that satisfies the patient’s needs.

Before oral implantology came into its own, patients with severe denture problems were treated by preprosthetic surgery (vestibuloplasty, lowering the floor of the mouth, or ridge-augmentation procedures aimed at improving the morphology of the denture-bearing area) or with dentures fitted with soft linings. Often, these treatment options did not offer a permanent solution (Stoelinga and coworkers, 1986; Mercier and coworkers, 1992; van Waas and coworkers, 1992).

But during the past few decades, dental implants have been commonly employed in the treatment of edentulous patients with denture problems. Implants can be used to restore the edentulous jaw in different kinds of ways. If a sufficient number of implants can be placed and the vertical and horizontal relationships are favorable, a fixed implant-retained prosthesis can be delivered. This prosthesis can only be removed professionally.

A second option is a removable denture. Both options differ in their esthetic possibilities, limitations for dental hygiene, and not least their cost.
effectiveness. A removable overdenture is less expensive than a fixed prosthesis on dental implants and represents an attractive treatment option for a large number of patients.

Because of the many factors influencing the choices treatment providers have, it would seem logical to split the decision-making process into several steps:

- The initial examination leading to a review of the treatment options and a preliminary treatment plan
- The specific treatment plan based on the patient’s choice of treatment options
- The proposed implant-prosthetic design

To begin with, the patient’s wishes and complaints, general health, and treatment history must be studied. An initial examination is carried out whose aim is to identify any relative or absolute contraindications for implant treatment. In this way we can see, at an early stage, whether the patient is a good candidate for oral implant treatment. The patient receives a broad outline of and general information on possible treatment options. Based on the patient’s wishes, a preliminary treatment plan is set up.

Following the preliminary treatment plan, specific information is gathered, looking at the possibilities of implant prosthetic constructions, and the patient is informed about the different treatment options and what may be expected from them.

A final treatment plan, including the number of implants, their size and form, their position in the jaw, and the type of superstructure, is then developed. The specific treatment steps, a corresponding time line, and the financial implications are decided on. Often this will be agreed on by the clinician and the patient in a signed informed consent. It is from here that the actual treatment takes its course.

### 3.1 Initial Examination

The aspects that need to be addressed belong to different areas: patient motivation, general health, smoking habits, dental history, extraoral and
intraoral examination, general radiological evaluation, indication, and preliminary treatment plan.

**General Aspects**

**Patient perspective/motivation.** Patients’ perception of implant treatment is not always objective; quite often they will have received their information about possible treatment options from the media or from other patients. Misinformation can be disastrous when treating implant patients. It is therefore important to identify the patient’s own wishes and esthetic demands. Often, patients have to be led to understand the difficulties and limitations associated with implant treatment. Patients must be aware that a certain degree of compromise may be required, and in some cases their expectations have to be adjusted to reality. Quality in dentistry can be defined as “satisfying the expectations the treatment provider has created for a patient.” It is therefore of utmost importance that the treatment provider has good insight into the patient’s expectations and can provide a treatment that meets the expected goals. Patients will be asked questions such as: “How long ago were your teeth extracted?” and “Why did you lose your teeth?” These questions give some insight into the treatment history and a patient’s attitude towards dental treatment. “How many dentures have you had since you lost your teeth?,” “How old is the last denture you had made?,” and “Are you wearing the last denture you had made?” deliver insights into the problems patients might have when wearing dentures. A patient who complains about a removable dental appliance and expects an FDP to work exactly like their natural dentition both esthetically and functionally is totally different from the patient who is looking for more retention for a removable denture.

From the patient’s perspective, a fixed restoration is sometimes preferred, especially by patients who have experienced an inadequate removable prosthesis and by patients with an excessive gagging reflex. There are also patients with a hopeless residual dentition who are candidates for total tooth extraction. They often choose to avoid this and may then ask for a fixed implant-supported rehabilitation.

Patients should also receive adequate information regarding the limitations of a fixed prosthesis, which is more demanding in terms of maintenance, sometimes causing phonetic problems, and is usually more expensive.
Moreover, patients must be informed about the final appearance of an implant-supported prosthesis and about how their smile will appear after rehabilitation. The clinician should be able to illustrate the most common types of rehabilitations using photos, videos, or graphics to highlight some of the benefits and limitations of the different treatment options.

A fixed prosthesis is usually more expensive than a removable denture, since implant components and laboratory materials often cost more. On the other hand, this is not a strict rule, as some types of removable implant-supported prostheses involve expensive materials and laboratory techniques.

A cost analysis is of course an important factor that influences the patient’s choice of the final type of prosthesis and must be discussed with the patient.

Finally, patients should be reassured that the scientific evidence clearly shows that both removable and fixed implant-supported rehabilitations of the edentulous jaw can significantly improve their quality of life (Wismeijer and coworkers, 1992, 1995, 1997; Feine and coworkers, 2002; Trulsson and coworkers, 2002).

**General health/medical risks.** The pretreatment evaluation should always include an analysis of the patient’s medical status. Absolute contraindications for implant treatment are rare, but several risk factors have been described in the literature. A higher risk of peri-implantitis has been demonstrated in patients who are affected by uncontrolled diabetes or immune diseases, bone diseases, who are undergoing treatment with oral bisphosphonates or radiation, who are immunocompromised, or who smoke (Ferreira and coworkers, 2006).

**Etiology of the patient’s edentulism.** The dental history of the patient is also of importance. The risks related to implant loss in patients who lost their teeth to caries or trauma are much lower than when patients lost their teeth to periodontal disease. If teeth were lost to periodontal disease, patients run a higher risk of developing peri-implant infection, even if they are completely edentulous (Karoussis and coworkers, 2004; Heitz-Mayfield, 2008).

**Age.** Age is sometimes seen by patients as a possible contraindication for implant treatment. The literature, however, gives no guidelines for an upper age limit when treating patients with oral implants. On the other hand, elderly patients often present general health problems that might eventually lead to
contraindications for therapy. Implants are be indicated in young patients (patients that have not yet reached the end of their growth phase) (Bernard and coworkers, 2004; Fudalej and coworkers, 2007).

**Extraoral Examination**

During the extraoral examination, special emphasis should be placed on the evaluation of the smile line and the amount of facial support. Especially in patients who have been edentulous for a longer period, a fixed implant-supported often does not yield the same esthetic results as a removable implant-retained prosthesis. Often, the morphology of the buccal crest of the alveolar ridge affords the upper lip inadequate support. In those cases, a fixed dental prosthesis might not give the expected esthetic result, as the implants will often be placed further posteriorly. The anterior teeth need to be positioned with a more anterior angulation, giving the upper lip at least some support and restoring the patient’s facial profile. A removable implant-retained overdenture can be extended labially more easily, allowing the restorative dentist to create a more natural esthetic result. A patient who exposes a large portion of the maxillary soft tissues while smiling must be considered an esthetic risk patient (Goodacre and coworkers, 2003).

**Intraoral Examination**

**Hygiene.** Oral hygiene can easily be evaluated in patients who are edentulous in only one arch. The literature does not show a significant correlation between oral hygiene and implant success. When treating edentulous patients, especially those who have been edentulous for a long time, one should remember that they will often have forgotten how to perform oral hygiene appropriately. In some cases, it would seem prudent to develop a treatment plan based on simple solutions (such as an implant over-denture) instead of some more elaborate implant-based treatment. For patients with a handicap that impairs adequate oral hygiene, it is also often necessary to provide a treatment plan that favors simple solutions.

**Periodontitis/history of periodontitis.** Any treatment of periodontitis must always be carried out before implant treatment. The bacterial component of peri-implantitis seems to be the same as in periodontitis. The subgingival plaque in peri-implantitis infections consists of an anaerobe bacterial flora dominated by gram-negative bacteria. Bacteria such as *Porphyromonas gingivalis*, *Tannerella forsythensis*, and *Spirochetes* are common. In partially
dentate patients, these pathogens most probably migrate from the subgingival area due to intraoral transmission (van Winkelhoff and coworkers, 2000). In patients who are edentulous in only one arch, periodontal conditions of the opposite arch should always be evaluated during the first visit.

**Acute infection.** The presence of acute infection is an absolute contraindication for oral implant treatment. These infections should be treated until healed before implants are inserted.

**Jaw opening.** When carrying out an intraoral examination, it is wise to register the jaw opening. A limited jaw opening often makes it impossible to carry out implant treatment in the posterior region.

One should also be careful with implant treatment in patients with a history of severe bruxism. These patients run the risk of overloading individual implants, so treatment plans involving FDPs must be based on vertical load on the implants. In these cases, an implant-retained overdenture may be the lesser risk. One advantage of a removable denture is that it is easier to repair than an FDP.

**Interarch relationships.** Discrepancies in interarch relationships, such as crossbites, extreme Angle class II or III jaw relationships, and an extremely reduced maxillo-mandibular space, can lead to biomechanical risks in the prosthetic phase. It is therefore important to recognize these potential problems at an early stage. Solutions to these problems may include:

- Not inserting implants
- Orthognathic surgery prior to implant placement
- Bone-grafting procedures
- An alternative prosthetic treatment plan that avoids the anticipated complications (removable instead of fixed)
- In the case of inadequate intermaxillary space, reducing the mandibular bone height, providing adequate space for the bar clip attachment or the fixed prosthesis, could be considered; an option might be an overdenture with single attachments

**Morphology of the edentulous bone crest.** Intraoral palpation should be used to evaluate the following: irregular bone structures, the sharpness of the edentulous alveolar ridge (knife-edge ridge), flabby ridges, muscle insertion
and the floor of the mouth, mandibular tori, and the shape of the arch.

A knife-edge ridge often needs correction before inserting implants. A plateau must be created that is wide enough to insert implants with an adequate width. In some cases, this might mean that the alveolar ridge has to be reduced by 5 mm or more. Furthermore, irregular bony structures under the soft tissues in the denture-bearing area should also be corrected, as they will cause discomfort for the patient otherwise.

The depth of the vestibule should also be inspected. Bone resorption often results in a shallow vestibule. A removable implant-retained overdenture is more likely to provide substantial lip support in these cases, giving a more acceptable esthetic result.

**Quality and quantity of the soft tissues.** During the intraoral examination, it is also advisable to inspect the amount of keratinized mucosa. It should be noted that this factor is not related to the success of implant treatment, but that it plays a part in patient comfort. If the implants are not surrounded by a cuff of keratinized mucosa, patients not infrequently complain about discomfort around the implants. The soft tissues tend to stretch along the surface of the implants and the implant abutments, causing pain. Large and thick keratinized tissues can be a helpful factor in fixed rehabilitations because it facilitates soft-tissue management to recreate inter-implant tissue, simulating papillae in a fixed rehabilitation. Thick tissues also help avoid collar or implant exposure (Figs 1a-c).
Figs 1a-c Thick keratinized tissues help improve soft-tissue management
and the esthetic result of the final rehabilitation.

**Intraoral examination of the edentulous maxilla.** The position of the incisal papilla related to the alveolar ridge reflects the amount of bone resorption in a sagittal dimension. A crestal or buccal position is usually associated with a higher degree of atrophy that might be a contraindication for a fixed prosthesis, unless the ridge is augmented.

In patients with an extremely resorbed alveolar ridge, flattening of the palate is usually observed. In these cases, a grafting procedure is often unavoidable if a fixed dental prosthesis is planned (Figs 2a-b).

![Image](image.png)

*Figs 2a-b* A crestal position of the incisal palatal papilla and flattening of the palate are usually associated with a higher degree of atrophy of the edentulous maxilla.

The presence of maxillary torus, in particular palatal torus, can complicate treatment with an overdenture with full palatal coverage, possibly creating problems with food impaction. Removal of these structures before or at implant placement should be considered.
**Intraoral examination of the edentulous mandible.** The lingual spine can sometimes cause problems when planning a fixed dental prosthesis and can be located further cranially to the edentulous crest in highly atrophic mandibles. As the tongue is attached to this bony exostosis via the lingual muscle, surgical reduction of this area might lead to functional problems (Fig 3). This area should not be involved in implant surgery and rehabilitation in order to avoid functional problems.

![Image](image.png)

*Fig 3 The lingual spine is more superficial when more severe atrophy is present.*

The presence of a mandibular torus can also represent a problem. The thin soft tissues that usually cover these structures are easily traumatized by the lingual flange of an overdenture. On the other hand, a short lingual flange can result in food impaction problems. Surgical removal of these structures should be considered.

**Preliminary radiographic examination.** The panoramic radiograph is probably the most convenient radiographic tool when considering dental implants in the edentulous arches. It provides general information for evaluating residual pathologic lesions and the amount of bone available for implant insertion. Image distortion, of course, is a factor to be considered. Panoramic radiographs present a wide range of distortion depending on the make and model of the radiographic imaging machine as well as the position of the patient, potentially leading to a magnification of the actual shape of the bone of up to 20%. Implant manufacturers provide implant templates with the corresponding magnifications to use in choosing implants for a specific
patient. It is also advisable to create a radiographic template with, for instance, metal ball bearings as indicators for calculating the magnification of the orthopantomograph in the future implant area. The actual diameter of the ball is known and can be used as a basis for the calculation (Fig 4).

Fig 4 The panoramic radiograph is a fundamental tool in the preliminary investigation of the edentulous patient and can often offer additional planning information.

In those rare cases where a favorable morphology of the edentulous ridge can already appreciated clinically a panoramic radiograph confirming positive bone anatomy may deliver sufficient information to plan a case correctly (Figs 5a-b).

Figs 5a-b If the clinical situation is clearly favorable, a panoramic radiograph that supports the clinical findings can be sufficient for the treatment plan.

In all cases that present a certain degree of atrophy especially if the treatment
plan is oriented toward a fixed rehabilitation, a precise radiological diagnosis should be obtained using computed tomography (CT).

Information gathered in the initial investigation stage gives the clinician a general idea of possible indications for a specific patient. The patient receives a broad outline of and general information on, possible treatment options. A preliminary treatment plan can be set up based on the patient’s wishes.

3.2 Specific Treatment Plan

One goal of a treatment plan for an edentulous arch is to decide whether a fixed or a removable implant-supported prosthesis can be provided, depending on the anatomical situation. As some patients prefer a fixed prosthesis, it is important, in an early stage of the treatment planning, to determine if a fixed restoration is feasible. A later change of the treatment plan from a fixed to a removable prosthesis could be disappointing for the patient; also, the position of the implants might be not ideal, and could, from a restorative point of view, be difficult to manage. The possibility of improving anatomical conditions and bone volume by reconstructive pre-implantation surgery should be also considered. Predictable surgical techniques allow for the creation of ideal conditions for a fixed rehabilitation, even in patients who have an unfavorable anatomy but who are motivated to receive a fixed rehabilitation. Finally the artificial reconstruction of soft tissues by means of pink ceramic also represents an option to compensate for an unfavorable anatomy in a fixed rehabilitation. Patient-related clinical and radiological findings should be considered in the decision between a fixed or removable rehabilitation supported by implants.

**Facial and lip support.** Facial support represents an important factor to be evaluated in edentulous patients. Since the edentulous patient usually wears removable dentures, the question is whether the actual prostheses provide sufficient support to the extraoral tissues. This can be answered by standard diagnostic procedures as commonly utilized when providing a removable prosthesis (Figs 6a-b).
Figs 6a-b Improved facial support has been verified in this patient wearing removable prostheses, increasing the vertical dimension and modifying the inclination of maxillary anterior teeth. After correction, the patient displays the full lip thickness.

To assess the extraoral soft tissues, the patient should be observed with and without the existing prosthesis in place, both frontally and in profile (Figs 7a-f).
Figs 7a-f The need for facial support can be assessed by observing the patient extraorally in both frontal and profile views. In this case, since an advanced degree of atrophy is present in both jaws, soft-tissue support was correctly provided by the removable prostheses. The profile changes markedly depending on whether the prostheses are in place.

In patients who require more soft-tissue support, the treatment plan should generally tend toward an implant-supported overdenture, because support can be created by extending the flanges of a removable prostheses. If the patient is strongly motivated in favor of a fixed rehabilitation, the option to correct the atrophy and reconstruct the atrophic jaws by means of pre-implant
surgery should be considered.

**Type of profile.** Compensatory facial support may be indicated in patients with a concave profile. In this case, the buccal flange of an implant-supported overdenture can play an important role in supporting the soft tissues (Figs 7c-d). In patients with a convex profile, on the other hand, an overdenture with a buccal flange may be contraindicated and exert excessive tension on the perioral tissues.

**Smile line.** The smile line (Figs 8a-c) of a patient with an edentulous maxilla should be evaluated with and without an adequate removable prosthesis in place. The smile line is determined by the tonus of the perioral muscles that define the movement of the upper lip during smiling. Based on the dental and gingival exposure rate, Tjan and coworkers (1984) have defined three different types of smile lines. In a low smile line, not more than 75% of the anterior teeth are visible; in an average smile line, between 75% and 100% of the anterior teeth and interproximal papillae are displayed; and in a high smile-line, the entire surface of the anterior teeth and a variable part of the surrounding gingival are visible. High smile lines are more frequent (ratio, 2:1) in women than in men.
Figs 8a-c High, average and low smile line.
In patients with a high smile line and substantial ridge resorption, implant-supported over-dentures are more often indicated, and the extension of a buccal flange can avoid esthetic problems related to the excessive height of the maxillary teeth. If the patient’s treatment preference is for a fixed prosthesis, a hybrid fixed rehabilitation with partial reproduction of the soft tissues with pink ceramic or composite should be considered.

If the smile line is evaluated without the denture, exposure of the alveolar ridge during smiling must be seen as a higher esthetic risk; the use of the buccal flange on an overdenture can increase esthetic problems. On the other hand, if a fixed rehabilitation is planned, a surgical reduction of the alveolar ridge prior to implant placement may be useful to avoid the exposure of the transition line between the prosthetic soft tissues and the mucosal ridge.

**Horizontal tooth display** (Fig 9). The amount of horizontal tooth display during smiling is another key diagnostic factor when deciding between a fixed or a removable rehabilitation. In a review article, Dong and coworkers (1999) stated that 57% of the subjects evaluated had a horizontal tooth display when smiling that extended to the second premolar (10-tooth horizontal display), 20% to the first molar (12-tooth horizontal display). If the tooth display is limited to 6 to 10 teeth, a satisfactory result can often be obtained with a fixed prosthesis, including limited distal cantilevers. If 12 to 14 teeth are displayed, a fixed prosthesis should be considered only if it is possible to insert implants (with or without bone reconstruction) in a more posterior position, providing adequate distal support for the prosthesis. A removable prosthesis may be the right solution when implants are placed in the anterior segment of the maxilla.
Fig 9 Wide smile showing the posterior teeth.

**Length of the upper lip.** The length of the upper lip (subnasally to the philtrum) is another diagnostic tool in developing the treatment plan (Fig 10).

![Fig 10 The length of the upper lip is measured subnasally to the philtrum.](image)

On average, patients with a short upper lip (16 to 20 mm) widely expose maxillary frontal teeth during smile, while patients that have an average lip (21 to 25 mm) or a long lip (26 to 30 mm) present reduced exposure of the maxillary anterior teeth and usually need less soft-tissue support (Vig and Brundo, 1978). A reduced lip length usually represents a relative indication for a removable rehabilitation, as more of the pink acrylic of the denture will be exposed.

**Evaluation of the intermaxillary relationship: diagnostic wax-up in articulated casts.** Bone resorption after tooth loss is followed by morphologic changes caused by a three-dimensional contraction of the alveolar ridge, resulting not only in inadequate bone volume for endosseous implants, but also in unfavorable vertical, anteroposterior, and transversal intermaxillary relationships (Cawood and Howell, 1988; Chiapasco and coworkers, 2008).

This phenomenon is usually compensated for in complete dentures by mounting the incisors anteriorly to the alveolar ridge in order to maintain a neutral occlusion.

To evaluate the feasibility of a fixed prosthesis or an over-denture and the
potential need for bone augmentation procedures, a detailed assessment of the morphologic situation and changes due to bone resorption must be performed. It is therefore mandatory to evaluate the relationship between the ideal position of the clinical crowns and the underlying bone. This can be investigated using a diagnostic set-up prepared according to the esthetic and phonetic principles used in complete denture rehabilitation. The diagnostic template is similar to the wax-up for a complete denture, with the correct vertical dimension but without the buccal flange, and is employed to evaluate whether adequate support of the surrounding facial soft tissues can be achieved. A correct set-up will show the amount of intermaxillary space, the angle class, the amount of labial denture extension to create the necessary lip support, and the position of the anterior teeth related to possible implant locations. To define the adequate arrangement of the anterior denture teeth, phonetic tests are used (Zitzmann and Marinello, 1999).

Once the crown length, angulation, and coronal shape have been determined, the distance between the cervical part of crowns and the residual bone crest can be assessed. In an ideal fixed-restoration set-up, clinical crowns should emerge at the soft-tissue level of the alveolar ridge (Figs 11a-d).
Figs 11a-d The diagnostic set-up shows ideal conditions for a fixed rehabilitation. The teeth are of normal length and seem to emerge naturally from the edentulous crest.

Conversely, when the patient presents with a higher degree of atrophy of the bone crest, the wax-up will reveal the presence of a relevant vertical or horizontal distance between the ideally positioned artificial teeth and the residual crest. In this case, an overdenture could be a better treatment option for compensating the horizontal and vertical “black holes” with artificial soft tissues (Figs 12 and 13a-c).

Fig 12 A relevant horizontal and vertical discrepancy is present in this case between the atrophied maxilla and the opposite arch.
Figs 13a-c A try-in denture based on the correct intermaxillary relationship and verified in the patient’s mouth (same case as in Fig 12). The wax-up try-in shows vertical and horizontal discrepancies between the maxilla and the opposite arch.

The wax-up should also represent the base for realizing a radiological diagnostic template reproducing ideal teeth positions and dimensions (Figs 14a-b). It should therefore include radiopaque markers or barium sulfate teeth, identifying future crown positions and implant axes and to verify the volume of available bone.
Figs 14a-b Diagnostic stent with radiopaque markers based on the wax-up with 2-mm holes at the center of every dental unit filled with gutta-percha (same case as in Figs 12 and 13a-c)

In the case of a mandibular rehabilitation, it is advisable to plan the incisal edges of the lower anterior incisors directly above the bar or the individual implant abutments. A set-up of the planned dental prosthesis helps visualize the prosthetic planning when evaluating the casts. Implant treatment must be based on the prosthetic objectives, so a set-up is also the basis for a drilling guide.

Supplementary radiographs. Also recommended is a lateral cephalometric or profile radiograph (Fig 15). Profile radiographs allow the definition of the intermaxillary relationships in the vertical and, in particular, sagittal planes.
This is extremely important in edentulous patients, because an unfavorable intermaxillary relationship (e.g. maxillary retrusion due to severe atrophy) may compromise the prosthetic rehabilitation. This type of radiograph also helps determine whether the available bone volume is sufficient for oral implants. Moreover, an accurate evaluation of sagittal intermaxillary relationships may determine the choice between a fixed or a removable implant-supported prosthesis. The latter may allow for the prosthetic compensation of a large intermaxillary discrepancy, while a fixed prosthesis may significantly reduce this possibility. Further information provided by profile radiographs are: (1) a cross-sectional view of the interior mandible, with emphasis on the symphysial (interforaminal) region; (2) the quality of the bone; (3) the thickness of the bone in the labial-lingual area mesial of the mandibular foramen; (4) the inclination and height of the intraforaminal area of the mandible; and (5) the possible presence of concavities in the anterior part of the mandible.
Fig 15 The cephalometric radiograph provides useful diagnostic information on inter-maxillary relationships in the sagittal plane. In this specific case, if an implant-supported rehabilitation is planned in the maxilla, the anteroposterior intermaxillary discrepancy could only be compensated for with a maxillary overdenture or with orthognathic and reconstructive surgery followed by implant surgery.

The minimal amount of vertical mandibular height necessary to insert implants is a matter of debate. Some clinicians feel that short implants (6 mm) that are bicortically anchored in the bone are a good treatment option (Stellingsma and coworkers, 2004). Others advocate surgical augmentation prior to implant placement.

Computed tomography is particularly useful if multiple implants are planned, if the anatomy of the alveolar ridges is not clear, or if the risk of damaging the alveolar nerve or the maxillary sinus is high. Where an FDP is indicated and implants are to be inserted distally of the mental foramen or next to the maxillary sinus, treatment planning becomes a lot more precise when drilling templates are constructed based on a CT analysis.

CT scans should always be performed in association with a diagnostic template, including radiopaque markers, to obtain more information and to create a precise relationship between the prosthetic project and the anatomy of the bone.

The markers are positioned at the center of each dental unit (the arch is generally extended to the first molars), following their ideal prosthetic axis. When planning the anterior teeth, the radiopaque marker should emerge slightly palatally, in correspondence with the cingulum, comparable to a screw-retained single-unit restoration. In the posterior segments, the marker should be placed corresponding to the central fossa of the tooth and have a slight palatal/lingual inclination, aiming at reproducing the original axis of the missing teeth.

Therefore, the CT scan can provide information regarding the relationship between the clinical crown and the underlying bone crest in the vertical and horizontal planes. CT scans will also provide precise information about bone density that can help choose the correct loading protocol (see also Chapter 5). Finally, the thickness of the soft tissues can be evaluated.
A CT scan can visualize different scenarios:

(1) The correlation between the prosthetically planned position of the implants and the bone crest profile is ideal. This prosthetic set-up can be realized in the final restoration. It is possible to plan implants following the axis defined by the radiopaque marker. In this ideal clinical situation, no augmentation techniques are required, and it is not necessary to change the implant axis to compensate for ridge atrophy. Measurements on the CT scan will allow for the selection of the best implant sites and yield the correct diameter and length of implants (Figs 16a-c).
Figs 16a-c CT scan of an edentulous maxilla with minimal bone resorption and ideal conditions for inserting implants following the planned prosthetic axis. The CT scan also allows the evaluation of bone
density and helps select implant diameters and lengths.

Fig 17 Placement of an implant with a standard endosteal diameter into a ridge with minimal bone resorption. There is no necessity for augmentation.

(2) There is a slight discrepancy between the prosthetically planned position of the implants and the bone crest profile. It is possible to plan the implant placement, but it is necessary to compensate for a certain degree of atrophy (Figs 18a-c).
Figs 18a-c CT scan showing a certain degree of bone atrophy that can
be compensated for by selecting reduced-diameter implants and simultaneous ridge-augmentation procedures (same case as in Figs 12 and 13a-c).

Possible solutions include:

- A removable prosthesis supported by implants, where the existing discrepancy can be corrected with the resinflanges
- Use of simultaneous augmentation techniques in order to correct implant fenestrations or dehiscences produced by correct prosthetically-driven implant placement
- Use of reduced diameter/length implants (Fig 19)
- Implant placement according to the available residual bone supply

![Fig 19 Placement of an implant with a reduced endosteal diameter into a horizontally augmented ridge.](image)
In the latter case, if a fixed rehabilitation is planned, a certain degree of compromise concerning implant position and axis may be accepted. Implants may be slightly tilted in a buccopalatal or in a mesiodistal direction, and angled abutments should be used.

(3) There is a severe discrepancy between the prosthetically guided position of implants and bone crest profile. This is the typical radiographic finding in cases affected by a severe atrophy of the maxilla. Knife-edge crests, superficial location of the mandibular canal and mental foramen, and pneumatized sinuses combined with vertical resorption of the maxilla do not allow implant placement without prior augmentation (Figs 20a-c).
Figs 20a-c CT of an edentulous maxilla affected by severe atrophy. In
this case, preliminary reconstructive surgery represents the only option for allowing implant insertion at a second stage.

Fig 21 Placement of an implant with a standard endosteal diameter into a horizontally and vertically augmented ridge.

Once the treatment plan has been defined, the CT will also facilitate precise surgical planning, including the choice of implant shape (cylindrical or tapered), diameter, and, in cases where bone atrophy is present, the length and type of horizontal or vertical bone augmentation.

3.3 Proposed Implant-Prosthetic Design
Treatment planning is mainly based on the anatomical situation, the patient’s requests, and the economic implications of different treatment options. Three main categories can be distinguished based on the anatomical situation:
Class I. In the absence of significant atrophy, the anatomical situation can be considered adequate for the realization of a fixed rehabilitation. All treatment options are available, and the choice between a fixed and a removable prosthesis is related to the patient’s expectations and a cost analysis (Figs 22a-d).

Figs 22a-d Panoramic radiographs showing the initial and post-treatment situations. In both cases, the radiographs demonstrate class I, both in the maxilla and in the mandible. In these cases, the treatment plan was mainly defined by the patient’s desires.

In rare cases, if no atrophy at all is present and the selected treatment option is an implant-supported overdenture, the surgical phase might include the removal of a certain amount of bone to create more intermaxillary space for a removable prosthesis.

Class II. If there is moderate vertical or horizontal atrophy, three main treatment options can be proposed.

- An implant-supported overdenture will compensate for different degrees of atrophy (Figs 23a-b).
Figs 23a-b In this class II case, the patient refused augmentation of the posterior atrophic maxilla. An implant-supported overdenture was the best treatment option.

Costs are usually lower than to those of a fixed dental prosthesis. This kind of prosthetic solution is less demanding in terms of oral hygiene maintenance.

- A hybrid fixed rehabilitation, including pink ceramic or acrylic to compensate for atrophy, or a fixed dental prosthesis with longer teeth (Figs 24a-c). In both cases, a certain degree of esthetic compromise cannot be avoided.
- If atrophy primarily involves the posterior region of the edentulous jaws, distally tilted implants can represent another option to support a fixed prosthesis.
Figs 24a-c A fixed prosthesis with longer teeth can represent an
acceptable compromise when a certain degree of vertical atrophy is present.

In some cases, pre-implant surgery will create the ideal conditions for realizing a fixed implant-supported prosthesis, converting the case to a class I case (absence of significant atrophy).

**Class III.** In the case of advanced atrophy, pre-implant surgery represents the only treatment option. The final choice of the type of rehabilitation (fixed or removable) will be determined by the degree of correction (partial or total) of the atrophy that can be obtained during pre-implant surgery.

In the case shown in Figs 25a-i, extreme atrophy affected both the maxilla and the mandible, which were augmented by means of onlay grafts harvested from the iliac crest and from the calvarial bone. After reconstruction and the successive implant placement, it was possible to insert a fixed hybrid rehabilitation in the mandible and an implant-supported overdenture (milled bar) in the maxilla. The decision to realize an overdenture in the upper jaw was primarily dictated by the patient’s esthetic demands. Despite bone reconstruction, it was not possible to convert the anatomy of the maxilla completely from a class III to a class I, and the buccal flange of the overdenture was necessary to create adequate support for the perioral soft tissues and to restore an ideal relationship between the teeth and the surrounding pink tissues.
A team approach, including a maxillofacial surgeon, is mandatory if major reconstructive surgery by means of extraoral bone grafts is considered necessary.

The final treatment plan can only be decided on after the patient has been informed of all the possible treatment options, including the advantages and disadvantages of the different treatment modalities. Especially when elaborate treatment options involving a team approach have been developed, it is important that all team members have a clear view of what is expected of them, at which point in time their contribution to the treatment is expected, and which team member is responsible for supervising the overall treatment process. The patient must be informed about all the stages of the treatment plan, how much waiting time must be expected between the different stages, how long a temporary tooth replacement is expected to be in function, and when the finalization of the treatment is to be expected.

The team member responsible for process control is also the person who the patient can approach with questions concerning the ongoing treatment. Naturally, the patient must also be informed about the treatment costs. The patient should sign an informed consent in which all these aspects have been summed up.
4 Treatment Options for the Edentulous Arch

P. Casentini, D. Wismeijer, M. Chiapasco

4.1 Edentulous Mandible: Implant-Retained Overdenture

Overdentures get support and retention from a superstructure attached to the implants. This superstructure defines the character of the denture that can be provided. We differentiate between tissue-supported, tissue/implant-supported, and mainly implant-supported overdentures (van Waas and coworkers, 1991).

In tissue-supported overdentures, the retentive mechanism of choice is a magnet, a ball attachment, a locator attachment, or a conical crown. The denture rests on the mucosal tissues; the attachments only ensure retention during lateral and extrusive movements.

Tissue/implant-supported overdentures get their retention via a superstructure consisting of two implants interconnected by a bar attached to gold caps that in turn are screwed onto the implants. These overdentures rest on the mucosal tissues in the posterior denture-bearing areas and on bar-splinted implants in the anterior region. The bar is the axis on which the denture can rotate. Retention is ensured during lateral and extrusive movements. During intrusive movements, the implants will carry the mucosal load of the denture in the anterior region, while the mucosal tissues will be loaded in the posterior region of the denture-bearing area.

Implant-supported overdentures rest primarily on the superstructure connected to the implants. The superstructure is placed on at least four implants, to interconnect them. During function, the mucosal denture-bearing areas are barely loaded.

Reports on the treatment of patients with fixed prosthesis on dental implants have mainly concentrated on the success of the implants rather than patient satisfaction. The success rate of the implants presented in the literature is generally high (Noack and coworkers, 1999; Schwartz-Arad and coworkers, 2005).
Patients with an edentulous mandible may experience problems with conventional dentures, such as a lack of retention while eating, problems with speech, esthetic problems, and problems concerning self-esteem. Any fixed dental prosthesis (FDP) on implants or implant-supported overdenture increases patient satisfaction.

Long-term randomized clinical trials have shown that patients with an edentulous mandible are more satisfied with implant-supported overdentures than with conventional dentures (Meijer and coworkers, 2003). Implants under overdentures evaluated for at least 10 years show success rates of 93% and higher.

Furthermore, research has shown that a one-phase implant insertion technique can achieve the same good results as a two-phase technique (Heydenrijk and coworkers, 2002). This would mean that the one-phase technique is more patient-friendly, because a second surgical stage is no longer required. Research has shown that in most situations, two implants and an overdenture are sufficient to provide the stability that conventional dentures often lack (Timmermann and coworkers, 2004). The McGill Consensus Conference of 2002 stated that “the evidence currently available suggests that the restoration of the edentulous mandible with a conventional denture is no longer the most appropriate first-choice prosthetic treatment. There is now overwhelming evidence that a two-part overdenture should be the first choice of treatment for the edentulous mandible” (Feine and coworkers, 2002). The same conclusion was presented by the York Consensus in 2009 (Thomason and coworkers). Generally speaking, magnets, telescopic crowns, ball attachments, and bars all give the same implant success rates. However, bar and clip attachments seem to deliver better retention and require less maintenance in the long run (Stoker and coworkers, 2007).

**Surgical guides**

The use of a surgical guide when placing implants ensures a predictable insertion in the optimal position. As already stated, determining the number and positions of the implants is up to the restorative dentist. It is then up to the surgeon to follow the prosthodontic guidelines. A surgical guide communicates the selected implant positions in detail, preventing incorrect positioning of the implants by the surgeon. A surgical guide to the edentulous
mandible can be based on an existing functional denture or on a wax-up of the new dental prosthesis in the correct maxillomandibular relationship in an articulator.

Implants in the edentulous mandible intended to supporting an overdenture are inserted between the two mental foramina. They should be equidistant from the midline, and the inter-implant distance should be between 15 and 20 mm. The hypothetical fulcrum through these two implants must run parallel to the hypothetical line between the TMJs.

When inserting four implants, the most distal one must be placed about 5 mm mesially of the mental foramina. The remaining implants are then spread evenly in the remaining space, giving the prosthodontist the possibility to design a superstructure with three bars.

Ideally, implants should be inserted perpendicularly to the occlusal plane planned for the overdenture. In the anterior region, the implants would be located directly beneath the lower incisors, reducing the risk of the denture rocking over the superstructure. It is advisable to create the drilling template from a transparent material, making it possible to look through it during the surgical procedures (Fig 1).

![Fig 1 Surgical guide for the edentulous mandible.](image)

### 4.1.1 Two Unsplinted Implants and an Overdenture
Determining the number of implants, the type of superstructure, and the implant sites should be up to the prosthodontist.
Two implants with a bar and clip attachment should be adequate where the mandible has a height of at least 10 mm and a patient requests more stability and retention for a complete denture.

Two implants with ball attachments, Locator abutments, magnets, or telescopic crowns are most often used when the patient’s oral hygiene is seen as a problem (Figs 2 and 3).

Patients unable to perform adequate oral hygiene and requiring assistance can be helped by this type of attachment. There are, of course, other situations where an optimal bar and clip design is not feasible. An insufficient vertical dimension or a tapered shape alveolar ridge would lead to a bar design
covering the frenulum of the tongue, thus impairing function, are two of these situations (Fig 4).

![Image](image_url)

**Fig 4** A bar that leaves insufficient space for the lingual frenulum.

**Benefits:** Easy oral hygiene and maintenance for the patient, especially in patients needing help when performing oral hygiene procedures or in elderly patients, including patients with extremely resorbed mandibles or unfavorable implant inclination. Can be used when there is little intermaxillary space. Laboratory procedures are less demanding. Good price/performance ratio.

**Limitations:** The retention system needs to be activated frequently. A metal reinforcement of the denture is sometimes required to avoid fracture. Disparallelism of the matrix in ball or locator attachments may cause retention loss. Magnets cannot be activated and have limited retention.

Most single-abutment retention devices allow for some rotation of the attachment around the abutment. They offer vertical retention but have little lateral stability. An imaginary line through the solitary abutments will form the axis of rotation for the denture (Fig 5). This means that the denture may rotate when loading either the incisal teeth or the molars. This lifting of the mandibular denture during function is often reported by patients as uncomfortable. It is therefore advisable to insert two implants with solitary abutments as far mesially in the jaw as possible. This insures an axis of rotation with minimal leverage anteriorly. It is further advisable to place the lower anterior teeth directly above the abutments, ensuring vertical loading of the abutments and attachments and reducing the risk of the prosthesis being lifted during function.
4.1.2 Two Splinted Implants and an Overdenture

With two implants interconnected by a bar as a treatment option, the implants are frequently placed at or mesially of the position of the canine teeth. Often, placing the implants a little further anteriorly has several advantages - especially when trying to obtain a tapered arch form and reducing the potential need for off-center bar placement. Furthermore, the bar should be placed directly below the incisal edges of the lower teeth (Fig 6). This reduces the tendency of the mandibular denture to rotate around the fulcrum created between the two abutments. If the implants are placed further distally, the line through the bar can be seen as the axis of rotation for the mandibular denture. Some clinicians choose to create a bar that is not straight and is soldered mesially of to the implants. This is not recommended, as the bar has a tendency to break, and the design exerts extra leverage on the implants (Fig 7)
Fig 6 Occlusal loading posterior or anterior to the axis of rotation causes the overdenture to rock and become unstable.
Fig 7a-b A bar soldered to the mesial of the implants acts as a fulcrum on the implants and has a tendency to break.

With a bar and clip on two implants, it is advisable not to use a round bar, since this facilitates denture rotation. An oval-diameter Dolder bar offers more retention and reduces the risk of the denture rocking. It is advisable to place the bar in a slightly angulated position, giving the clip more leeway in the posterior than in the anterior direction (Fig 8).
**Fig 8** The Dolder bar is angulated distally giving the clip less anterior leeway. The anterior part of the clip is activated.

**Benefits:** Higher stability and retention of the overdenture. The retention system needs to be activated less often.

**Limitations:** Not applicable in V-profile mandibles and where the residual height of the mandible is less than 10 mm. Oral hygiene is more demanding for the patient. More interocclusal space is needed for the denture and the mesostructure. Clinical and laboratory procedures are more demanding than solitary attachments.

**4.1.3 Four (or More) Splinted Implants and an Overdenture**

Four implants and a bar and clip mesostructure are advisable when the alveolar bone height is less than 10 mm, since the bone-to-implant surface area becomes relatively limited when shorter implants are inserted. Four interconnected implants should also be inserted if the opposing jaw has a
(partial) natural dentition. There is a risk of overloading when the opposing
dentition consists of natural teeth. If the mandible has a tapered-arch shape,
the choice of four interconnected implants might be advisable rather than of
two single implants. Here, the two central implants would usually be spaced
more closely than when inserting implants (Fig 9). The distalmost ones of the
four implants are placed directly mesially of the mental foramen. Other
indications for four implants might include tender mucosa and an extensively
resorbed mandible, leading to dehiscence of the mandibular nerve, which
causes pain when the overdenture is loaded. When inserting four implants in
the interforaminal area, the implants are sometimes placed closer together. In
some cases, the bars will be relatively short, offering less retention to the
clips in the overdenture (Mericske-Stern and coworkers, 2000). Some
clinicians choose to create distal extensions. However, complications have
been reported for this design (Dunnen and coworkers, 1998). Instead of
extending the bar, two Roach ball attachments can be soldered on distally,
giving the extra retention that might be required (Fig 10).

![Fig 9 A tapered arch where four rather than two interconnected implants were chosen for retention due to the short interimplant distance.](image)
Figs 10a-b A Dolder bar with two Roach ball attachments giving extra retention in situations where the length of the bar might not be adequate.

Little has been published on inserting three implants and a bar and clip design for implant overdentures or on five or more implants and an overdenture in the edentulous mandible.

**Benefits:** Higher stability and retention of the overdenture thanks to implant support. The retention system needs to be activated less frequently. Applicable in V-profile mandibles and where the residual height bone of the mandible is less than 10 mm (connecting four 6-mm to 8-mm implants) and density of bone is low. Avoids compression of the alveolar nerve in extremely resorbed mandibles. Applicable in cases of poor salivary flow.
**Limitations:** Oral hygiene is more demanding for the patient. More interocclusal space is needed for the denture and the mesostructure. Clinical and laboratory procedures are more demanding. The surgical risk of damaging the mental nerve is higher, since implants are placed in the proximity of the mental foramen. Higher costs are involved.

**4.1.4 Fixed Dental Prosthesis in the Edentulous Mandible**

Some patients say they prefer an FDP because they expect this type of construction to be more comfortable. They expect it to feel more like natural teeth that an overdenture would. As a patient cannot remove the FDR oral hygiene is important; patients who have become totally edentulous will often have had problems with oral hygiene. Not all edentulous patients can be considered good candidates for FDPs, as they are not capable of keeping their oral hygiene up to the expected level. Other possible limitations include the amount of available bone, the interarch relationship, or the costs involved.

An FDP can only be considered if sufficient lip support can be provided. Diagnostics and treatment planning can only be carried out correctly if casts of the patient’s maxilla and mandible can be studied in an articulator. Crossbites, maxillomandibular relations, intermaxillary space, and so on can then be assessed in the proper interarch context. As prosthodontics dictates the amount, site, and type of implants, a mockup is essential. Especially in cases where the mandible shows a great deal of resorption but the patient prefers an FDP over an overdenture, the amount of lip support and the labial extension of the FDP necessary to obtain a good esthetic result must be carefully analyzed, and the patient must be informed accordingly. The esthetic limitations of FDPs have been extensively discussed by Zitzmann et al (Zitzmann and coworkers, 1999). When patients have been edentulous for a longer period the buccal plate of the maxilla and mandible tend to resorb. In this case, the buccal flange of the denture has to be extended to give it more body, offering lip better support. It is, however, not always possible to fabricate an FDP that gives the necessary support and at the same time complies with the obligatory mechanical and oral-hygiene requirements (Fig 11).
Fig 11a Lack of lip support in an edentulous patient with severe jaw atrophy.

Fig 11b The same patient with a denture with extra thick flange in situ.

**Implant number and positions**

The mockup has to be evaluated in situ to ensure that the expected esthetic result can be achieved. If not, an implant-retained overdenture is to be preferred over an FDR. Many patients consider an FDP based on a metal frame with acrylic teeth (a wraparound) to be a “mere” screwed-in complete denture. They feel that it does not look like real teeth, and the esthetics is thought to resemble those of a denture. However, due to bone resorption, an FDP will often have more volume than the natural teeth had. This is necessary to create an acceptable maxillomandibular relationship and adequate lip support. This becomes clear when the articulated casts are studied; it is wise to inform patients that these types of limitations can be
expected. A mockup can be a very useful tool for explaining this to patients. The prosthetic planning can also be used to create a drilling template, defining the exact implant sites and inclinations. A CT or CBCT scan can help determine whether the bone volume is sufficient to insert the implants in the correct position.

In other cases, for instance if there is little intermaxillary space or the patient has an extreme Angle class II/III jaw relationship, there is a risk that the screw holes for the FDP are in an unfavorable position.

In some cases, due to implant-angulation problems, the screw holes must be located in the buccal cusps of the (pre)molars or in the labial or incisal edges of the cuspid or incisors, leading to esthetic and functional complications. It is not necessary to screw the prosthesis down on all abutments; a combination of screw retention and cementing is also possible (Fig 12). Two abutments can be used to screw the FDP in place; the other abutments are then fitted out as cementable posts so the FDP can be cemented on those. When removing the FDR the screws on the mesial and distal implants are taken out, and the bridge is tapped loose using vertical force. Simpler designs like this, consisting of fewer parts, are usually cheaper for the laboratory to provide. They also have the advantage of requiring fewer screw holes in the denture teeth.

![Fig 12 The FDP is screw-retained on two of the five implants. It is cemented on the remaining three.](image)

The FDP design must also allow the patient to keep oral hygiene up to the expected standard. The restorative dentist must provide the technician with
the necessary interdental brushes in order for the FDP to be manufactured such that patients can perform the necessary hygiene procedures with dental hygiene products to which they have easy access. The patient must be able to perform the proper dental hygiene procedures without damaging the soft tissues, the implants, or the FDP.

4.1.5 Four Splinted Implants and a Fixed Prosthesis

For FDPs in edentulous patients where implants are inserted between the mental foramina in the mandible, the minimal number of implants required is four. The possible length of the cantilevers depends on the shape of the mandibular arch, the distance between the implants, the length of the implants, and on whether the implants have been inserted in more or less a straight line or follow a more pronounced curve.

If the implants are inserted in a more or less straight line, the FDP will often provide the patient with a shorter dental arch due to the limited length of the cantilevers (Figs 13a-b). If the implants are inserted in a curve, the dental arch can be longer. It is advised to reduce the length of the cantilevers to a maximum of 1.5 times the anteroposterior (AP) spread, which is the distance from a line drawn between the posterior edges of the two distal implants and the midpoint of the anterior implants (Fig 14). If a patient cannot accept the shortened dental arch, an overdenture is the alternative.
Figs 13a-b Limited cantilever lengths due to the positioning of the implants in a relatively straight line.
Cantilevers opposing natural teeth run a higher fracture risk than those opposing a complete maxillary denture, because the occlusal forces introduced when loading the cantilevers are much greater. For this reason, it is advisable to insert the implants as far distally as possible, supporting the FDP over its entire length and reducing the risk of implant overloading and prosthesis fracture.

**4.1.6 More Than Four Splinted Implants and a Fixed Prosthesis**

A FDP on more than four implants is indicated when the cantilevers would get too long. When distal areas of the mandible show only limited vertical and sagittal resorption, implants can also be inserted distally of the mental foramina. The number of implants is then no longer limited by the available amount of intraforaminal bone. Six to eight or even more implants can then be inserted (Figs 15a-d). This can be the case if the maxilla has been restored this far distally, if the first and second natural maxillary molars are still in situ or if the patient has an extreme Angle class II/III relationship.

Limitations: Oral hygiene is much more demanding for the patient. Revision in case of mechanical complications is more demanding. A higher level of surgical precision based on the treatment plan is necessary. Clinical and laboratory procedures are more demanding. The surgical risk of damaging the mental nerve is higher because implants are placed in the proximity of the mental foramen. Higher cost. Cantilever extension can be limited.

4.2 The Edentulous Maxilla
As in the edentulous mandible, many treatment options are available. However, more restrictions regarding the distribution and number of implants are present. This is often due to a less favorable quality and quantity of the bone in the edentulous maxilla.

4.2.1 Two Unsplinted or Splinted Implants and an Overdenture
It has been shown that placing two implants in the anterior maxilla to support an implant-retained overdenture is a risky procedure, possibly due to the unfavorable environment and bone quality (Weng and Richter, 2007). Fractures of mesostructures and superstructures have been reported. Very few studies supporting this treatment option are available. Therefore, four should be the minimum number of implants for a long-term reliable removable prosthesis.

4.2.2 Four to Six Unsplinted Implants and an Overdenture
Four to six unsplinted implants supporting an overdenture in the maxilla can be a treatment option, although this indication has little support in the literature. The indication to leave implants unsplinted is related to the distribution and position of the implants. For example, they can be
unfavorably spaced (too close to each other or too far apart) or angulated. If telescopic crowns are used, they should not be placed in the anterior region of the maxilla only. With this kind of rigid connection, the distal saddles of the overdenture act like cantilevers in a fixed prosthesis, potentially overloading the supporting implants (Figs 16a-d).
Figs 16a-d Maxillary overdenture retained by six implant-supported telescopic crowns.

**Benefits:** Oral hygiene is easy to perform. Indicated in cases with insufficient intermaxillary space.

**Limitations:** Possible overloading if there is no proper distribution of telescopic crowns. Limited scientific evidence. Laboratory procedures are more demanding. Higher costs.

**4.2.3 Four to Six Splinted Implants and an Overdenture**

Four well-distributed and splinted implants (with a minimal diameter and length of 4.1 and 8 mm) inserted in the anterior maxilla usually represent the minimum for an implant-supported overdenture. Placing the implants in the anterior segment of the edentulous maxilla, between the first premolars, usually helps avoid a sinus lift procedure, reducing morbidity and cost for the patient. Since early loading of the implants can be considered predictable in these situations (see Chapter 5), this treatment option usually requires only limited treatment time. If a Dolder bar is planned as a final superstructure design, the distribution of the implants should allow for a sufficient length of the bar segments, and the interimplant distance must be sufficient. If the anatomy of the residual bone allows only limited implant diameter or length, the option to increase the number of implants from four to six should be considered. More than six maxillary implants supporting an overdenture must be considered a very exceptional solution (Figs 17a-e).
Figs 17a-e Maxillary overdenture retained by four implants splinted by a Dolder bar. The patient received a similar treatment in the mandible.

**Benefits:** Higher stability and retention of the overdenture thanks to implant support. Extra lip support thanks to an extended buccal flange. Easy solutions for phonetic problems. Applicable even where bone density is low. Applicable in cases of poor salivary flow.

**Limitations:** Oral hygiene is more demanding for the patient. More intermaxillary space for the denture and the mesostructure are needed. Clinical and laboratory procedures are more demanding. Higher costs.

**4.2.4 Four to Six Splinted Implants and a FDP**
Six well-distributed implants can be considered adequate to support a fixed prosthesis in the maxilla. Little scientific evidence exists to indicate the minimum number, diameter, length, and ideal position of the implants to support a maxillary fixed prosthesis.

### Implant Choice and Distribution

If six implants are used, standard-dimension implants should be preferred. If reduced-length (6 mm) and reduced-diameter (3.3 mm) implants are utilized, more implants should be considered in the treatment plan, especially if the antagonist dentition consists of natural teeth or a fixed prosthesis. Implants with a reduced prosthetic platform (Narrow Neck implants) can be used in the lateral incisor positions in order to achieve a better emergence profile.

A prosthesis extended to the first molar areas is usually recommended, but a limited distal extension to the second premolar areas can also be considered adequate in terms of masticatory function and esthetics (shortened dental arch concept). This is indicated when the AP spread is limited (Fig 14).

Ideally, the distal implants should be placed as far distally as possible to shorten the cantilevers. Generally speaking, implants should also be placed as parallel as possible to simplify the prosthetic rehabilitation (Fig 18).

![Parallel implants with sufficient interimplant distance facilitate subsequent prosthetic procedures.](image)

A sufficient interimplant distance should be maintained in order to allow oral hygiene procedures. Different implant positions can be accepted, respecting the general concept of an adequate distribution of implants along the
maxillary arches.

Fig 19 Splinted implants at positions 16-13-11-21-23-26.

Fig 20 Splinted implants at positions 16-14-13-23-24-26.
Fig 21 Splinted implants at positions 16-14-12-22-24-26.

Fig 22 Splinted implants at positions 15-14-13-23-24-25 with or without distal cantilevers.
Fig 23 Splinted implants at positions 15-13-11-21-23-25 with or without distal cantilevers.

Traditional Metal-Ceramic Framework Versus Hybrid (Toronto) or Wrap-Around Framework
This choice is primarily based on interarch relationships and the degree of bone resorption. If there is a sufficient amount of residual bone and intermaxillary relationships are favorable, a traditional metal-ceramic framework can be considered to realize a fixed prosthesis (Figs 24a-g).
Figs 24a-g In the presence of favorable interarch relationships, six well-
Distributed implants can be an adequate basis for a fixed maxillary prosthesis.

If a higher degree of bone resorption is present and reconstructive surgery is not an option, the final design of the rehabilitation will usually include a certain amount of mimicking of the lost soft and hard tissues. This will help avoid excessive crown elongations in the esthetic zone and improve support to the perioral soft tissues. A hybrid framework with pink ceramics or resin should be the first option in this case (Figs 25a-e). A higher degree of compliance is required of the patient with regard to oral hygiene procedures. Furthermore, the suprastructure has to be screw-retained.
Figs 25a-e A Toronto bridge with pink ceramics can represent a valid solution for the rehabilitation of the edentulous maxilla if a certain degree of atrophy remains uncorrected by reconstructive surgery.

Revision in case of mechanical problems is easier to perform if the prosthesis is not a metal-ceramic one.

**Segmented Versus One-Piece Frameworks**

In general, segmenting the final rehabilitation allows for easier revision or repair, simplifies the laboratory procedures, and helps achieve a passive fit. On the other hand, the option to segment the prosthesis is not always
available and will be dependent on the distribution of the implants (Figs 26a-e).

Figs 26a-e If implants are inserted in both quadrants in the positions of the central incisors, canines, first premolars, and first molars, it will be possible to segment the rehabilitation into four three-unit bridges.

Some factors such as distribution, reduced implant dimensions, the need for distal cantilevers, or a final design of the prosthesis that includes pink ceramics can represent an indication for a one-piece fixed prosthesis. In these cases, CAD/CAM technology is now able to simplify laboratory procedures
and allows a more predictable passive fit (Figs 27a-f).
Figs 27a-f CAD/CAM technology can simplify the fabrication of implant abutments and framework in complex rehabilitations. In this case, an eleven-unit zirconia and ceramic bridge was designed to restore the edentulous maxilla.

**Tilted Implants**

In some cases, tilting the more distal implants can be considered an option to support a maxillary fixed prosthesis. Distally tilted implants allow a reduction of the cantilever length and provide additional distal support to the prosthesis. A distal inclination of the implants also allows the placement of implants of adequate length (Fig 28) (Capelli and coworkers, 2007; Testori and coworkers, 2008).

![Fig 28 Schematic representation of a maxillary FDP on six implants involving two tilted implants in the posterior region.](image)

In the case presented (Fig 29a-d), implant positions were influenced by anatomic limitations. Residual bone was only available in the anterior part of the maxilla, and a more complex surgical intervention was not desired. Distally tilted implants gave sufficient support for a fixed prosthesis extended to the second premolars. In the mandible, segmentation of the rehabilitation was possible due to a more favorable implant distribution.
Figs 29a-d Distally tilted implants can be used to improve support for the prosthesis in the load-bearing distal segments.

The only option to provide a maxillary fixed prosthesis (usually a hybrid screw-retained Toronto bridge) supported by only four implants that has some scientific evidence to back it up is a distal inclination of the two more distal implants (Figs 30 and 31a-c) (Malo and coworkers, 2005; Tealdo and coworkers, 2008).
4.2.5 More Than Six Segmentally Splinted Implants and a FDP

If there are no anatomic limitations and it is possible to insert eight implants, placing them in the positions of the first molars, first premolars, canines, and central incisors will allow segmentation of the fixed rehabilitation into four three-unit bridges. This can simplify laboratory procedures and help achieve a passive fit. Intervention in the case of problems or repair procedures will be easier to perform (Figs 32a-d).
Figs 32a-d A rehabilitation consisting of four segments, each on two implants.

If the decision to place eight instead of six implants is based on the use of implants with a reduced diameter (3.3 mm) or length (6 mm), it would seem more prudent to connect more implants in the rehabilitation, resulting in a restoration consisting of one or two segments.

**Benefits (for all maxillary fixed prosthesis):** Maximum prosthesis stability. Psychological benefit for the patient. Possibility to segment the rehabilitation if six to eight implants are used. Applicable in cases of poor salivary flow.

**Limitations (for all maxillary fixed prosthesis):** Lip support is more difficult to realize. Oral hygiene is more demanding for the patient. Clinical and laboratory procedures are more demanding. It is more difficult to resolve phonetic issues. Higher cost.

**Acknowledgments**

**Restorative Procedures**
Figs 24a-g:
Eugenio Romeo - Milan, Italy
Marco Ghisolfi - Milan, Italy
Figs 25a-e:
Angelo Giampaolo - Milan, Italy
Figs 29a-d:
Martin Tschurtschenthaler - Bruneck, Italy
Figs 31a-c:
Nicolò Gruden - Giussano, Italy
Guidelines for Selecting the Appropriate Loading Protocol

G.O. Gallucci

5.1 Implant Loading Protocols in Edentulous Patients

While healing periods of 3 to 6 months have traditionally been considered critical for a predictable osseointegration of dental implants, modified surgical and loading protocols have also shown predictable outcomes. This chapter will discuss the relevant clinical guidelines for selecting the appropriate loading protocol for edentulous patients with implant/prosthetic rehabilitations.

Protocols for the treatment of edentulous maxilla and mandible with removable or fixed prostheses present a variety of options regarding the numbers of implants, their strategic distribution, the transitional prosthesis, and the definitive prosthetic design. These clinical considerations are generally assigned the highest level of importance and, ideally, should not be adapted to facilitate a specific loading protocol. Loading protocols only represent just another step of the treatment sequence, and their implementation should not alter the desired final implant/prosthetic design.

Multiple parameters have been identified as influential in achieving successful osseointegration with modified loading protocols in the completely edentulous arch. These factors include: patient health, oral conditions, occlusion and function/parafunction, characteristics of the proposed implant sites, implant size and shape, implant material and surface properties, implant distribution in the arch, as well as timing and methodology of implant placement including primary implant stability, loading procedures, and long-term maintenance.

As presented in Chapter 2, the following terms were adopted by the 4th ITI Consensus Conference for loading protocols in edentulous patients:

- **Conventional loading.** Dental implants not connected to prostheses are
allowed a healing period of more than 2 months after implant placement.

- **Early loading.** Dental implants are connected to the prostheses between 1 week and 2 months subsequent to implant placement.
- **Immediate loading.** Dental implants are connected to the prostheses within 1 week subsequent to implant placement.

A separate definition for delayed loading is no longer needed, since it will be included under the definition of conventional loading.

In order to accurately present the guidelines for selecting the appropriate loading protocol, considerations for the edentulous maxilla and mandible with removable or fixed prosthetic designs will be analyzed separately.

Recommendations for loading protocols in edentulous patients discussed in this chapter are based on the validation process presented in Chapter 2.

### 5.2 The Edentulous Maxilla

In the case of maxillary rehabilitations, the implant/prosthetic design should ideally result from a careful patient selection and diagnostic planning. This allows for the selection of appropriate artificial teeth and emergence profiles, as well as occlusion, phonetics, lip and facial support, and esthetic parameters, all of which will determine treatment feasibility and the patient’s approval of the proposed treatment plan.

Parameters for loading protocols are of particular importance regarding the maxillary bone volume and density, the relationships of the maxillary sinuses with the alveolar process, and the resorption pattern after tooth extraction. The achievement of primary stability may be influenced by the placement of shorter or smaller-diameter implants to accommodate a reduced bone volume, or standard-size implants placed in bone of low density. In this context, the selection of a specific loading protocol is often based on the primary stability achieved after implant placement.

#### 5.2.1 Conventional Loading for Maxillary Overdentures

This loading protocol describes the use of four to six implants placed in the edentulous maxilla and restored with an overdenture after a healing period of 2 months. The implant/prosthetic design includes four to six implants
connected by a bar device or four to six free-standing implants (Table 1).

Some authors reported that optimal survival rates of maxillary overdentures can be enhanced with well-planned treatment protocols, including conventional loading and splinted implants. Maxillary overdentures with conventional loading have been clinically well documented with four to six splinted implants.

Recently, a minimum of four free-standing implants with locator abutments has been proposed to support palate-free maxillary overdentures. After a conventional healing time, prostheses were attached to the implants, resulting in a 100% survival rate at the 12-to 48-month follow-up. However, more extensive clinical trials would be needed to demonstrate the long-term outcomes of this simplified approach.

In general, a good level of evidence for maxillary overdenture is available, although still less than for mandibular overdentures, since only prospective and retrospective studies are available for analysis. Mean implant survival rates of 94.8% to 97.7% during a mean follow-up period of 5 years (range: 1 -10 years) have been reported in the literature, with a prosthetic survival rate of 91.4%.

5.2.2 Early Loading for Maxillary Overdentures

This approach describes overdentures on maxillary implants that were functionally loaded no earlier than 1 week after implant placement and no later than 2 months afterwards. Implant/prosthetic designs included four to six implants connected by a bar construction or four to six free-standing implants with locator attachments (Table 1).

An early-loading protocol with maxillary overdentures supported by splinted implants should ideally be reserved for cases where bone volume and bone density allow for excellent primary stability. In cases where implants have been placed in the extraction socket, in augmented bone, or in combination with a bone-augmentation procedure, an early-loading protocol would not be recommended.

The implant survival rate for early-loaded free-standing implants with maxillary overdentures has been reported to be 87.2% at the 2-year follow-up, so this implant/prosthetic design is not suitable for early loading with maxillary overdentures.
5.2.3 Immediate Loading for Maxillary Overdentures

Immediate loading with maxillary implant overdentures is a protocol in which a removable prosthesis is attached to the implants and placed in occlusal contact within 1 week after implant placement. Scientific evidence for this loading protocol and prosthetic design is scarce, so this protocol is not recommended (Table 1).

5.2.4 Conventional Loading for Maxillary Fixed Rehabilitations

This loading protocol describes the use of dental implants in an edentulous maxilla to support fixed prostheses after a healing period of 2 months. Prosthetic designs for maxillary fixed rehabilitations include: (1) a fixed splinted rehabilitation supported by four to six anterior implants (placed between the maxillary sinuses) and bilateral distal cantilevers; (3) a fixed splinted rehabilitation supported by six to eight anterior-posterior implants without bilateral cantilevers; and (3) a complete fixed segmented rehabilitation supported by eight anterior-posterior implants (Table 2).

Scientific evidence on fixed-implant rehabilitations in the edentulous maxilla reports implant survival rates ranging from 95.5% to 97.9%. A conventional loading approach is scientifically and clinically validated according to the validation methodology proposed at the 4th ITI Consensus Conference.

Conventional-loading protocols for maxillary fixed implant rehabilitations are indicated in cases with poor primary stability, in implants placed in association with bone augmentation, in short implants, or in implant/prosthetic protocols with a minimal number of implants. Here, the number of implants and their distribution in the arch would affect the long-term implant survival rate. This is not the case for reduced healing periods, where this particular parameter plays an important role in early failures. Current scientific evidence for fixed implant rehabilitation in the edentulous maxilla indicates that a minimum of six implants with an anterior-posterior distribution presents a more favorable survival rate at 10 years than prosthetic designs with four or five implants with the anterior distribution only.

Since a conventional-loading protocol allows for at least a 2-month healing phase, one particular concern during this period is the provisional prosthesis.
Options include relining the existing denture or the fabrication of a new complete removable prosthesis. It is critical at this stage to avoid direct contact between the denture base and the freshly placed implants. To reduce the load transferred from the prosthesis to these implants, it is advisable to use a soft relining material.

**Table 1 Indications for loading protocols with maxillary overdentures.**

<table>
<thead>
<tr>
<th>Implant/prosthetic design</th>
<th>Conventional loading</th>
<th>Early loading</th>
<th>Immediate loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWD</td>
<td>CWD</td>
<td>CD</td>
<td>CD</td>
</tr>
<tr>
<td>CD</td>
<td>CD</td>
<td>CID</td>
<td>CID</td>
</tr>
<tr>
<td>CID</td>
<td>CID</td>
<td>CID</td>
<td>CID</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retention</th>
<th>Bar design (with or without cantilevers) over four splinted implants</th>
<th>Bar design over six splinted implants</th>
<th>Four free-standing implants with Locator or telescopic crown attachments</th>
<th>Six free-standing implants with Locator or telescopic crown attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthesis</td>
<td>Palate-free overdenture</td>
<td>Palateless overdenture</td>
<td>Palateless overdenture</td>
<td>Palateless overdenture</td>
</tr>
<tr>
<td>Interarch relation</td>
<td>Adequate interarch space</td>
<td>Adequate interarch space</td>
<td>Reduced interarch space</td>
<td>Reduced interarch space</td>
</tr>
</tbody>
</table>

*CWD: clinically well documented - light green
CD: clinically documented - yellow
CID: clinically insufficiently documented - red
M1: first molar, PM2: second premolar, PM1: first premolar, C: canine, LI: lateral incisor
→: Optional bar segment as a distal extension

**Table 2 Indications for loading protocols with maxillary fixed rehabilitat.**
### Implant/prosthetic design

<table>
<thead>
<tr>
<th>Conventional loading</th>
<th>Early loading</th>
<th>Immediate loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>CID</td>
<td>CID</td>
</tr>
<tr>
<td>SCV</td>
<td>CD</td>
<td>CWD</td>
</tr>
<tr>
<td>SCV</td>
<td>CD</td>
<td>CWD</td>
</tr>
<tr>
<td>SCV</td>
<td>CD</td>
<td>CWD</td>
</tr>
</tbody>
</table>

### Implant number and distribution

<table>
<thead>
<tr>
<th>Implant number and distribution</th>
<th>Clinic design</th>
<th>Clinic design</th>
<th>Clinic design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four anterior</td>
<td>Full-arch with distal cantilevers</td>
<td>Increased interarch space, adequate bone volume in the anterior maxilla</td>
<td>Six anterior-posterior</td>
</tr>
<tr>
<td>Six anterior</td>
<td>Full-arch with distal cantilevers</td>
<td>Increased interarch space, adequate bone volume in the anterior maxilla</td>
<td>Full-arch</td>
</tr>
<tr>
<td>Six anterior-posterior</td>
<td>Full-arch</td>
<td>Increased interarch space, adequate bone volume in the anterior/posterior maxilla</td>
<td>Segment</td>
</tr>
<tr>
<td>Eight anterior-posterior</td>
<td></td>
<td></td>
<td>Four three FPDs*</td>
</tr>
</tbody>
</table>

### Prosthesis

<table>
<thead>
<tr>
<th>Prosthesis</th>
<th>Clinic design</th>
<th>Clinic design</th>
<th>Clinic design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-arch with distal cantilevers</td>
<td>Increased interarch space, adequate bone volume in the anterior maxilla</td>
<td>Increased interarch space, adequate bone volume in the anterior/posterior maxilla</td>
<td>Full-arch</td>
</tr>
<tr>
<td>Full-arch with distal cantilevers</td>
<td>Increased interarch space, adequate bone volume in the anterior maxilla</td>
<td>Increased interarch space, adequate bone volume in the anterior/posterior maxilla</td>
<td>Segment</td>
</tr>
<tr>
<td>Full-arch</td>
<td></td>
<td></td>
<td>Four three FPDs*</td>
</tr>
</tbody>
</table>

### Clinics

- Increased interarch space, adequate bone volume in the anterior maxilla
- Increased interarch space, adequate bone volume in the anterior/posterior maxilla

**SCV:** scientifically and clinically validated - dark green

**CWD:** clinically well documented - light green

**CD:** clinically documented - yellow

**CID:** clinically insufficiently documented - red

**M1:** first molar, **PM2:** second premolar, **PM1:** first premolar, **C:** canine, **CI:** central incisor, **LI:** lateral incisor

*The segmentation design represents the final prosthesis. For fixed transitional prosthesis a full-arch one-piece is indicated.*

- →: Cantilever
- ←: Segmentation area

#### 5.2.5 Early Loading for Maxillary Fixed Rehabilitations

Early implant loading with fixed rehabilitations describes a protocol in which implants have been in occlusal contact no earlier than 1 week after implant placement and no later than 2 months afterwards (Table 2).
Early-loading protocols can be applied with predictable results, using rough-surfaced implants for the rehabilitation of the completely edentulous maxilla with fixed prostheses. Clinical studies have shown no significant differences between early and conventional loading of implants with fixed prostheses in the edentulous maxilla, with a follow-up time of 1 to 5 years. Resulting implant survival rates range from 93% to 99%. However, an early-loading protocol also requires a removable transition period similar to the conventional one, only shorter. Because of this, an early loading approach for a maxillary fixed prosthesis presents slight differences from conventional loading. Recent improvements to implant surfaces could benefit this loading protocol, although more scientific and clinical evidence is still being developed.

Early-loading protocols for maxillary fixed implant rehabilitations are indicated where bone volume is adequate for at least six standard-size implants in native bone. It should ideally be avoided in cases with insufficient primary stability, implants placed in association with simultaneous bone augmentation, short implants, or implant/prosthetic protocols with a minimal number of implants.

5.2.6 Immediate Loading for Maxillary Fixed Rehabilitations

This loading protocol describes maxillary implants that have been placed in occlusal function via fixed prostheses no later than 1 week after placement.

Various implant/prosthetic protocols have been proposed for immediate implant loading in the edentulous maxilla: (1) eight maxillary implants immediately loaded via a full-arch fixed interim prosthesis that was later replaced with a segmented final rehabilitation, this approach being compatible with the osseointegration, as shown by other prosthetic designs; (2) six to seven implants for immediate loading of a maxillary fixed provisional prosthesis subsequently replaced by a full-arch one-piece prosthesis as a final prosthetic design; and (3) four immediately loaded implants. Here, scientific evidence is scarce, and the placement if some unloaded “emergency” implants has often been recommended. This indicates that such a small number of implants would not be appropriate for immediate loading (Table 2).

The scientific literature on immediate loading with fixed provisional prostheses in the edentulous maxilla presents an implant survival rate ranging
from 95.4% to 100%. One notable finding was that most of the failed implants were located in the posterior maxilla. According to the 4th ITI Consensus Conference, this loading protocol has been clinically well documented for six or more implants.

The immediate-loading protocol for maxillary fixed implant rehabilitations is indicated where bone volume is adequate for at least six standard-size implants in native or previously grafted jawbone. In addition, an adequate interarch relationship is desirable. As for early loading, this protocol should ideally be avoided in cases with insufficient primary stability, implants placed in association with simultaneous bone augmentation, short implants, or implant/prosthetic protocols with a minimal number of implants.

Long-term results for conventional and immediate loading are reported to be similar in terms of implant survival rate, the level of scientific evidence, the sample population, and the outcome homogeneity. In this context, immediate loading avoids an—often complex—adaptation of the provisional complete denture after surgery and possible exposure of the implants to non-controlled premature loading.

Several immediate provisional techniques have been proposed: (1) the complete denture conversion for either intrasurgical impressions or direct relining; (2) a pre-fabricated provisional template to be adapted either in the mouth by direct relining or in the laboratory on a working model obtained from an intrasurgical impression; and (3) a pick-up technique avoiding intrasurgical impressions, direct relining, or master-cast fabrication (see Chapter 6).

### 5.3 The Edentulous Mandible

In the mandible, the resorption pattern after tooth extraction often involves bone remodeling in the two coronal thirds, while the basal third of the mandible remains stable. Another important anatomical element in the mandible is the dental nerve running along the posterior segments until it emerges in the premolar areas. Based on these anatomical considerations, there is a clear distinction between the anterior and posterior segments of the edentulous mandible.

The mandibular interforaminal zone is an ideal area for implant placement.
The bone volume is normally adequate for up to six implants. In addition, the bone density of the area is favorable for achieving implant primary stability.

Among all these anatomical properties, the interforaminal area often allows for an anterior implant distribution only. While this situation is suitable for implants intended to support/retain a mandibular overdenture, mandibular fixed rehabilitations often call for distal cantilevers.

When implants can be placed in an anterior and posterior distribution, one particular clinical consideration is the flexural deformation of the mandible on movement. In this context, when implants are distributed in the anterior and posterior areas of the mandible, a segmented prosthetic design can be used for the final rehabilitation.

The clinical issues presented and the implant/prosthetic parameters should be taken into consideration when selecting the appropriate loading protocol.

5.3.1 Conventional Loading for Mandibular Overdentures

This loading protocol describes the use of two to four implants placed in the edentulous mandible, to be connected to an overdenture after a minimum healing period of 2 months (Table 3). Several implant/prosthetic designs have been proposed, including: (1) two implants with single ball-shaped or locator attachments; (2) two implants splinted with a rigid bar construction; (3) four or more implants connected with a rigid bar construction; and (4) four or more single implants with Locator attachments.

When the number of implants required for a long-lasting outcome was clinically investigated, several clinical studies have suggested that there was no difference in the clinical and radiographic status of patients treated with an overdenture on two or four implants during a 5-year evaluation period.

Conventional loading for mandibular overdentures has been scientifically and clinically validated, with implant survival rates ranging from 97.1% to 100% during a mean follow-up period of 1 to 10 years.

As with all conventional loading approaches in edentulous patients, it is important to avoid overloading the freshly placed implants during the healing period by using a soft relining material.

Table 3: Indications for loading protocols with mandibular overdenture.
### 5.3.2 Early Loading for Mandibular Overdentures

This approach describes mandibular implant overdentures that are functionally loaded no earlier than 1 week after implant placement and no later than 2 months afterwards.

The survival rate of early-loaded rough-surface implants is similar to that of implants loaded in a conventional time frame, on the assumption that primary stability was obtained. The clinical considerations are similar for early and conventional loading approaches with mandibular overdentures (Table 3).

However, differences in the quality of scientific evidence remain, since mandibular overdentures with an early loading approach have been clinically validated.
documented by fewer clinical trials compared to conventional loading.

The early-loading protocol for mandibular overdentures is indicated in cases where bone volume is adequate for standard-size implants. It should ideally be avoided in cases with insufficient primary stability or where implants are placed in association with simultaneous bone augmentation.

### 5.3.3 Immediate Loading for Mandibular Overdentures

Immediate loading with mandibular overdentures is a protocol in which implants are connected to the prosthesis within 1 week after implant placement. Implant/prosthetic designs include: (1) two single immediate implants with ball or locator attachments; (2) two immediately loaded and splinted implants; (3) four free-standing implants immediately loaded with Locator attachment; and (4) four or more implants connected with a bar construction (Table 3).

Large clinical studies suggest that immediate loading with four splinted implants achieves survival rates similar to delayed loading.

Similar results have been reported in the literature for an immediate-loading protocol with four free-standing implants supporting a mandibular overdenture. However, such a protocol is supported by only a few clinical trials reporting a 2-year follow-up.

Immediate loading for mandibular overdentures with two splinted implants can be successfully used and immediate loading with two free-standing implants may become a predictable treatment option. Here the evidence is based on only a few clinical trials, and further research with a larger number of patients would be beneficial to validate this procedure.

The scientific evidence has been clinically ample for the immediate-loading protocol using four splinted implants.

The immediate-loading protocol for mandibular overdentures should be reserved for cases where standard-size implants are placed, achieving maximum primary stability.

### 5.3.4 Conventional Loading for Mandibular Fixed Rehabilitations

This loading protocol describes the use of implants placed in an edentulous mandible to support a fixed dental prosthesis after a healing period of 2
months. Implant/prosthetic designs include: (1) four to six implants with a one-piece full-arch fixed prosthesis and (2) six implants with a segmented fixed prosthesis (Table 4).

The long-term clinical results of mandibular implant-supported fixed rehabilitations are predictable in terms of prosthetic function and implant stability. Generally, the conventional loading of mandibular fixed-implant prostheses has been scientifically and clinically validated with implant survival rates ranging from 97.2% to 98.7% in 10 years of follow-up.

Implant numbers and distributions are directly influenced by the anatomical situation and implant/prosthetic designs present an anterior only or an anterior-posterior distribution. In the anterior distribution, the length of the distal cantilevers is determined by the number of implants supporting this type of rehabilitation.

As with conventional-loading protocols for other clinical indications, special attention should be given to the postoperative adjustment of the mandibular denture.

*Table 4 Indications for loading protocols with mandibular fixed rehabilitations*

<table>
<thead>
<tr>
<th>Implant/prosthetic design</th>
<th>Conventional loading</th>
<th>Early loading</th>
<th>Immediate loading</th>
<th>Implant number and distribution</th>
<th>Prosthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CWD</td>
<td>CID</td>
<td>CD</td>
<td>Four anterior</td>
<td>Full-arch with one-unit bilateral distal cantilevers</td>
</tr>
<tr>
<td></td>
<td>SCV</td>
<td>CD</td>
<td>CWD</td>
<td>Six anterior</td>
<td>Full-arch with two-unit bilateral distal cantilevers</td>
</tr>
<tr>
<td></td>
<td>SCV</td>
<td></td>
<td></td>
<td>Six anterior-posterior</td>
<td>Full-arch in one piece</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Six anterior-posterior</td>
<td>Segment into three FPD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Increased interarch space</td>
<td>Increased interarch space, adequate bone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Increase interarch space, adequate bone</td>
</tr>
</tbody>
</table>


5.3.5 Early Loading for Mandibular Fixed Rehabilitations

This loading protocol describes mandibular fixed-implant rehabilitations with functional loading between 1 week and 2 months after implant placement (Table 4).

Early loading of implants in the edentulous mandible with fixed-implant rehabilitations has been clinically documented with a survival rate ranging from 98.6% to 100% in a 1-to 3-year follow-up. A small number of studies report that early loading of implants supporting cross-arch fixed prostheses in the edentulous mandible can be a predictable procedure. Clinical trials with one-year follow-up of early loading with rough-surface and machined-surface implants report that the implant survival rate was significantly higher for rough-surface implants. Treatment outcomes for early loading in the edentulous mandible with fixed prostheses are comparable with conventional protocols.

An early-loading protocol for fixed implant rehabilitations in the edentulous mandible is indicated where bone volume is adequate for at least six standard-size implants. It should ideally be deferred in cases with insufficient primary stability, implants placed in association with simultaneous bone augmentation, implants reduced in length, or a minimal number of implants to support the fixed prosthesis.

5.3.6 Immediate Loading for Mandibular Fixed Rehabilitations
Immediate loading with mandibular implant overdentures describes a protocol in which a fixed provisional is attached to the implants and placed in occlusal function within 1 week after implant placement. Osseointegration with immediate implant loading via fixed provisional restorations can be successfully achieved in the edentulous mandible.

However, implant/prosthetic protocols with five to six implants are better documented than those with four implants (Table 4). This protocol with fewer implants raises the concern of jeopardizing the stability of a fixed prosthesis in the adverse event of failure of an implant.

Immediate loading of rough-surface implants with a fixed provisional restoration has been clinically well documented, with 1-to 3-year survival rates from 99.4% to 100%.

As with immediate loading in other clinical situations, standard implant size, primary stability, and implant placement in an adequate bone volume are prerequisites for this loading protocol.

When the implant/prosthetic design includes implants in the anterior mandible, distal cantilevers should ideally be avoided in the immediate provisional; hence functional and esthetic parameters should be carefully assessed.

Immediate provisional techniques are similar to those presented for the edentulous maxilla with immediate loading, including complete denture conversion and pickup technique.

5.4 Treatment Regulators and Risk Factors

In selecting loading protocols for the treatment of edentulous patients, several parameters should be considered, including systemic and local risk factors. Some of the implant/prosthetic diagnostic parameters discussed in earlier chapters play an important role as treatment regulators.

Treatment regulators involve clinical considerations at all diagnostic, planning, surgical, and prosthodontic and maintenance levels, suggesting a specific indication for a given loading protocol.

Medical Condition and Local Risk Factors
Reports on the tendency for subjects with diabetes to have higher failure rates are conflicting. Clinical studies have shown no or minimal significant differences for increased risk of implant failure. Once the indication for implants in an edentulous patient with diabetes is confirmed, a conventional or early loading approach should ideally be selected. This allows for the monitoring of postoperative healing during the determined healing phase.

Bisphosphonate therapy and implant surgery, including the duration and the dosage of the medication and the type of the bisphosphonate, have been reported to play an important role in a potential bisphosphonate-related osteonecrosis of the jaws. Although there is not enough data to estimate the risk for oral bisphosphonates in implant therapy, involving the patient’s physician would help determine the treatment selection. If implant placement is planned, a conventional-loading protocol would be indicated.

Smoking is a risk factor for implant survival and success. Data suggest that smoking is a risk factor for implants placed in augmented sinuses. In addition, several studies have identified smoking as a risk factor for radiographic marginal bone loss, with the effect being dose-related. Before selecting a conventional loading approach in smoker patients, the indication for implant placement has to be confirmed in relation to the specific smoking habits and the willingness of the patient to reduce smoking during treatment.

Reduced manual dexterity is presented as a risk factor for edentulous patients when it comes to oral hygiene maintenance and the removal of overdentures. In this case, the ideal implant/prosthetic design should be carefully selected to ensure that these patients can effectively perform oral care. Here, a conventional-loading protocol with regular check-ups seems to be the approach indicated.

**Treatment Regulators**

Bone volume and density, surgical technique, implant size, and primary stability are important treatment regulators for loading protocols in edentulous patients. For protocols with a reduced healing time, such as early or immediate loading, an ideal implant length of 10 mm intraosseous anchorage in native or healed bone is recommended. In cases with simultaneous bone augmentation to regenerate bone deficiencies, conventional loading is indicated. The extent of the healing period is normally determined by the bone-regeneration approach in association with
the primary implant stability achieved. In some cases, it will be necessary to extend the healing time beyond the 2-month minimum recommended for a conventional-loading protocol.

Implant surface properties play an important role in reducing loading times. In particular, rough surface implants have demonstrated both improved bone-to-implant contact (BIC) and resistance to movement. Rough-surface implants are generally used for all loading protocols nowadays. Recent improvements, including a chemically modified rough surface, have been reported to increase BIC and to yield higher implant torque values 3 weeks after placement. This particular finding, when implants comply with all other treatment regulators, broadens the range of indications for early loading in several clinical situations.

The number of implants and their distribution in the arch is another important regulator and it should primarily be related to the desired final implant/prosthetic protocol. A larger number of implants with an anterior-posterior distribution (cross-arch stabilization) for a fixed prosthesis or splinted implants for overdentures are the most suitable for early or immediate loading when other treatment regulators are optimal. For implant/prosthetic designs with fewer implants, implants with only an anterior distribution or free-standing implants with a conventional loading approach seem to be an appropriated loading protocol.

Patient expectations regarding treatment planning are considered another regulator influencing the selection of a specific loading protocol. Thus, edentulous patients with a successful history of wearing a complete denture who were seeking to improve their comfort by means of dental implants may well tolerate a conventional healing time without the associated difficulties of other loading protocols. Conversely, edentulous patients with difficulties carrying a complete denture might favor a shorter protocol.

All the above treatment regulators are normally assessed together when selecting the appropriate loading protocol.

5.5 Risk of Complications

Biological and technical complications can occur in the treatment of edentulous jaws with implant/prosthetic rehabilitations. In terms of
complications associated with the selected protocol, a primary concern is the interference with the normal implant osseointegration process during the healing phase. For conventional- and early-loading protocols in edentulous patients, loading the implant with uncontrolled forces from the temporary prosthesis must be avoided. Here, soft relining is normally performed to prevent this condition. When the implants are to be loaded conventionally, some protocols suggest a one-week period before wearing the prosthesis.

For immediate loading, either with an overdenture or a fixed provisional, the load transfer to the implants should ensure that implant micromovements are minimized to avoid early implant failures. For overdentures, the bar construction is responsible for splinting all implants to neutralize the forces transferred from the overdenture at insertion/removal as well as during function. In the case of a fixed provisional, the all immediately loaded implants must be rigidly splinted to avoid implant overloading. Fractures of the immediate transitional fixed prosthesis can also cause implant overload and interfere with osseointegration.

Screw retention is recommended for all types of fixed temporary prostheses. This eliminates complications caused by excess cement being displaced into the wound zone.

During the healing phase of immediately loaded implants, monthly follow-ups are advisable to monitor implant stability and oral hygiene.

### 5.6 Difficulty Level of the Prosthodontic Treatment

The ITI SAC classification provides clear guidelines for treatment planning, implant placement, and prosthetic considerations. Based on this SAC classification, the difficulty level of the prosthodontic treatment (provisional and final prostheses) associated with different loading protocols is presented in Table 5.

*Table 5 SAC classification for loading protocols and prosthodontic difficulty level in edentulous patients.*

<table>
<thead>
<tr>
<th>Removable</th>
<th>Fixed</th>
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<tr>
<td>Maxilla</td>
<td>Mandible</td>
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<tr>
<td>4 implants</td>
<td>≥6 implants</td>
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<td>≥6 implants</td>
<td>2 implants</td>
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<td>2 implants</td>
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5.7 Conclusions
Selecting the appropriate loading protocol for the implant/prosthetic treatment of edentulous patients includes the assessment of diagnostic parameters, treatment planning considerations, loading regulators, prosthodontic sequences, treatment difficulty levels, and patient expectations.
6 Clinical Case Presentations

6.1 Early and Conventional Loading

6.1.1 Early Loading of Two Implants in the Mandible and Final Restoration with a Retentive-Anchor-Supported RDP

A.G.T. Payne, A. Tawse-Smith, R.K. De Silva, W.J. Duncan

A 63-year-old male edentulous and maladaptive patient presented with an inability to wear his existing complete maxillary and mandibular dentures. He had been edentulous for 41 years, and there had been three unsuccessful attempts by dentists to provide complete dentures for him. Efforts to wear both complete dentures were always initially encouraging, but over time, he invariably found that he was unable to wear the complete mandibular denture, and this pattern had persisted for 20 years. After seeing local newspaper advertisements, he requested having his complete mandibular denture stabilized with implants.

According to the Prosthodontic Diagnostic Index, the patient was diagnosed as class II, with evidence of favorable minimal mandibular residual ridge resorption. Using both panoramic and lateral cephalometric radiographs, the residual bone height was found to be in the region of 20 mm, which resisted horizontal and vertical movement of the denture base (Figs 1a-b). The location of the muscle attachments had limited the influence on the denture base stability and retention. The edentulous maxilla was of category B, and there were minor modifiers in terms of the psychological aspects of the severe gagging response. Although the patient was deemed suitable for a mandibular fixed implant-supported bridge, he preferred a removable overdenture for financial reasons.
To facilitate a 2-week early-loading protocol, new diagnostic complete maxillary and mandibular dentures were fabricated using standard procedures, and the vertical dimension of occlusion was established (Figs 2a-b). Gagging responses related to the maxillary denture dictated that the posterior border in the region of the post-dam be shortened to facilitate wear. Even with this modification, the patient was only able to tolerate his conventional complete mandibular denture for a limited time.
The preoperative diagnostic panoramic radiograph (Scanora, Soridex, Helsinki, Finland) was used to identify the implant lengths required. On the day of surgery, 2 g of amoxicillin were given orally, 1 hour before the operation. The patient was instructed to rinse his mouth with 0.2% chlorhexidine digluconate solution (Savacol, Colgate Oral Care, Sydney, Australia) for 1 minute prior to the operation.

Two Straumann Standard RN SLA implants of 14 mm length were placed using the original Straumann non-submerged protocol. Analysis during surgery and of the radiographs defined the case as Lekholm and Zarb bone quantity B and bone quality 3. The interimplant distance was determined at 22 mm by first marking the midline with a round bur (Fig 3). Then, using the
pilot drills, sites were prepared 11 mm to either side of midline using a modified implant-paralleling device.

Fig 3 Determining the inter-implant distance using a midline mark as reference.

Finally, using the alignment pins (Ø 2.2 mm to 3.5 mm) supplemented with depth gauges, the osteotomies were completed with a 4.1-mm tap (Figs 4 to 6). Resonance frequency analysis (Osstell, Integration Diagnostics, Göteborg, Sweden) confirmed the initial primary stability with ISQ readings of 62.

Fig 4 Alignment pins.
Fig 5 The osteotomies are completed and the implants placed.

Fig 6 Implants placed with mounts still connected.

A modification to the standard protocol was that instead of using healing caps on the implants, both retentive anchors were placed during the surgery and torqued to 35 Ncm (Fig 7). Mucoperiosteal flap closure was then completed using interrupted or horizontal mattress sutures (Vicryl 4-0, Ethicon, Johnson & Johnson, Brussels, Belgium; Fig 8).
Immediately after surgery, a denture tissue conditioner (Viscogel, DeTrey, Weybridge, England) was applied to a generously relieved undersurface (Fig 9), and the patient was permitted to wear his complete mandibular denture with his complete maxillary denture postoperatively. The patient was advised not to brush the implants during the first week, and the sutures were removed on day 7. The patient was placed on a soft diet for the first 2 weeks and a strict regime of denture removal at night. The postoperative care protocol also included twice daily 0.2% chlorhexidine digluconate rinses and daily bilateral peri-implant application of a 0.2% chlorhexidine digluconate gel (PerioGard, Colgate Oral Care, Sydney, Australia) using the denture as a reservoir.
Exactly 2 weeks after surgery, following mucosal healing and in line with the planned early-loading protocol, the tissue conditioner was removed from the mandibular denture and prepared for a closed-mouth reline impression (Impregum, 3M ESPE, Seefeld, Germany) (Fig 10).

Recommended laboratory procedures were followed, with transfer pins for the retentive anchors being placed into the impression, and the laboratory models were poured in type III die stone. The Dalla Bona-type gold matrices were placed onto the transfer pins, and blockout procedures were followed and the dentures processed. The final mandibular two-implant overdenture had old-style Dalla Bona-type gold matrices included on the intaglio surface (Fig 11).
Prior to the delivery of the prostheses the following day, the labial periphery of the mandibular implant overdenture was reduced in the region of the implants to minimize the possibility of irritation leading to peri-abutment or peri-implant mucosal enlargement (hyperplasia). The intaglio surfaces of the complete maxillary denture and the mandibular two-implant overdenture were checked using pressure-disclosing paste, and the occlusion was refined using a full remount and selective grinding procedure. Oral hygiene instructions were provided to the patient on overdenture insertion and they were reinforced with professional cleaning at the annual recall.

The patient was recalled at 6 weeks (Figs 12 and 13), 12 weeks (Fig 14), and annually thereafter. Minor adjustments to the denture contours were made to facilitate comfortable function. With this completion of treatment, the patient immediately reported a return to full-time denture wearing and being able to eat a wide variety of foods. As a result, his self-confidence in front of his work colleagues had improved dramatically.
Fig 12 Recall at 6 weeks. The ball attachments were removed to take resonance frequency readings at implant level to assess implant stability.

Fig 13 Recall at 6 weeks.
**Ten-year follow-up**

The patient was followed through a 10-year recall period up to 2008, with standardized panoramic radiographs (Figs 15 to 18).
Fig 16 Panoramic radiograph, recall at 1 year.

Fig 17 Panoramic radiograph, recall at 5 years.

Fig 18 Panoramic radiograph, recall at 10 years.
In addition, intraoral radiographs of the coronal parts of the implants indicated stable peri-implant bone conditions and negligible crestal bone loss (Figs 19a-b to 22a-b).

*Fig 19a Right implant, baseline at 2 weeks.*
Fig 19b Left implant, baseline at 2 weeks.
Fig 20a Right implant, recall at 1 year.
Fig 20b Left implant, recall at 1 year.
Fig 21a Right implant, recall at 5 years.
Fig 21b Left implant, recall at 5 years.
Fig 22a Right implant, recall at 10 years.
Fig 22b Left implant, recall at 10 years.

The sequential resonance frequency readings indicated improved osseointegration over time. The peri-implant mucosal response around the implants was excellent through the recall period (Figs 23a-c and 24a-c).
Fig 23a Recall at 5 years with retentive anchors removed.

Fig 23b Recall at 5 years.

Fig 23c Recall at 5 years.
Fig 24a Recall at 10 years with retentive anchors removed.

Fig 24b Recall at 10 years.

Fig 24c Recall at 10 years.
During this 10-year follow-up period, the patient was also provided with three maxillary implants between year 1 and year 3 to support a bar-retained overdenture in the maxilla in order to complete the rehabilitation of his edentulous predicament. A different implant system was used (Southern Implants, Irene, South Africa).

Prosthodontic maintenance was minimal related to the activation of the old-style Dalla Bona-type gold matrices, using the recommended activating or deactivating instruments (Figs 25 and 26).

![Image](image1.png)

**Fig 25** Minimal prosthetic maintenance was required.

![Image](image2.png)

**Fig 26** Prosthetic maintenance was performed using the recommended activating or deactivating instruments.

There were no fractures of matrix lamellae during the 10-year period,
indicating excellent longevity (Fig 27).

Fig 27 Original Dalla Bona-type gold matrices.

A decision was made to replace these matrices when the mandibular implant overdenture was relined at the 7-year recall. The original Dalla Bona-type gold matrices were replaced with new elliptical Straumann gold matrices with lamellae inserts to facilitate easier replacement over the next 10-year period (Figure 28).

Fig 28 Replacement elliptical Straumann gold matrices.

Using the recommended screwdriver, the new elliptical matrices were adjusted to obtain the correct retention for the patient. There was no evidence of wear of the spherical portions of the retentive anchors after the 10-year period.
6.1.2 Conventional Loading of Two Implants in the Mandible and Final Restoration with a Locator-Supported RDP

A. Boeckler, D. Morton

An 83-year-old male patient requested treatment for his existing maxillary complete overdenture and mandibular complete denture. He reported no general medical conditions of significance that would affect his dental treatment and was taking no prescription medication. He denied suffering from oral pain and displayed no evidence of parafunctional habits or temporomandibular joint disorder.

Oral and radiographic evaluation revealed two retained maxillary teeth (13 and 15) supporting prefabricated ball-shaped attachments. Both teeth were mobile and associated with active periodontal disease and extensive dental caries; these were considered non-restorable and were recommended for extraction.

The patient’s existing complete maxillary and mandibular prostheses were approximately 2 years old. He was very satisfied with the appearance of both prostheses. His chief complaint was related to the instability and lack of retention associated with the existing mandibular prosthesis (Figs 1 and 2).
He was satisfied with the performance and functional characteristics of the maxillary prosthesis. A detailed evaluation of the vertical dimension of occlusion and the interocclusal rest space revealed that his existing prostheses were satisfactory. The maxillary and mandibular edentulous residual alveolar ridges were atrophic (Figs 3 and 4), although each residual ridge displayed adequate regions of attached keratinized mucosa.
The patient understood the need for the extraction of the remaining diseased maxillary teeth. He expressed a strong desire to maintain his existing prostheses if practical. In addition, he requested that improvements be made to the functional characteristics of his mandibular denture, while maintaining the prosthesis, at minimal expense.

Subsequent to the detailed consideration of all the treatment options, the patient accepted the following treatment plan. The remaining maxillary teeth were to be removed as soon as possible, and the existing maxillary denture lined initially with tissue conditioner, prior to permanent rebasing. Treatment for the mandibular arch included the surgical placement of two narrow-connection, reduced-diameter bone-level implants in the canine regions.
Upon successful healing, the implants were planned to support Locator abutments. The patient’s existing complete mandibular prosthesis would then be re-based and retrofitted to incorporate Locator attachments, improving the support, stability, and retention of the prosthesis while maintaining the existing vertical and esthetic relationships. This treatment plan satisfied the patient’s desire to utilize his existing prostheses and would establish oral health.

The existing mandibular denture was duplicated in clear autopolymerizing acrylic resin (PalaXpress Clear, Heraeus Kulzer, Hanau, Germany). The duplicate denture was reduced in the intraforaminal region, between the first premolars, and metal indicator balls were positioned in the preferred canine regions (Fig 5). A panoramic radiograph was obtained, confirming adequate bone height to support dental implants (Fig 6).

*Fig 5 Reduced duplicate denture with metal indicator balls.*
Two narrow-connection reduced-diameter dental implants were planned for several reasons including the presence of a narrow residual ridge and a small band of attached keratinized tissue (Fig 7).

A conservative mid-crestal incision was made under local anesthesia. The residual ridge was exposed through the elevation of full-thickness flaps with no releasing incisions. The knife-edge crestal region was reduced using surgical rongeurs, and the harvested bone was preserved in anticipation of the need for local bone augmentation subsequent to implant placement.

The desired implant sites were identified using a surgical template (Fig 8). Osteotomies were prepared without complication (Fig 9), and the two implants positioned (Straumann Bone Level NC SLActive, Ø 3.3 mm, length 10 mm; Figs 10 and 11). The inclination and position of the implants were confirmed prior to the removal of the implant-positioning mount (Fig 12).
Fig 8 Identifying the surgical sites.

Fig 9 Prepared osteotomies.

Fig 10 First Straumann NC SLActive implant (Ø 3.3 mm, length 10 mm).
Cover screws were positioned, and minor areas of SLActive surface exposure on the facial aspects of the implants were augmented using the bone chips previously retained and covered with a periosteal cover. Each implant was submerged at wound closure. The patient’s existing mandibular prosthesis was modified to provide relief in the region of the implants and the surgical site. It was lined with tissue conditioner (Visco-Gel, Dentsply DeTrey, Konstanz, Germany) and adjusted as indicated, and the patient was released.

The implants were allowed to heal without disturbance for a period of 10 weeks (Fig 13). Localized access was made to the implants under local anesthesia. The cover screws were removed without incident and replaced.
with narrow-connection healing abutments (Fig 14). Each implant was deemed stable. The existing denture lining was removed and replaced to register the healed soft-tissue architecture and the healing abutments.

![Fig 13 Result after 10 weeks of healing.](image1)

![Fig 14 Implants and healing abutments following reentry.](image2)

The surgical site was allowed an additional 4 weeks of healing (Fig 15). The healing abutments were then removed (Fig 16) and the depth of the mucosa assessed. Locator abutments were then chosen to allow supramucosal positioning of the attachments (Figs 17 and 18). The vertical bulk of the denture was considered non-contributory with regard to abutment height. The supramucosal position of the Locator abutments ensured access for continued home maintenance and facilitated self-alignment of the denture on insertion.
Fig 15 After another 4 weeks of healing (14 weeks total).

Fig 16 Situation following removal of the healing abutments.

Fig 17 Locator abutment for a narrow-connection bone-level implant.
Each abutment was positioned and torqued to the recommended 35 Ncm without complaint (Figs 19 and 20). Teflon spacers and titanium caps with low-density polyethylene (LDPE) transfer units were positioned (Figs 21 and 22). Subsequent to the removal of the existing lining, the denture base was relieved with a disclosing medium to ensure accurate tissue adaptation with no contact in the regions of the abutments and attachments (Fig 23). A final rebasing impression was then taken using a poly-ether impression material (Impregum, ESPE, Seefeld, Germany) with a corresponding adhesive (Polyether adhesive, ESPE), using the mandibular denture as an impression tray (Figs 24 and 25).
Fig 20 The two abutments protruding past the soft tissue.

Fig 21 Teflon spacers in place.

Fig 22 Titanium caps with LDPE transfer units connected.
Fig 23 Relief of the denture base.

Fig 24 Preparing for the final rebasing impression.

Fig 25 Final rebasing impression.
The rebasing and attachment indexing were planned to facilitate the return of the mandibular denture at the same appointment. Locator abutment analogs were positioned in the impression (Figs 26 and 27), and a master cast was poured in improved dental stone (Jade Stone, Whip Mix Corporation, Louisville, KY, USA; Fig 28).

Fig 26 Locator analog.

Fig 27 Locator analogs in the rebasing impression.
Titanium caps were then positioned onto the abutment analogs, sandblasted, and primed (Alloy Primer, Kuraray, Tokyo, Japan) to improve the seal and retention to the denture base. The denture base was then rebased (PalaXpress, Heraeus Kulzer, Hanau, Germany), incorporating the Locator attachments, and finished (Figs 29 and 30).

*Fig 28 Master cast.*

*Fig 29 Maxillary denture, occlusal view.*
The denture was then verified for tissue adaptation and the alignment of the attachments to the abutments (Fig 31). The occlusal and vertical relationships were verified with minor adjustments made through a clinical remounting process. The patient’s ability to remove the prosthesis without difficulty was confirmed, and post-treatment oral hygiene instruction was provided.

Follow-up assessments were undertaken after 48 hours and 1 week. Minor adjustments to the denture base were made as indicated. At the 1-week follow-up, the black processing blanks were removed (Fig 32) and replaced with the blue (6.7 N) attachments using a locator core tool (Figs 33 to 37).
Fig 32 Removing the black processing blank.

Fig 33 Color-coded attachments.

Fig 34 A blue attachment was selected.
Fig 35 Integrating the blue attachment into the denture.

Fig 36 Locator core tool used to secure the blue attachment in place.

Fig 37 Both Locator attachments in their final positions.
Further reevaluation appointments took place after 6 and 24 weeks and after 12 months. The patient continues to report complete satisfaction with the prosthesis with regard to function, comfort, and esthetic outcome. No clinical or radiographic concerns were noted (Figs 38 and 39).

Fig 38 Clinical situation at follow-up.

Fig 39 Panoramic radiograph at follow-up.

This conservative and efficient treatment should be considered for patients with appropriate indications.

**Acknowledgments**

**Laboratory Procedures**

Frank Siebert, Master Dental Technician, Rübeling + Klar Dental-Labor – Halle (Saale), Germany
6.1.3 Conventional Loading of Two Implants in the Mandible and Final Restoration with a Bar-Supported RDP

H.J.A. Meijer

A 63-year-old female patient was referred to the University Medical Center in Groningen, Netherlands, for dental implant treatment. The patient had been edentulous in the upper jaw for 20 years. The remaining teeth in the lower jaw had been removed two years before the consultation. The patient was wearing her first maxillary denture and her second mandibular denture; the latter was 1 year old at the time. The conventional upper denture had functioned satisfactorily for many years, but the patient complained about reduced stability and insufficient retention of her lower conventional denture. Her medical history revealed no significant findings. The intraoral examination revealed minor resorption of the maxillary alveolar process and extreme resorption of the mandibular alveolar process. Retention and stability of the maxillary denture were normal, while the mandibular denture exhibited no stability or retention at all, and the occlusion was balanced without anterior contact. Radiographic diagnosis included a rotational panoramic radiograph and a lateral cephalometric radiograph (Figs 1 and 2).

Fig 1 Baseline rotational panoramic radiograph.
The height of the mandible was 20 mm with a slight knife-edge ridge, as measured in the symphysis region on the lateral cephalometric radiograph (Cawood and Howell class IV). The treatment plan proposed to the patient included two endosseous implants in the interforaminal region of the mandible, a mandibular overdenture supported by a bar attachment system, and a new conventional denture in the maxilla. The patient was informed of the risks and gave her written informed consent.

**Procedure**

Two Straumann Standard dental implants (Ø 4.1 mm, length 14 mm) were inserted under local anesthesia after the removal of the bony knife-edge ridge aspect. The implants were inserted in the canine region of the mandible, each about 1 cm away from the midline. The procedure was carried out in a one-stage technique. Postoperative analgesics and 0.2% chlorhexidine digluconate
mouth rinses were prescribed, but no antibiotics. The patient was not allowed to wear her mandibular denture during the first week after surgery, after which the sutures were removed. A soft liner was applied after selectively relieving the mandibular denture at the implant site. The patient also received oral hygiene instructions. Prosthetic procedures started after a 6-week healing period. The implants were stable and surrounded by healthy peri-implant mucosa (Fig 3).

Fig 3 Two Straumann Standard implants at the end of the 6-week healing period.

The preliminary impression was taken using stock metal trays and alginate (Fig 4). Custom composite trays were fabricated with openings for screw-retained synOcta impression posts. The impression posts were fixed at the implant level (Fig 5).
Fig 4 Preliminary impression for manufacturing the custom tray.

The tray was placed over the impression posts, and any contact between the post and the tray was avoided to allow the tray to rest firmly on the denture-bearing mucosa. The screw of the post was positioned above the opening of the tray (Fig 6).

Fig 5 The impression posts mounted on implants.

Fig 6 Custom impression tray with posts.

The final impression was taken in a hard polyether material. The impression material around the posts was administered by a syringe. The tray was filled and placed on the alveolar process. During setting, the screws had to remain uncovered to facilitate removal of the impression (Fig 7).
Fig 7 Impression taken with a stiff polyether impression material. The screws of the impression posts are visible.

The posts were connected to implant analogs in the impression tray, and the master cast was poured (Figs 8 and 9).

Fig 8 Implant analogs connected to the impression posts.
In this way, the implant location and the denture-bearing area were reproduced. Before determining the vertical and horizontal dimensions of the new dentures, the bar and the acrylic base of the overdenture were fabricated. A stable and well-retained base made it easier to record the interarch relationship. SynOcta abutments were chosen as connections between implants and titanium copings. An ovoid titanium bar was connected to the titanium copings, and a gold clip was selected (Fig 10).

Requirements for placing the bar include parallelism with the line between the temporomandibular joints, accessibility for oral hygiene, no encroachment on the tongue space, and accommodation of the positions of the artificial teeth. The acrylic denture base was poured and the clip
incorporated (Figs 11 and 12).

Fig 11 Final acrylic base of the overdenture.

Fig 12 The clip in the denture base.

An occlusal wax rim was attached to the denture base (Fig 13).
Fig 13 Occlusion wax rim on the denture base.

The synOcta abutments were connected to the implants in the patient’s mouth, and the bar was screwed on the abutments (Figs 14 and 15).

Fig 14 synOcta abutments connected to the implants.
To check the seating of the clip on the bar, a two-component silicone-based disclosing material was inserted in the area of the clip and placed on the bar in the mouth (Fig 16).

After the setting of the disclosing material, the denture base was removed. There was to be a connection between the clip and the bar but no connection between the bar and the acrylic, which was verified (Fig 17).
If a connection between the bar and the acrylic had existed, the area would have had to be relieved and the seating rechecked.

Occlusal wax rims on bases were used to determine the vertical dimension and the level of the occlusal plane and to record the maxillomandibular relation (Figs 18 and 19).
After completion of the tooth set-up, the trial dentures in wax were tried in intraorally and corrections were made. The lingualized occlusion concept with bilateral balanced guidance and ceramic teeth was used (Figs 20 and 21).
The tooth set-up was approved by both the dentist and the patient, and the conventional upper denture and mandibular overdenture could be finished in the laboratory (Fig 22).

At the delivery of the prostheses, the synOcta abutments were placed and tightened to 35 Ncm with a torque controller. The bar was connected and the occlusal screws were tightened to 15 Ncm. After insertion, the adaptation of the base was examined with disclosing material. Once the adaptation had been checked, occlusion and articulation were examined. If necessary, the retention force of the clip can be adjusted at this stage.
The patient was taught to remove the overdenture and to clean the prosthesis and bar. A few days after delivery, the first check-up was performed, and peri-implant radiographs were taken to record peri-implant bone levels at the outset of the functional period (Figs 23 and 24).

Fig 23 Intraoral radiograph at overdenture delivery: right implant.
Follow-up
A regular yearly recall system was applied. The status of the alveolar process was checked intraorally together with peri-implant items such as plaque and calculus accumulation, mucosa, sulcus depth, and bleeding. The evaluation of the prosthesis included the fit of the denture base, occlusion and articulation, fracture of denture base or teeth, and clip loosening or fracture. At the 4-year follow-up, the patient presented a satisfactory clinical situation and a favorable peri-implant bone level (Figs 25 to 26).
Fig 25 Bar after 4 years in function.

Fig 26 Rotational panoramic radiograph after 4 years in function.

No complications had occurred during these 4 years and the patient was still very satisfied with the improved function of the mandibular denture.

Acknowledgments

Surgical Procedures
Prof. G.M. Raghoebbar – Groningen, Netherlands

Laboratory Procedures
Gerrit van Dijk – Groningen, Netherlands

6.1.4 Conventional Loading of Six Implants in the Mandible and Final Restoration with a Full-Arch Metal-Ceramic FDP
A. Boeckler, D. Morton

A 68-year-old, completely edentulous male patient presented for evaluation and treatment options. He reported excellent general health and was taking no regular medication. He had been edentulous for approximately 12 years, having lost his teeth to periodontal disease and dental caries.

The patient’s chief complaint was incompetent function. His secondary concerns included his appearance (Fig 1) and the desire for a predictable outcome.

![Fig 1 Patient’s lip line at baseline.](image)

He attributed his reduced functional capacity to his lower complete denture, which he described as poor. He was particularly concerned with the denture’s instability and poor fit. In general terms, he was satisfied with the maxillary complete prosthesis. The maxillary prosthesis was characterized by adequate retention, stability, and support, although the fit was considered less than ideal (Fig 2).
The intraoral evaluation revealed moderately resorbed maxillary and mandibular arches. All tissues appeared to be healthy, and there was no evidence of inflammation or infection. The residual mandibular ridge appeared to be adequate with regard to regions of attached, keratinized tissue (Fig 3).

The existing prostheses displayed wear and both occlusal and aesthetic deterioration. An assessment of rest space revealed inadequate restoration of occlusal vertical dimensions. Radiographic evaluation confirmed the absence of underlying pathologies.
The patient was provided with several treatment alternatives:

**Option I.** Removable complete prostheses in both arches.

**Option II.** Removable complete maxillary prosthesis in conjunction with a removable complete implant-supported mandibular prosthesis.

**Option III.** Removable complete maxillary prosthesis in conjunction with a fixed implant-supported complete mandibular prosthesis.

Subsequent to detailed discussions regarding the advantages and disadvantages of each option, the patient consented to option III, a removable complete maxillary prosthesis in conjunction with a fixed complete implant-assisted mandibular prosthesis.

The patient’s existing mandibular prosthesis was duplicated in clear auto-polymerizing polymethyl methacrylate (PalaXpress Clear, Heraeus Kulzer, Hanau, Germany). Six metal balls (Ø 5 mm) were positioned into the duplicate denture in the desired implant positions. A panoramic radiograph was obtained (Fig 4), confirming adequate height of bone in the region between the mental foramina.

![Fig 4 Metal balls planned implant positions on the radiograph.](image)

The metal balls were then replaced with drill sleeves to form the surgical template (Fig 5).
Six dental implants (Straumann RN Standard, Ø 4.1 mm, length 12 mm) were positioned under local anesthetic, and transmucosal healing abutments were placed (Ø4.8 mm, height 1 mm). A postsurgical radiograph was obtained (Fig 6).

The implants were allowed to heal for a period of 3 months. The healing abutments were removed without incident (Fig 7). Preliminary impressions were made of the mandible and the maxillary arch in irreversible hydrocolloid (Tetrachrom, Kaniedenta, Herford, Germany). A conventional customized impression tray with perforations for impression caps was fabricated for the mandible (DC Tray, Dental Central, Trittau, Germany). SynOcta impression caps were positioned (Fig 8). An open-tray (pickup)
impression was made in polyether impression material (Impregum, 3M Espe, Seefeld, Germany; Fig 9) and a preliminary jaw relation registration was performed. The cast for the mandible was fabricated in type IV dental stone (Unibase 300, dentona, Dortmund, Germany). Impression copings were repositioned on the mandibular cast and a framework fitting around the impression copings were fabricated from Co-Cr-alloy (Triloy, Dentaurum, Ispringen, Germany; Fig 10).

Fig 7 Implants after removing the healing abutments.

Fig 8 synOcta impression posts connected.
After provisional articulation of the casts, acrylic-resin baseplates were fabricated for each arch (DC Tray, Dental Central). A window was created in the mandibular baseplate to facilitate picking up of the acrylic resin-impression analog matrix in the final impression (Fig 11).
To obtain passivity for the future restoration, the impression copings were positioned and intraorally linked to the customized Co-Cr-framework with autopolymerizing poly-methyl methacrylate (Pattern Resin, GC, Tokyo; Fig 12).

Each baseplate with acrylic rim was then utilized as a custom tray (Fig 13), facilitating the making of the final impression for each arch using polyether impression material (Impregum, 3M Espe) and the recording of the maxillomandibular relationship (jaw relation records, Fig 14). A facebow registration was obtained (Artex, Amann Girrbach, Pforzheim, Germany), and the final casts (Unibase 300, dentona) articulated on a semiadjustable articulator.
Fig 13 Baseplate used as a custom tray.

Fig 14 Jaw relation records with matrices encased in acrylic resin baseplate.

Teeth (Vitapan anteriors and posteriors, cuspiform, VITA Zahnfabrik, Bad Säckingen, Germany) were positioned on the maxillary wax rim (supported by the baseplate), and the mandibular matrix was retained by plastic bite registration aids according to the proposed occlusal vertical dimension and esthetic arrangement (Fig 15).
The position of the maxillary teeth in particular was individualized to satisfy the patient’s esthetic demands (Fig 16). The patient’s satisfaction with the proposed tooth position was confirmed at try-in (Fig 17).
Upon verification and acceptance of the tooth positions, a polyvinyl siloxane putty matrix (alphasil perfect, Omicron, Lindlar, Germany) was fabricated to relate the mandibular tooth position to the mandibular master cast (Fig 18).

Abutments (synOcta 1.5) were then positioned into the implant analogs (Fig 19), and a full-contour wax-up (Finocrown, Fino, Bad Bocklet, Germany) for the proposed metal ceramic fixed dental prosthesis was made.
Fig 19 Abutments connected to the implant analogs.

The pattern was then cut back to provide the ideal ceramic proportions using the silicone matrix (Figs 20 and 21).

Fig 20 Cutbacks, lingual view.
The framework was then cast in high-precious alloy (DeguDent U, DeguDent, Hanau, Germany) and verified for fit on the master cast, then finished (Figs 22 and 23).
The framework’s passivity and contours were then evaluated orally and considered satisfactory (Fig 24).

The metal-ceramic mandibular fixed dental prosthesis was finalized along with the final maxillary tooth position (Art i-motion, Debomed, Nienhagen, Germany; Fig. 25).
The final esthetic contours of both prostheses were modified and adjusted to satisfy the patient’s demands (Figs 26 and 27).
Once confirmed and accepted, the final positioning of the maxillary denture teeth was undertaken, and it was processed in polymerized polymethyl methacrylate (Aesthetic autopolymer, Candulor, Wangen, Switzerland).

At delivery, synOcta 1.5 abutments were positioned in each implant and tightened to a torque of 35 Ncm (Fig 28).

The definitive metal-ceramic mandibular fixed dental prosthesis was positioned and verified for clinical passivity and esthetic satisfaction (Figs 29 and 30).
Access for hygiene maintenance was also confirmed, and the patient was provided with comprehensive post-delivery oral-hygiene instructions (Fig 31).
The maxillary complete prosthesis was adjusted as required for adaptation and extension (Pressure Indicator Paste, Keystone Europe, Wijchen, Netherlands). An interocclusal rearticulation record was obtained, and minor occlusal adjustments were made on the articulator. The maxillary complete prosthesis was then delivered to the patient (Fig 32). The patient was satisfied with the final esthetic and functional outcome (Figs 33 and 34).
The patient has had regular yearly follow-ups subsequent to treatment. After 5 years of service, the functional and esthetic satisfaction of the patient has been maintained, and no evidence of radiographic abnormalities has been noted (Figs 35 to 37).
Fig 35 At the 5-year follow-up, anterior view.

Fig 36 Mandibular FDP at the 5-year follow-up.

Fig 37 Radiograph at the 5-year follow-up.
Acknowledgments

Surgical Procedures
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Laboratory Procedures
Andreas Senke, Master Dental Technician, Zahntechnik Xental – Großkugel, Germany

6.1.5 Transition from a “irrational to treat” Maxillary Dentition to a Full-Arch Segmented FDP by Early Loading of Eight Implants Placed Using the Staged Approach

L. Cordaro

The staged approach permits the transition from an “irrational to treat” dentition to a full arch implant supported restoration without any need to use a removable provisional prosthesis or to apply the immediate-placement and immediate-loading techniques.

A failing dentition is the usual indication for a staged treatment.

On the other hand, the dentition should still contain many residual teeth, but with few or none of them being suitable for use as definitive abutments for a full-arch fixed restoration. This situation is usually the result of advanced periodontal disease or of the failure of an extensive fixed prosthesis.

The staged approach usually includes the following treatment steps (Table 1):

Table 1 Timing of the staged approach for restoration of an “irrational to treat” dentition with a fixed cross-arch implant-supported restoration.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Treatment</th>
<th>Timing, maxilla (weeks)</th>
<th>Timing, mandible (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial periodontal treatment</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>Tooth extraction and preparation of residual teeth as abutments; FDP removal if</td>
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<td>0</td>
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<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>First-stage implant insertion</td>
<td>3–6</td>
<td>3–6</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Second-stage implant insertion (immediately after extraction) and loading of the first-stage implants</td>
<td>11–14</td>
<td>6–9</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Loading of the second-stage implants; completion of extractions</td>
<td>19–22</td>
<td>12–18</td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>Standard prosthetic phase</td>
<td>23–26</td>
<td>16–22</td>
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</table>

1. **Periodontal treatment.** Active periodontal pockets must be eliminated before the prosthetic treatment is started. This is crucial because proper soft-tissue healing and post-extraction implant insertion cannot be safely accomplished in the presence of active periodontal lesions (Fig 1a).

![Fig 1a Periodontal treatment.](image)

2. **Tooth extraction and insertion of the first provisional.** A provisional cross-arch FDP to be relined in the mouth is prepared using standard techniques. Strategic extraction of some teeth is performed and the remaining teeth are prepared as abutments for the provisional acrylic-reinforced restoration. At this stage, the ovate-pontic technique may be used for soft-tissue conditioning in order to maintain the facial prominence of the tissues around the remaining abutments. If this is the case, the failing FDP is removed now. The teeth to be kept for the first
provisional phase should be strategically chosen to maintain support for the provisional restoration. The clinician should also consider the quality and quantity of the bone at the future implant site to guarantee the primary stability of adequately dimensioned implants (Fig 1b).

Fig 1b Tooth extraction and insertion of the first provisional.

3. **First-stage implant insertion.** After soft-tissue healing (3 to 6 weeks), implants are inserted in the extraction sockets or in the edentulous spaces that were present at patient presentation. Flap elevation should be kept to a minimum. After implant surgery, the first provisional can be redelivered after minimal adjustments. The number and position of the implants are determined depending on the available support by the natural abutments that are temporarily kept in order to safely support the first provisional FDP. At least four implants are inserted at this time (Fig 1c).
4. **Loading of the first-stage implants and second-stage implant insertion.**

After normal healing—6 weeks in the lower jaw, and 8 weeks in the maxilla for SLA (sandblasted, large-grit, acid-etched) surface implants (Straumann AG, Basel, Switzerland)—a second surgical step is performed. During the same session, the first-stage implants are connected to provisional abutments, other teeth are extracted, and immediate post-extraction implants are placed where needed. Some residual natural abutments may be still kept in place to support a second provisional FDP which will have mixed support. This procedure prevents implant overloading (Fig 1d).
5. **Loading of the second-stage implants.** After healing of the newly placed implants, the remaining teeth are extracted. Abutments are connected, and the patient is ready for the last treatment step (Fig 1e).

![Fig 1e Loading of the second-stage implants.](image1)

6. **Definitive prosthetic phase.** Final soft-tissue conditioning is performed and impressions are taken for the final restoration. The definitive abutments may differ in size and type from the ones used for the provisional. A screw-retained or cemented design may be used for either the provisional or the definitive prosthesis (Fig 1f).

![Fig 1f Definitive prosthetic phase.](image2)

The following clinical case illustrates this approach.
**Clinical Situation**

A female patient in good general health, a smoker (20 cigarettes/day) with poor oral hygiene, complained of tooth mobility and difficulty in chewing.

The patient’s primary desire was to receive a “definitive and reliable fixed restoration.” She was also concerned about her long and flaring anteriors, but did not want to have the missing mandibular teeth restored.

At presentation, the patient was wearing a removable partial prosthesis to replace her left central incisor. Her upper canines exhibited class III mobility and had less than one-third of their bony support left (Figs 2 to 6). Teeth 16, 13, 12, 22, 23, and 25 had deep pockets (more than 6 mm).
Figs 2 to 6 Clinical baseline situation: Advanced periodontal disease, flaring, and hypereruption of the anteriors. The upper incisors and canines exhibit class III mobility.

The full-mouth radiographic survey (Fig 7) confirmed the diagnosis of advanced periodontal disease. In the upper arch, the right first molar, the remaining incisors, and the left second premolar had to be extracted (Table 2)
Fig 7 Maxillary radiographic survey. Advanced periodontal bone loss at teeth 16, 13, 12, and 11. The furcation involvement of tooth 24 was discovered clinically. Recurrent caries had been present at tooth 25, extracted by the referring dentist before the first examination.

Table 2 Diagnoses for the residual maxillary teeth.

<table>
<thead>
<tr>
<th>Tooth</th>
<th>17</th>
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<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
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<td>Questionable</td>
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The patient was told that teeth 17, 15, 13, 23, 24, and 27 might support a 14-unit full-arch restoration. The canines exhibited class III mobility and deep pockets that might be treated with periodontal surgery. A conservative approach will include periodontal surgery and a restoration supported by four reliable and two questionable abutments (the upper cuspids).

After considerable discussion, the following treatment plan is accepted by the patient: All maxillary teeth except the second molars were to be extracted and the patient were to be provided with an implant-supported full-arch restoration.

To facilitate a fixed provisional throughout the treatment, a staged approach was proposed.

This approach is based on the concept of selective extraction of some of the remaining teeth, maintaining others and eventually preparing them as abutments for a fixed provisional restoration. Implants may be placed in the edentulous spaces and allowed to heal without loading.

Once osseointegration has occurred, implants may be loaded with the fixed
provisional restoration. Second-stage implant insertion and the remaining extractions can then be performed and the final prosthetic phases implemented.

**Treatment Steps**

The initial periodontal treatment was followed by the first surgical and prosthetic phases. The maxillary incisors, the left premolars, and the right first molar were extracted. The remaining maxillary teeth were prepared as abutments to support a provisional acrylic full-arch restoration (Figs 8 and 9). Table 3 lists the teeth to be extracted during the first stage.

*Fig 8 The provisional acrylic restoration is ready for relining.*

*Fig 9 Occlusal view of the prepared teeth and the empty alveolar sockets before insertion of the provisional restoration.*
At this stage, two second molars, two canines and the right second premolar supported the provisional restoration.

*Table 3 Diagnoses for the teeth to be extracted during the first stage.*

<table>
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<th>Tooth</th>
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<td>Reliable</td>
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<tr>
<td>First extractions</td>
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The patient was ready for implant insertion 6 weeks after the extractions. Oral hygiene had improved, and the mobility of the canines had decreased, probably because of the cross-arch stabilization provided by the provisional restoration (Figs 10 to 12). The extraction sockets were completely filled with soft tissue at this stage. The periodontal tissues had improved, showing no signs of active inflammatory lesions. The early post-extraction implant insertion protocol was used (type 2 according to the 2004 ITI Consensus).

*Figs 10 to 12 Clinical situation 6 weeks after the extractions.*

The panoramic radiograph showed an ideal bone situation regarding
mesiodistal and vertical dimensions, but the extraction sockets exhibited minimal bone fill.

Fig 13 Panoramic radiograph before implant insertion (first stage). The reduced bony support of the premolars is clearly visible, and the extraction sockets do not exhibit complete bone fill.

According to the definitive treatment plan the implants were to be placed symmetrically at the positions of the central incisors, canines, first premolars, and first molars. At this stage, implants were placed only at the positions of the central incisors, first premolars, and first molars.

Fig 14 Occlusal view of implants the inserted in the anterior region and in the upper left quadrant. These implants were submerged.
Placement of the canine implants was postponed because these teeth were retained at this point to support the provisional fixed prosthesis.

Implant surgery was performed with minimal flap elevation. It is considered mandatory to visualize the alveolar crest during surgery, but every attempt was made to minimize the extent of flap elevation. Submerged healing was chosen in the anterior region and in the left posterior quadrants, where some minor bone grafting was performed. Non-submerged healing was used in the upper right quadrant.

Antibiotics (amoxicillin and clavulanic acid, 1 g twice daily) were prescribed for 5 days. The patient was instructed to perform chlorhexidine digluconate mouth rinses twice daily. No chewing restrictions were suggested.

Straumann implants (Ø 4.1 mm) with an SLActive surface were placed in this case.

Soft-tissue healing was examined at suture removal (10 days after surgery; Fig 16) and 2 weeks later (10 weeks after the treatment had started, Fig 17). During this period, the patient was wearing the original fixed provisional restorations, which had been trimmed to allow the tissue to heal undisturbed (Fig 18). No attempt was made at this stage to perform soft tissue conditioning. In this particular case, the patient used the chlorhexidine digluconate mouth rinse excessively, causing tooth staining.
Fig 16 Occlusal view at suture removal, 10 days after implant surgery.

Fig 17 Occlusal view 2 weeks after suture removal. Good soft-tissue maturation.
Fig 18 A tooth-supported provisional fixed restoration was used during healing of the first-stage implants.

The implants were first loaded 5 weeks after insertion of the first-stage implants (11 weeks after the beginning of the treatment). Following exposure of the implant neck in the central incisor area with a punch, abutments for cemented restorations were connected to the implants at the central incisor and first premolar positions. Posterior support was provided at this stage by the second molars, with no need to load the implants at first molar site. The canines were still in place at this point. The provisional restoration was supported by four teeth and four implants during this phase (Fig 19). Conditioning of the soft tissues began at this time.

Fig 19 Occlusal view at loading of the first-stage implants. The provisional restoration used during this stage was the original one, but adjusted so as to be supported by a combination of implants and teeth.

The panoramic radiograph showed the correct positioning of the implants and implant integration (Fig 20).
Fig 20 Panoramic radiograph at the time of loading the first-stage implants (11 weeks after tooth extraction). Correct implant positioning and evident bone-to-implant contact.

The last surgical step was performed during the following week. The canines were extracted, and implants were placed immediately (type 1 procedure according to the 2004 ITI Consensus). Healing caps were inserted to achieve transmucosal healing for the non-loaded implants. Straumann Tapered Effect (TE) implants were used; these have a conical design that reduces the gap between the inner walls of the socket and the implant body. The rationale is that there is no need to graft the defect if the gap between the implant and the bone in an extraction socket is less than 2 mm wide. Using conical implants may simplify the surgical technique.

The panoramic radiograph (Fig 21) showed the implants placed at the canine sites during the last surgical stage. Four implants were loaded at this stage, while the remaining four were left unloaded for undisturbed healing.
The postoperative medication was the same as during the first stage. The patient wanted to postpone the extraction of the right second premolar for another 2 weeks; this final extraction was performed concurrently with the removal of the sutures of the second-stage implants (Fig 22). Soft-tissue conditioning continued during this phase.
Four weeks after the insertion of the last implants (16 weeks after the first implant insertion), the soft tissues had healed, and impressions were taken.

A nice parallelism was seen for the implants inserted in this case, so impressions were taken at implant level for the implants not yet loaded, and at abutment level for the four implants previously loaded (the central incisors and first premolars). It was not necessary to remove the abutments that had been used for the provisional restoration. Snap-on transfers were used for the impression (Fig 23).

![Figure 23: Impressions were taken after soft-tissue maturation. The occlusal view shows the snap-on transfers used (red synOcta at implant level, yellow 4-mm solid abutments for cemented restorations, gray 5.5-mm solid abutments for cemented restorations). Good soft-tissue conditioning was achieved in the pontic area.](image)

Four three-unit bridges were provided for this patient, which facilitated a passive precision fit and should make future maintenance easier. Two single crowns were provided to restore the maxillary second molars. The frameworks were tried in first (Figs 24 and 25).
Fig 24 Occlusal view of the frameworks at try-in showing the definitive prosthetic design: four separate three-unit bridges supported by two implants each. The second molars were restored with two single crowns.

Fig 25 The prosthetic concept facilitated a passive precision fit and should make future maintenance easier.

The healing of soft tissues was deemed acceptable at this stage (18 weeks after insertion of the first-stage implants), finalizing the case for the delivery of the final restoration (Figs 26 and 27).
Fig 26 Occlusal view of the abutments and tissues at the delivery of the final restoration.

Fig 27 Anterior view of the abutments and tissues at the delivery of the final restoration. Soft-tissue conditioning was complete.

The final restoration was delivered to the patient 19 weeks after implant insertion and 25 weeks after the active treatment had started. The emergence profile of the anteriors and the excessive overbite were corrected. The tooth dimensions were considered reasonable. This restoration should be reliable and easy to maintain. If complications occur at a later point, segmental treatment can be provided without having to redo the entire restorative work.
Figs 28a-d The final metal-ceramic restoration.

Fig 29 Panoramic radiograph 18 months after treatment.

Acknowledgments

Laboratory Procedures
Paolo Giovanni – Roma, Italy

6.1.6 Conventional Loading of Eight Implants in the Maxilla
and Final Restoration with a Full-Arch Gold-Ceramic FDP

M. Chiapasco

A 35-year-old Caucasian female presenting with advanced periodontal disease involving both the maxillary and the mandibular dentition was referred for evaluation.

The patient, a non-smoker in good general health, requested treatment for recurrent periodontal abscesses, tooth mobility, and discomfort during chewing, as well as restoration of her missing teeth with a fixed prosthesis to improve mastication and esthetics.

All residual maxillary teeth exhibited plaque deposits, deep pockets, bleeding on probing, and class III mobility and were evaluated as hopeless. All residual mandibular teeth except tooth 37 could be maintained after periodontal therapy (Figs 1a-b).

*Fig 1a Initial clinical situation.*
The preliminary treatment plan included extraction of the residual maxillary teeth and of tooth 37, temporary rehabilitation of the maxilla by means of a removable denture, and treatment of periodontal disease affecting the residual mandibular teeth.

An intraoral examination following tooth extraction (Fig 2) and initial panoramic radiograph demonstrated severe atrophy of the maxillary alveolar ridge in association with expanded maxillary sinuses. A CT scan was taken to evaluate the residual bone volume in consideration of an implant-supported rehabilitation.
A CT scan confirmed a severe three-dimensional atrophy of the maxillary arch. The relevant horizontal and vertical resorption in association with expanded sinuses (less than 3 mm of ridge width throughout the entire arch and less than 2 mm of ridge height in the posterior maxilla) rendered the placement of implants impossible (Figs 3a-c).

Figs 3 a-c The traditional and 3-D CT scans confirmed the severe resorption of the alveolar ridge, which is incompatible with implant placement either in the anterior and posterior maxilla.

As the patient refused any kind of removable prosthetic rehabilitation, the treatment plan provided for a fixed implant-supported prosthesis. To plan for a prosthetically driven bone reconstruction, a wax-up was prepared on the plaster casts and a preoperative template defining the ideal position of the future maxillary dentition was created (Figs 4a-b).
Figs 4a-b Preoperative planning: A preoperative template that 
highlights the vertical and horizontal discrepancies was created to guide 
the reconstruction of the bone.

The relevant vertical and horizontal discrepancies, the presence of expanded sinus cavities, and the insufficient bone volume directed the treatment toward a three-dimensional reconstruction by means of onlay and inlay autologous bone grafts taken from extraoral sites. This solution allows the recreation of proper intermaxillary relationships and adequate bone volume for implant placement according to a prosthetically driven planning. Treatment planning also included the rehabilitation of the mandible using new tooth-supported prostheses and the replacement of teeth 36 and 37 by implants.

The reconstruction was performed under general anesthesia, with a combination of bone grafts taken from the calvarial bone and the anterior iliac crest (Fig 5). Accurate shaping and fixation of the bone blocks was realized to guarantee a maximum contact area between the transplanted bone and the receiving site (Figs 6a-c). Tension-free suturing of the flaps was also essential for uneventful healing (Fig 7).
Fig 5 Bone harvesting from the calvarial bone.
Figs 6a-c Bone blocks harvested from the calvarial bone and from the
iliac crest were progressively assembled and secured in place with screws to recreate adequate bone volume.

Fig 7 Tension-free suturing after releasing the periosteum was essential for uneventful healing.

A new panoramic radiograph and CT were taken after the bone reconstruction (Figs 8 and 9)

Fig 8 Postoperative panoramic radiograph showing the three-dimensional reconstruction of the maxilla.
The patient was not allowed to wear a removable prosthesis during the first 8 weeks postoperatively; at the end of this period, a new temporary prosthesis relined with soft material was inserted.

Following uneventful healing, impressions were taken and a surgical template was obtained from a wax-up five months later, based on the new anatomical situation. The template included twelve teeth with Ø 3-mm holes to guide the burs for implant site preparation. Although a maximum of eight implants was planned, all the teeth in the template were prepared with drilling holes to allow the choice of the best site for implant placement in the reconstructed maxilla.

Following the template, eight Straumann implants (Regular Neck, Standard Plus, Ø 4.1 mm and 3.3 mm) were placed in the maxilla and left to heal submerged. The implants were placed at sites 16, 14, 13 12, 22, 24, 25, and 26 (Figs 10 and 11).
Figs 10a-c After 5 months of healing, reentry was performed and implants were positioned in a prosthetically driven way following the indications of a surgical template.

Fig 11 The panoramic radiograph after implant placement demonstrated the proper distribution of the implants.

After 3 months, the implants were exposed, 4.5 mm transmucosal healing caps were connected, and the lack of keratinized mucosa on the buccal aspect
was corrected using a wide split-thickness flap transposed from the palatal to the buccal side (Figs 12a-b).

**Figs 12a-b** After an additional 3 months of healing, the implants were uncovered, and transmucosal healing abutments were positioned.

After a further healing period of three weeks (Fig 13), a screw-retained temporary fixed prosthesis was inserted in the maxilla. Provisionalization was also performed in the lower arch to define a new correct occlusion plan (Fig 14). A temporary fixed prosthesis is important in patients with bone grafts as it allows the gradual loading of the transplanted bone. Esthetics and phonetics can also be verified during the provisionalization phase, and requests for changes from the patient can be recorded.

**Fig 13** Healing status of the soft tissues 3 weeks after reentry, immediately before taking the impression.
Fig 14 Clinical view of the temporary screw-retained fixed rehabilitation. Temporary bridges supported by natural abutments were also placed in the mandible to recreate a correct occlusion.

After 3 months of provisionalization, the final prosthetic rehabilitation was started. Eight synOcta straight and 15° angled abutments were selected to support a one-piece cemented framework. Auro-galvanic copings were utilized as intermediate elements between the implant abutments and the gold-ceramic framework, in order to achieve a complete passive fit. Gold copings were bonded to the framework with a dual-curing cement, and the framework including the auro-galvanic copings was bonded to the implant abutment with a temporary cement (Figs 15a-c).
Figs 15a-c Definitive synOcta abutments were screwed onto the implants. Auro-galvanic copings were used as intermediate elements between the implant abutments and the bridge to obtain a passive fit. The one-piece gold ceramic bridge is ready to be delivered.

Definitive tooth- and implant-supported bridges were also inserted in the mandible (Figs 16a-b and 17).

Fig 16a Clinical view of the final rehabilitation.
Follow-up visits and professional oral hygiene were scheduled every 4 months and a radiographic control once a year (Figs 18a-b).
Fig 18a Clinical view 3 years postoperatively.

Fig 18b Radiographic view 3 years postoperatively.

Acknowledgments

Prosthetic Procedures
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Laboratory Procedures
Sandro Bertoglio and Gianni Zibetti – Busto Arsizio, Varese, Italy

6.2 Immediate Loading

6.2.1 Immediate Loading of Two Implants in the Mandible and Final Restoration with a Bar-Supported RDP

G.T. Stoker
A 56-year-old female patient was referred to the clinic because of retention problems with her mandibular denture. She had been completely edentulous for more than 33 years and wore her sixth set of complete conventional dentures, which had been delivered 5 years previously. An oral surgeon had performed a vestibuloplasty in the interforaminal region of the mandible with a piece of skin tissue 12 years earlier.

The panoramic radiograph (Fig 1) and lateral cephalometric radiograph (Fig 2) exhibited the hypotrophy of the inferior alveolar process. The mandible was a Cawood class VI, and the height of the mandible in the interforaminal zone was 15 mm.

Fig 1 Panoramic radiograph, baseline situation.
In the mandible, there was only a narrow zone of attached mucosa and less retention for a conventional denture (Fig 3).
The treatment plan included the installation of two implants interconnected with a bar and loaded the same day as the final mandibular overdenture. In the maxilla, a complete conventional denture was indicated. To realize immediate loading and function of the two intended implants, a mandibular denture had to be made ahead of the surgical stage. The complete maxillary and mandibular dentures were made according to a standardized protocol, which yielded an optimal fit and balanced occlusion and articulation. Before implant insertion, the newly manufactured denture was checked in terms of fit, esthetics, speech, occlusion, and articulation. The patient did not wear this new denture before the surgical stage.

Before the surgical procedure, the mandibular denture was prepared by making two bores in the denture marking the desired positions of the implants. For this purpose, the location of the implants was established according to the position of the contact point between the lateral incisor and the canine. The perforations were made with a round bur (Ø 2 mm) starting at the deepest point of the mucosal site of the mandibular denture (Fig 5) and in a direction perpendicular to the occlusal plane (Fig 6). Figs 7 and 8 show the mucosal and occlusal aspects of the mandibular denture as a surgical guide.
Fig 5 Perforations starting at the deepest point of the mucosal site.

Fig 6 Proceeding in a direction perpendicular to the occlusal plane.

Fig 7 Mucosal aspect of the mandibular denture as a surgical guide.
The patient had an appointment early in the morning to provide sufficient time for the laboratory to carry out the technical part, i.e. soldering the bar and clip mount in the mandibular denture. Fig 9 shows the hypotrophism of the inferior alveolar process.

Local anesthesia was performed in the interforaminal zone. The mandibular denture was fitted in the mouth of the patient and secured in place by bilateral finger pressure. Through the holes in the denture, two transmucosal center points were drilled in the mandibular bone to a depth of 2 mm using a round bur (Figs 10a-c).
Figs 10a-c Creating transmucosal center points.
After the denture was removed, the mucosal perforations were visible (Fig 11), and a conventional surgical procedure was started with an incision over the crest of the process and elevation of the mucoperiostal flap.

![Fig 11 Visible mucosal perforations after removing the denture.]

The center points were visible in the crest of the bone (Fig 12).

![Fig 12 Center points in the crest of the bone.]

If necessary, the surgeon should angle the implant osteotomies so that any undercut of the mandible are taken into account, but the positions where the implants emerge are determined by the center points (Fig 13).
Two Straumann SLActive Standard RN implants (Ø 4.1 mm, length 12 mm) were inserted and tightened to a torque of at least 35 Ncm (Fig 14).

Directly after the implant placement, 1.5-mm synOcta abutments were inserted and tightened to a torque of 25 Ncm (Figs 15 and 16). The wound was closed and sutured with Seralon 5-0.
Impression caps were placed on the abutment for the impression taken with the mandibular denture as a tray (Fig 17).
The abutments and impression caps were sterilized for use during the surgical stage. The position holes in the mandibular denture were enlarged on the mucosal side to afford sufficient space for the implant impression caps (Fig 18).

The denture was checked in the mouth for unwanted interference with the impression caps (Fig 19).
Fig 19 Checking for interferences intraorally

An impression was taken with the mandibular denture and the new maxillary denture in full occlusion, as in a rebasing technique (Figs 20 to 22).

Fig 20 Injecting the impression compound around the impression caps.
Fig 21 The mandibular denture serves as an impression tray. Finally, protective caps were placed on top of the abutments and the patient was sent home.

Fig 22 Protective caps on both abutments.

The impression was sent to the dental laboratory, where the ovoid Dolder bar was soldered and the retention clip mounted in the mandibular denture. Rebasing was also performed. The retention clip had standard activation (Figs 23 and 24).
The patient returned later on the same day, and the bar, the mandibular overdenture, and the maxillary denture were delivered (Figs 25 to 27).
Fig 25 Dolder bar in situ.

Fig 26 Full frontal view.

Fig 27 Patient’s smile after delivery.
The patient was instructed not to remove her overdenture the first night. She was permitted to eat with the overdenture in place, but advised to avoid biting hard food for the first two weeks. No further instructions were given. The next day, the patient appeared for another visit, and the overdenture was taken out to rinse and clean her mouth with water. The patient was instructed on how to remove and replace the mandibular overdenture. She was instructed to rinse 4 times a day with a 0.12% chlorhexidine digluconate solution for 5 days. The sutures were removed 2 weeks after surgery, and a postoperative panoramic radiograph was taken (Fig 28).

![Postoperative panoramic radiograph](image)

*Fig 28 Postoperative panoramic radiograph.*

Check-ups were scheduled for 3 months after surgery and overdenture placement and yearly from then on. The panoramic radiograph at the 2-year follow-up demonstrated well-integrated implants and stable peri-implant bone conditions (Fig 29).
Fig 29 Panoramic radiograph, 2-year follow-up.

Acknowledgments

Prosthetic Procedures
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Laboratory Procedures
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6.2.2 Immediate Loading of Four Implants in the Mandible and Final Restoration with a Full-Arch Metal Framework FDP

P. Tortamano, M.S. Bello-Silva, L.O.A. Camargo

A fully edentulous 65-year-old woman was referred to our clinic for esthetic and functional dental rehabilitation.

The patient presented with inadequate complete maxillary and mandibular prostheses, insufficient vertical dimension, and extensive tooth wear. The clinical examination and anamnesis showed no local or systemic contraindications, no signs or symptoms of bruxism, and an absence of smoking habits. The treatment proposed was implant placement in the mandibular interforaminal area and immediate loading with a fixed definitive prosthesis. A removable mucosa-supported complete prosthesis was indicated for the upper jaw, since its bone structure offered satisfactory retention and
the financial condition of the patient disfavored a full-mouth implant-supported rehabilitation (Fig 1).

![Fig 1 Baseline clinical status. Fully edentulous jaws in need of esthetic and functional rehabilitation.](image)

**Preoperative procedures**

Preparatory procedures were conducted before surgery to establish the patient’s functional characteristics for the fabrication of the prosthesis. A denture tooth set-up (Trilux, Dental Vipi, Pirassununga, Brazil) on a polypropylene base (Bio Art, São Carlos, Brazil) was fabricated using a semiadjustable Whip-Mix articulator (Bio Art), and all the conventional steps for the preparation of a complete denture were followed (Fig 2). The patient’s functional parameters, such as the centric relation, vertical dimension, shade, alignment, and position of the artificial teeth, compensation curves, and occlusal scheme, were recorded. The same criteria were adopted for the arrangement of the conventional upper complete denture. The set-ups were tried in the mouth to confirm the esthetic, functional, and phonetic parameters (Fig 3).
The mandibular trial denture was duplicated in acrylic resin for use as a surgical template. The maxillary prosthesis was replaced by a plaster cast (Herodent, Vigodent, Rio de Janeiro, Brazil), over which a polymerized condensation silicone base (Zetalabor, Zhermack, Badia Polesine, Italy) was placed. The silicone impression registered the form and position of the mandibular teeth, as well as the vertical dimension of occlusion (VDO). This impression was obtained by closing the articulator with the nonpolymerized silicone against the mandibular teeth until the preestablished vertical dimension retained by the incisal guide pin was obtained.
Implant Placement

The patient received 500 mg of amoxicillin (Amoxil, Glaxo-SmithKline, London, United Kingdom) and 50 mg of rofecoxib (Vioxx, Merck, Whitehouse Station, USA) 12 hours before surgery. Surgical procedures were performed under local anesthesia. Four Straumann Standard implants (Ø 4.1 mm, length 10 mm, Regular Neck prosthetic platform 4.8 mm) were placed in the interforaminal areas with the aid of the surgical template (Figs 4 to 6). This area presents higher success rates in both immediate- and delayed-loading situations, which is attributed to bone quality in this region. The initial stability of each implant was measured with the Periotest instrument (Siemens, Bensheim, Germany).

Fig 4 Incision of the mandibular mucosa.

Fig 5 The surgical template in the mouth, guiding the drilling for
final implant placement.

Fig 6a Labial/buccal view of the four implants in the mandibular interforaminal area.

Fig 6b Incisal/occlusal view of the four implants in the mandibular interforaminal area.

**Final Impression**

When initial stability was attained, an impression was taken and the master cast was obtained. Impression copings were connected with chemically activated acrylic resin (Pattern Resin, GC America, Alsip, IL, USA). After polymerization, the resin connectors union was sectioned in the area between the implants and re-joined with the same resin to compensate for the tension induced by the shrinkage of the material (Fig 7).
Impression copings screwed onto the implants, connected by acrylic resin and dental floss. The resin connectors union was sectioned between the implants to compensate for shrinkage.

The denture teeth and the polypropylene base in the implant region were removed from the mandibular prosthesis to expose the impression copings connected by resin (Fig 8). The incisal portions of the teeth were retained to ensure stability. The assembly was seated over the alveolar ridge and positioned without any interference from the base in relation to the impression copings. Condensation-polymerized wash silicone (Xantopren, Heraeus Kulzer, Hanau, Germany) was injected under the resin-connected impression copings, and more of the same silicone was inserted into the inner part of the polypropylene base, which acted as a custom impression tray (Fig 9).
positioned in the mouth to check for interference.

Fig 9 The functional impression of the ridge and implants, retaining the preestablished maxillomandibular relationship.

The denture base/tray containing the impression material was placed onto the ridge, ensuring that no interference occurred between the impression copings and the tray. The patient was asked to keep the teeth seated in the preestablished contact position and to maintain this position until the impression material had polymerized. The impression copings were then disconnected from the implants, and the impression was removed from the mouth. Implant analogs were screwed onto the impression copings, and a Velmix type IV plaster (Kerr, Orange, CA, USA) was poured to obtain the master cast (Fig 10). The master cast was seated against a maxillary plaster and silicone cast and maintained in position with wooden sticks attached to the casts with sticky wax. The set was then mounted to the lower arm of the articulator (Fig 11).
Fig 10a Impression ready for connecting implant analogs prior to pouring the master cast.

Fig 10b Impression still on poured master cast.
Fig 11 The master cast mounted on the lower arm of the articulator, guided by the maxillary plaster and silicone cast.

**Final Prosthesis**

The entire base was removed from the master cast, and the mandibular artificial teeth were seated in the plaster/silicone cast, facilitating the wax-up of the metal framework (Fig 12). The framework was cast and seated on the master cast, then tried in intraorally to verify its alignment (Fig 13).

Fig 12 Mandibular denture teeth connected to the plaster/silicone cast, guiding the metallic framework wax-up.

Fig 13 Metal framework seated in the mouth. Good fit on the implants.

All mandibular denture teeth connected to the plaster/silicone cast were
arranged on the framework and attached with wax (Fig 14). The maxillary trial denture and mandibular framework with the attached teeth were seated in the mouth. After occlusal contacts, VDO, and esthetics were confirmed, a functional impression of the maxillary arch was taken. The definitive maxillary and mandibular prostheses were fabricated and placed within 48 hours of surgery (Fig 15).

*Fig 14 Mandibular denture teeth seated on the framework, facilitated by a maxillary plaster/silicone cast.*

*Figs 15a-b Definitive prostheses seated in the mouth.*

After 10 days, the sutures were removed without dislocating the prosthesis. After 90 days, the mandibular prosthesis was removed, so that torque could be applied to the abutments as suggested by the manufacturer (Fig 16).
Fig 16 Clinical status of the implants 90 days after application of the load.

**Post-Treatment Follow-up**

At subsequent monthly clinical examinations, the prosthesis was removed to ascertain the absence of implant mobility, pain, foreign-body sensations/dysesthesia, peri-implant bleeding, and infection with suppuration of the implanted area. At 6, 12, and 24 months, regular radiographs were obtained to verify radiolucent areas around the implants (Figs 17a-c).

Figs 17a-c Radiographs 24 months after implant placement.

After 3 months, there was no loss of implants (survival rate: 100%). There were no signs or symptoms of pain, peri-implant infection, or inflammation, with or without suppuration, at any follow-up session, with the exception of the immediate postsurgical period, during which mild edema and inflammation were observed. None of the four implants presented bone loss after 24 months; thus, the success rate obtained was 100%. The integrity of the prostheses and their components was also observed during the follow-up
period.

The success of the present technique is thought to be related to its careful execution. As with prostheses used in the delayed-loading procedures, immediately loaded prostheses must offer a maximum of passive fit, adequate occlusal clearance, and a rigid framework that reduces physical challenges to the bone tissue, especially during the implant-healing phase. Moreover, these prostheses must not neglect important requirements for the rehabilitation of a completely edentulous patient, such as esthetics, centric relation, VDO, and lip support.

The present technique establishes and clinically verifies functional prosthetic parameters, such as vertical dimension, centric relation, tooth position, and esthetics, before implant placement. These recordings are transferred to the definitive prosthesis with accuracy and reliability. Another advantage is that the opposing arch may include natural teeth, a complete prosthesis, or a partial fixed prosthesis.

The follow-up of other cases in which the present technique was conducted indicates that immediate loading of prostheses supported by four implants in the anterior mandibular area provides safe, quick, and predictable restorations while meeting all the requirements for an appropriate definitive fixed rehabilitation.

**Acknowledgments**

**Restorative Procedures**
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**Laboratory Procedures**
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**6.2.3 Immediate Loading of Six Implants in the Maxilla and Final Restoration with a Full-Arch Gold/Ceramic FDP Involving the Concept of Tilted Implants**

**P. Casentini**

A 61-year-old male patient with a failing fixed maxillary rehabilitation and a fixed mandibular rehabilitation requested a new fixed maxillary
rehabilitation.

The patient was wearing a temporary metal-reinforced maxillary bridge inserted two years before the consultation. He reported that his previous dentist did not want to insert a definitive framework because he considered the residual teeth to have a negative prognosis. The patient reported a history of recurrent caries and endodontic complications as the main reason for the previous extractions. The anamnesis was negative for periodontal disease and bruxism.

The patient’s chief compliant was the mobility of his maxillary prosthesis, which needed to be re-cemented frequently, and discomfort during chewing. Moreover, the patient was not satisfied with the esthetic appearance of his maxillary teeth, which he found too long. The patient asked for a stable and comfortable fixed maxillary rehabilitation and firmly rejected any removable solution.

The patient was free of systemic diseases, was not on any regular medication, and did not smoke.

The extraoral examination revealed a normal physiognomy and a low lip line. A wide horizontal tooth display was present, and missing molars were evident during smiling (Fig 1).

![Fig 1 Baseline situation with a wide horizontal tooth display.](image)

Intraoral examination showed a metal-reinforced temporary maxillary bridge with distal cantilevers, supported by natural abutments at sites 13, 12, 23, and 24, which exhibited class II mobility. The shape of the teeth in the temporary
bridge was found to be unsatisfactory, and their length was excessive (Fig 2). The bridge was removed to evaluate the actual prognosis of the residual maxillary abutments (Fig 3). All the abutments revealed degree III mobility and secondary caries and were evaluated as hopeless.

![Fig 2 Unsatisfactory bridge with excessive crown length.](image)

In the mandible there was an metal-reinforced temporary anterior bridge supported by natural abutments 43, 31, 32, and 33. The fourth quadrant contained a gold/resin bridge connecting supported by abutments 44, 45, and 48. Tooth 48 presented secondary caries, and its prognosis was considered poor. In the third quadrant, a temporary bridge was supported by two Straumann RN implants at sites 34 and 36, inserted one year before consultation. No significant periodontal pockets were present at any site, and
the prognoses of all mandibular abutments except tooth 48 were favorable. Oral hygiene was satisfactory, but some plaque and supragingival calculus were present at consultation. The intermaxillary relationship was considered favorable, and no mucosal pathology was diagnosed. The patient’s esthetic expectations were evaluated as realistic.

The patient provided a recently taken CT scan showing a sufficient bone quantity in terms of height and width from the right canine area to the left first premolar area. In the distal sections of the maxillary bone, the volume for implant placement was adequate in width but not in height due to pneumatized and healthy maxillary sinuses (Figs 4a-e).
Figs 4a-e Preoperative diagnostic CT scans showing no pathological findings.

Since the patient rejected any removable restoration, two treatment options were proposed:

**Option I:** A fixed maxillary prosthesis supported by six to eight implants inserted after bilateral maxillary sinus floor elevation and grafting of the sinuses using a lateral window technique. In this case, due to the longer treatment time, a removable temporary prosthesis would have to be used,
since the residual natural teeth could not be preserved.

**Option II:** Placement of six implants and immediate loading with a fixed screw-retained temporary prosthesis, in case of adequate primary stability. Implants were planned in position 13 and 23 (post-extraction), 11 and 21 (healed sites) and 14/15 and 24/25 (distally tilted). After osseointegration, definitive rehabilitation with an implant-supported fixed prosthesis, including distal cantilevers extended to the first molar.

The patient selected option II as the more favorable one, since it would let him avoid the removable prosthesis; he was also attracted by the possibility of avoiding more invasive staged and time-consuming surgical procedures.

The patient was informed that a certain level of esthetic compromises was unavoidable, as the rehabilitation would probably result in longer teeth. He gave his informed written consent.

Immediate loading was planned following the pick-up technique, but the technique was slightly modified in that six implants instead of eight were considered adequate in this case and the distal implants were tilted distally, following the inclination of the anterior wall of the maxillary sinus to provide better distal support. Since implants of an adequate diameter and length could be used, six implants were considered sufficient to support a fixed prosthesis.

After mounting the diagnostic casts in an articulator, a wax-up was realized for all teeth between the second premolars, and a provisional template was subsequently obtained to serve as a surgical stent and subsequently to represent the base for realizing the screw-retained temporary bridge. A wide-base support on the palate and in the maxillary tuberosity region were provided to stabilize the template (Fig 5). Distally tilted implants were included in the design of the provisional template.
Following the administration of local anesthesia, a full-thickness flap was elevated in the maxilla with an intrasulcular and a mid-crestal incision extended from the midline to the first molar region. Releasing incisions were added at midline and at the distal extremities of the flap. Residual maxillary teeth were extracted and the implant sites prepared following the provisional template (Figs 6a-b). Implant osteotomies at the post-extraction sockets were realized through the palatal wall, avoiding any contact with the buccal walls of the sockets. A small window in the lateral wall of the maxillary sinus allowed for the probing the anterior sinus wall and was useful in preparing the distally tilted implant sites (Figs 7a-b).
Figs 6a-b Implant sites prepared using the provisional template.

Figs 7a-b A small window for probing the anterior sinus wall was useful in preparing the distally tilted implant sites.

Six Straumann Tapered Effect (TE) SLActive implants were placed. Two
were inserted at sites 11 and 21 (Ø 4.1 mm, length 12 mm; Figs 8a-b). At site 12, a smaller TE implant (Ø 3.3 mm, length 12 mm) was used to avoid fenestration of the buccal socket wall. At sites 15 and 25, two longer TE implants (Ø 3.3 mm, length 14 mm) were used.

Fig 8a Implants 12 to 14 mm in length.

Fig 8b Tapered implants at the distal sites.

The selection of TE implants was based on the need to achieve adequate primary stability in an immediate-loading protocol including two post-extraction sites in the softer bone of the maxilla. The choice of a highly osteoconductive and rapidly osseointegrating SLActive surface was related to the need to reduce the time for osseointegration and the risk of failure.

The reduced diameter for the apical part of the distal implants was intended
to minimize the risk of implant penetration into the sinus and interference between adjacent implants.

All the implants presented primary stability and an insertion torque above 35 Ncm.

After the temporary synOcta titanium coping (previously sandblasted by the dental lab) had been connected, a filling material (deproteinized bovine bone mineral, DBBM) was used to fill the gap between the buccal wall and the implants at the post-extraction sites and to thicken the buccal wall. The same material was used for a ridge-preservation protocol at sites 13 and 24 and was stabilized with a collagen membrane (Fig 9). Flaps were sutured with a 5-0 polyamide suture (Fig 10).

Fig 9 Stabilizing the DBBM with a collagen membrane.

Fig 10 Flaps sutured with a 5-0 polyamide suture.
The provisional template was then inserted and any contact between the template and the copings was eliminated by widening the occlusal perforations. A correct intermaxillary relationship was registered by bringing the template in centric occlusion with the antagonists, and the soft tissues were insulated with a U-shape piece of rubber dam (Fig 11).

Fig 11 Provisional template in situ before auto-polymerizing resin insection.

The access holes for the screws of the titanium copings were sealed with cotton, and autopolymerizing resin was injected to connect the template and the titanium copings.

After polymerization, the copings were unscrewed, and the template, including the copings, was sent to the dental lab for refinement.

Healing abutments were screwed onto the implants using light manual force, and the patient was discharged from the dental office.

The next day, the temporary screw-retained bridge was delivered to the patient after application of a chlorhexidine digluconate gel. Internal connection cylinders of synOcta copings were partially reduced by the dental technician in order to allow complete seating of the bridge (Figs 12 a-b).
Figs 12a-b Temporary screw-retained bridge before delivery with modified internal connection cylinders of the synOcta copings.

Moderate swelling was present, but the patient reported no significant pain, and the temporary restoration was delivered without complications. The occlusion was carefully checked to obtain uniform and well-distributed contacts with the opposite arch (Figs 13a-b).

Fig 13a Immediately loaded bridge after delivery.
Fig 13b Checking the occlusion of the temporary restoration.

The patient was satisfied with the esthetic appearance of the temporary rehabilitation (Fig 14). A panoramic radiograph confirmed the correct fit of the temporary prosthesis (Fig 15).

Fig 14 Satisfactory appearance of the provisional.
The patient received postoperative instructions. An antibiotic was prescribed for 6 days post-operatively and chlorhexidine digluconate mouth rinses for 14 days post-operatively. A soft diet was prescribed for the first 4 weeks after loading.

After 6 weeks of healing, the peri-implant soft tissues showed no signs of inflammation. The temporary restoration was removed, and osseointegration was confirmed by the percussion of the implants. A preliminary impression was taken to realize a customized open tray for the definitive impression.

The definitive rehabilitation process started 8 weeks after loading. Six screw-retained synOcta impression posts were connected to the implants and an open-tray impression with a polyether material was taken at the first prosthetic visit (Figs 16a-b).
Since the vertical dimension and other occlusion parameters of the temporary rehabilitation were found to be correct, the temporary bridge was used as a reference to register the intermaxillary relationships. At the second prosthetic visit, the temporary bridge was sectioned at the midline, and the intermaxillary relationships were recorded with the aid of a resin jig prepared by the dental lab. These devices were constructed utilizing Straumann bite-registration aids that assured precise positioning and were relined with a small quantity of autopolymerizing resin (Figs 17a-b). In the same prosthetic visit, a facebow recording was made (Figs 18a-b).
A wax-up of the definitive rehabilitation was checked at the third prosthetic visit. The smile line, esthetic appearance, support of facial tissues, phonetics, and correct 3-D position of the occlusal plane were verified (Figs 19a-b). At this stage it was decided to slightly reduce the length of the anterior teeth, since a certain reduction of the overbite was considered possible and appropriate.
Based on the wax-up, the dental technician selected four standard synOcta abutments for the anterior implants and fabricated two customized gold abutments (screwed on top of two synOcta 1.5-mm abutments; Figs 20a-b) for a cemented framework. The dental lab also prepared six auro-galvanic copings and the definitive gold framework segmented three ways for try-in during the following prosthetic visit. Auro-galvanic copings were created as intermediary elements between the implant abutments and the metal framework to achieve a completely passive fit. A tolerance gap between the auro-galvanic copings and the framework was created to allow for a complete and passive framework fit.

Fig 20a Four standard synOcta abutments.

Fig 20b Two customized gold abutments screwed on top of two synOcta 1.5-mm abutments.
At the fourth prosthetic visit, the implant abutments were screwed onto the implants, the auro-galvanic copings were positioned on them, and the gold framework was tried in for precision and passive fit (Figs 21a-c).

Fig 21a The implant abutments attached to the implants.

Fig 21b Auro-galvanic copings in place.
The biscuit try-in of the gold ceramic bridge was performed at the fifth prosthetic visit. The shape of the final crowns relative to the smile line and occlusion was also checked.

After complete ceramic veneering and refinement, the final rehabilitation was delivered at the sixth prosthetic visit (Figs 22a-b).

The auro-galvanic copings were sandblasted by the dental lab and bonded inside the framework directly in the oral cavity with a dual-curing cement (Figs 22c-d).
The titanium abutments were definitively inserted at a controlled torque of 35 Ncm. The bridge, including the auro-galvanic copings, was then cemented onto the implant abutments with a temporary cement, and final occlusal adjustments were performed (Figs 23a-c).
Figs 23a-c The definitive restoration after temporary cementing.

The precision of the framework was checked radiographically (Fig 24a-c).

Accurate maintenance instructions, including the use of a Super-Floss (Oral-B), were given to the patient.

Follow-up visits and professional oral hygiene were scheduled every 4 months and a radiographic control once a year.

At the 24-month follow-up visit, the peri-implant soft tissues showed no
signs of inflammation, and no significant bone resorption was present around the implants (Figs 25a-b). The patient was fully satisfied with the esthetics and function of his implant-supported rehabilitation.

Fig 25a At 24 months, the peri-implant soft tissues showed no signs of inflammation.

Fig 25b The radiograph at 18 months indicated no significant bone resorption around the implants.

Acknowledgments

Laboratory Procedures
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6.2.4 Immediate Loading of Six Implants in the Maxilla and
A 63-year-old male patient was referred for a consultation and treatment of partial edentulism in the maxilla.

The patient presented with residual anterior teeth and declined a partial removable prosthesis. He reported that the maxillary posterior teeth had been extracted due to mobility and periodontal disease two months before the consultation.

The patient’s chief complaint was that his residual maxillary teeth were mobile and that he was unable to chew. The patient’s desire was a stable and comfortable fixed maxillary rehabilitation.

The patient was a light smoker (fewer than 10 cigarettes/day), and his medical history was without significant findings. He was not on any regular medication at the time of consultation.

The extraoral examination revealed a normal physiognomy with a correct distribution of the facial thirds. The patient presented a low lip line, and the transition line between teeth and soft tissues was not exposed during a forced smile.

The intraoral examination showed the presence of residual teeth 13, 12, 11, 21, and 23 in the maxilla. Teeth 21 and 23 were connected by a fixed partial prosthesis with a one-unit distal cantilever. All residual maxillary teeth except tooth 13 showed significant mobility, recession of the soft tissues with exposure of the cementoenamel junction and an interproximal probing depth of more than 6 mm.

In the mandible, teeth 48, 44, 43, 42, 32, 34, 35, and 37 were present. Teeth 43, 42, 33, 35, and 37 were connected by two fixed partial prostheses. The residual mandibular teeth showed no significant mobility, with the exception of tooth 48. The probing depths of the mandibular residual teeth were less than 4 mm, except at tooth 48, which presented a complete furcation involvement.

The intermaxillary relationship was favorable, and no pathology of the mucosa was diagnosed (Fig 1).
The patient provided a panoramic radiograph showing the situation before the extraction of the posterior maxillary teeth (Fig 2).

The preliminary treatment plan included initial cause-related periodontal therapy with scaling and root planing to remove plaque and calculus deposits and to improve the patient’s level of oral hygiene. A maxillary CT scan was then taken after the patient had been provided with a diagnostic stent including radiopaque markers. The CT revealed adequate bone volume in terms of height and width to place implants with a minimum length of 10 mm and a diameter of 4.8 mm up to the site of the first molar (Fig 3).
After the initial cause-related periodontal therapy, the patient was reevaluated. The level of oral hygiene was considered adequate, but mobility and probing depths at the residual maxillary teeth did not show any significant improvement.

Several treatment options were discussed with the patient, which included:

**Option I:** Extraction of the residual maxillary teeth, an interim removable prosthesis, and subsequent placement of four to six implants for an implant-supported overdenture.

**Option II:** Periodontal therapy and an attempt to rescue teeth 13 and 12 (all other maxillary teeth exhibited class III mobility and were considered hopeless), a removable temporary prosthesis, and subsequent implant treatment in the edentulous segments (two implants at sites 14 and 16 to support a three-unit bridge and four implants at sites 11, 23, 24, and 26 to support a segmented or one-piece bridge).

**Option III:** Removal of the residual maxillary teeth, immediate placement of six implants at sites 16, 14, 13, 23, 24, and 26, and immediate loading by means of a fixed temporary prosthesis. After osseointegration, definitive rehabilitation with an implant-supported fixed prosthesis.

The patient selected option III, because it was the only one that avoided a removable prosthesis (which he vehemently rejected even for a short period). The patient gave his informed written consent to this treatment.

Immediate loading was planned following the pick-up technique, but the technique was slightly modified in that six implants instead of eight were considered adequate in this case. That the patient had no history of bruxism was also taken into consideration. The decision to avoid implant placement in the central incisor region was also useful in terms of promoting soft-tissue

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**Fig 3 Preoperative diagnostic CT scan.**
conditioning in this very critical area. Finally, mesiodistal space management and distribution between the four incisors were considered easier to perform, taking into account the migration of tooth 11 and the presence of a diastema between teeth 11 and 12.

After mounting the diagnostic casts in an articulator, a wax-up was realized for all teeth between the two first molars, and a provisional template was subsequently obtained from the wax-up. The provisional template functioned as a surgical guide during surgery and represented the base for realizing the temporary screw-retained bridge. A wide-base support on the palate and in the maxillary tuberosity region were provided to stabilize the template (Figs 4a-b).

Following the administration of local anesthesia, the residual maxillary teeth were extracted and the provisional template was used as a surgical stent to guide implant placement (Fig 5).
Since the canines’ alveolar sockets presented no fenestrations or dehisences of the buccal wall and all the other implants were inserted in healed sites with crest widths of more than 8 to 10 mm, a flapless approach was chosen. Access to the bone crest was obtained by punching with a mucotome (Fig 6). Implant osteotomies at post-extraction sockets were realized through the palatal wall, avoiding any contact with the buccal walls of the sockets.

Six Straumann Tapered Effect (TE) SLActive implants were placed following the standard protocol. At the distal sites, two Ø 4.1-mm TE implants with a length of 10 mm were used; for the four remaining sites, TE implants with a length of 14 mm were used (Fig 7). All the implants presented optimal primary stability and an insertion torque above 35 Ncm.
The choice of TE implants was based on the need to achieve optimal primary stability in an immediate-loading protocol. Based on the clinician’s experience, TE implants in healed sites do not cause any adverse effects and improve primary stability. The choice of using a highly osteoconductive and rapidly osseointegrating SLActive surface was related to the loading protocol. A filling material (deproteinized bovine bone mineral, DBBM) was used to fill the gap between the buccal wall and the implants at the post-extraction sites. The same material was used for a ridge-preservation protocol at sites 12, 11, and 21. The extraction sockets were finally sealed with a collagen sponge stabilized by 5-0 polyamide sutures.

After removal of the inserting devices, six synOcta titanium copings for temporary restorations were screwed onto the implants (Fig 8). The copings had been sandblasted by the dental lab.
Fig 8 synOcta titanium copings for temporary restorations in place.

The provisional template was then inserted and any contact between the template and the copings was eliminated by widening the occlusal perforations. A correct intermaxillary relationship was registered by bringing the template in centric occlusion with the antagonist arch, and the soft tissues were insulated with a U-shape piece of rubber dam.

The access holes for the screws of the titanium copings were sealed with cotton, and autopolymerizing resin was injected to connect the template and the titanium copings (Fig 9).

Fig 9 Template connected to the titanium copings.

After polymerization, the copings were unscrewed, and the template, including the copings, was sent to the laboratory for refinement.

Healing abutments were screwed onto the implants using light manual force, and the patient was discharged from the dental clinic.

The next day, the temporary screw-retained bridge was delivered to the patient after application of a chlorhexidine digluconate gel. Swelling was completely absent, and the patient reported no significant pain. A slight compression of the anterior extraction sockets was obtained by an ovate pontic design (Figs 10a-c).
Figs 10a-c The screw-retained temporary bridge.

The occlusion was carefully checked to obtain uniform and well-distributed contacts with the opposite arch. A panoramic radiograph confirmed the correct adaptation of the temporary prosthesis (Fig 11). The patient received post-operative instructions: an antibiotic was prescribed for 6 days postoperatively and chlorhexidine mouth rinses for 14 days postoperatively. A soft diet was prescribed for the first 4 weeks after loading.

Fig 11 Panoramic radiograph. Correctly adapted temporary prosthesis.
The patient was also recommended to limit his smoking for the duration of the treatment.

After 6 weeks of healing, the peri-implant soft tissues showed no signs of inflammation. The temporary restoration was removed, and osseointegration was confirmed by percussion of the implants. Positive soft-tissue conditioning could be achieved and was optimized by a small gingivectomy performed with a diamond bur after soft-tissue reshaping. The temporary bridge was relined with auto-polymerizing resin and refined (Figs 12 to 14).

Fig 12 Peri-implant soft tissues showing no signs of inflammation.
Figs 13a-b A small gingivectomy performed with a diamond bur.

Fig 14 The temporary bridge back in situ after local relining with
After 4 more weeks, the temporary bridge was again removed and an open-tray impression taken with a poly-ether impression material, using screw-retained synOcta copings (at the first prosthetic visit).

Since the vertical dimension, the inclination of the occlusal plan, and the esthetic appearance of the temporary rehabilitation were found to be correct, the temporary bridge was used to obtain at chairside the correct 3-D position of the master cast in relation to the lower arch. At the second prosthetic visit, the temporary bridge was repositioned and screwed onto the master model (Figs 15 and 16) obtained from the definitive impression, then articulated with the opposite arch. The master model was connected to the articulator with plaster (Fig 17).

Fig 15 Master model based on the definitive impression.
The laboratory created a wax-up for the definitive rehabilitation and then produced six titanium abutments using a CAD/CAM procedure (etkon/Straumann) (Fig 18). A plastic replica of the final framework in six segments was also prepared for verification in the patient’s oral cavity (Fig 19).
At the third prosthetic visit, the titanium abutments were screwed onto the implants (Fig 20), and the segmented try-in framework was positioned on them. A one-piece structure was obtained by connecting different pieces of the resin framework with a low-contraction composite material (Fig 21).
Based on the tested try-in framework, the laboratory created the definitive model used for further CAD/CAM procedures to produce the definitive zirconia bridge (Figs 22a-b).
Figs 22a-b Definitive model used for further CAD/CAM procedures.

After scanning the definitive cast and the resin framework with the etkon scanner, the laboratory sent the CAD data to the etkon milling center and received the zirconia one-piece bridge in return (Figs 23a-b).

Fig 23a The situation that was scanned.
At the fourth prosthetic visit, the temporary bridge was removed, the titanium abutments were screwed in place, and the zirconia framework was tried in (Fig 24); the precision and passive fit were verified clinically and by radiographs, confirming the correct seating of the framework (Figs 25a-b).

At the fifth prosthetic visit, the biscuit try-in was performed, and the precision and passive fit were again tested. The shape of the final crowns relative to the smile line and the occlusion were also checked.

At the sixth prosthetic visit, following completion of ceramic veneering by the laboratory, the final rehabilitation was delivered to the patient (Fig 26).
Titanium abutments were definitively connected at a controlled torque of 35 Ncm. The screw access holes were sealed with gutta-percha, and the definitive rehabilitation was cemented with a temporary cement (Figs 27a-d).

Fig 26 Completed restoration.

Figs 27a-d The finished restoration in situ.

Accurate maintenance instructions, including the use of Super-Floss (Oral-
B), were given to the patient.

Considering the dental history of the patient and his periodontal disease, follow-up visits and professional oral hygiene were scheduled every 3 months and a radiographic control once a year.

At the 18-month follow-up visit, the peri-implant soft tissues showed no signs of inflammation, and no significant bone resorption was present around the implants (Figs 28, 29a-b). The patient reported being fully satisfied with the esthetics and function of his implant-supported rehabilitation.

![Fig 28 At 18 months, the peri-implant soft tissues showed no signs of inflammation.](image)
Figs 29a-b The radiographs at 18 months indicated no significant bone resorption around the implants.

Acknowledgments

Restorative Procedures
Nicolò Gruden – Giussano, Italy

Laboratory Procedures
Marco Cominetti – Milan, Italy
6.2.5 Immediate Loading of Four Implants in the Mandible and Six Implants in the Maxilla and Final Restoration with a Full-Arch Metal Framework FDP and a Full-Arch CAD/CAM Zirconia Framework FDP

P. Casentini

A 65-year-old female patient with a failing residual maxillary dentition and a complete mandibular removable denture was referred for consultation and treatment.

The patient’s chief complaint was that her upper residual teeth were mobile and she was unable to chew. The patient also asked us to improve the esthetic appearance of her smile. The patient’s desire was a stable and comfortable dentition in both jaws, and she specifically asked for a fixed rehabilitation.

The patient reported a history of recurrent caries, endodontic complications, and periodontal disease as main reasons for previous teeth extractions. The anamnesis was negative for bruxism and TMJ disorders. The patient had no systemic diseases, was not on any medication, and did not smoke.

The extraoral examination revealed a medium lip line, a wide diastema between the two central incisors (which, according to the patient, had appeared recently), and a partial collapse of the perioral soft tissues, probably due to loss of the correct vertical dimensions (Figs 1, 3, and 4).
Fig 1 Patient’s smile at baseline with recent diastema.

Fig 2 Intraoral baseline situation.

Fig 3 Anterior view of the lower facial half. Partial collapse of the vertical perioral soft tissues.
The intraoral examination (Fig 2) demonstrated the presence of two metal-ceramic maxillary fixed prostheses involving teeth 11, 12, 14, 15, 16, 17, 21, 22, and 23. The precision of the prosthetic margins of the previous rehabilitation was not considered adequate. Due to pathologic tooth migration, a diastema was present between the two central incisors. Teeth 24 and 25 appeared to have been prepared as natural abutments, but the crowns were no longer present. The two bridges and residual abutments showed advanced mobility, secondary caries, and periodontal pockets.

In the completely edentulous mandible, the patient was wearing a complete denture with insufficient retention and with abrasion of the posterior teeth. The patient used an adhesive paste to increase the retention of the lower denture. A medium to advanced degree of atrophy of the mandibular ridge was diagnosed during palpation. The edentulous ridge presented a regular and rounded profile. The intermaxillary relationship was normal. No pathology of the mucosa was diagnosed. The patient’s esthetic expectations were evaluated as realistic.

At the consultation, the patient presented with an orthopantomograph and a recent CT scan. The former (Fig 5) confirmed advanced loss of periodontal support and the presence of secondary caries. It also demonstrated the presence of a root fracture of tooth 16, periapical pathology at tooth 12, and inadequate endodontic treatment of all residual abutments.
The CT scan (Fig 6) showed a good quantity of bone in height and width from the right maxillary canine to the left second premolar. In the more distal sections of the maxilla, the bone was inadequate for standard implant placement as it had a maximum height of only 6 mm. The CT scan also showed the presence of septa in both the maxillary sinuses and a mucosal cyst in the right maxillary sinus. Bone density was considered normal in the anterior maxilla and reduced in the posterior areas. In the mandible, the CT scan revealed sufficient bone volume to insert implants in the interforaminal region.

**Fig 6 CT scan, baseline situation.**

**Diagnosis and Treatment Planning**

To improve support for perioral tissues and to rebuild the lost vertical dimension were considered the main treatment objective. Taking into account the multiple pathologies and mobility, all maxillary teeth were evaluated as not restorable. A new rehabilitation of both arches was necessary in order to recreate acceptable intra- and extraoral esthetics and function.
Different treatment options were discussed with the patient:

**Option I:** New, more comfortable removable rehabilitation with new complete dentures after the extraction of the residual maxillary teeth. Improved retention of the mandibular denture could then be achieved with an implant-supported overdenture.

**Option II:** Implant-supported maxillary and mandibular overdentures, after the placement of four to six implants in the maxillary intercanine area and two to four implants in the mandibular interforaminal region.

**Option III:** Fixed implant-supported rehabilitation of the maxilla and the mandible. In the maxilla, the residual bone volume would not allow for the standard placement of six implants, and the distal implants would have to be tilted to the inclination of the anterior maxillary sinus wall. In the mandible, a fixed hybrid screw-retained prosthesis supported by four implants with distal cantilevers was proposed as the final rehabilitation.

The patient selected option III because she was attracted by the possibility of a fixed rehabilitation without major reconstructive surgery. Rehabilitation was started in the upper jaw, where the patient felt the greater discomfort. Extraction and simultaneous implant placement was planned in order to reduce treatment time. Once ideal primary implant stability was attained, immediate loading with a temporary fixed prosthesis was planned to improve patient comfort during the healing period and to avoid a removable prosthesis in the maxilla. Implant placement in the mandible was planned in a second stage, and eventually followed by an immediately loaded hybrid fixed prosthesis. The patient gave her informed written consent.

After mounting diagnostic casts in the articulator, a wax-up of the future rehabilitation was realized (Figs 7 and 8) to optimize the shape of the maxillary teeth and eliminating the diastema between the central incisors. Based on the wax-up, a provisional template was obtained to act as a surgical guide; after implant insertion, it could also function as the base for the immediate-loading temporary screw-retained bridge. To guarantee adequate template stability, wide-base support on the palate and at the maxillary tubererosities was provided (Figs 9 and 10).
Fig 7 Maxillary restoration wax-up, anterior view.

Fig 8 Maxillary restoration wax-up, occlusal view.

Fig 9 Provisional restoration/surgical guide, anterior view.
Surgical Procedure and Immediate Loading in the Maxilla

Following administration of local anesthesia, the residual maxillary teeth were extracted and implant sites were prepared following the guidelines of the provisional template at sites 15, 13, 11, 21, 23, and 26 (Figs 11 and 12). A flapless approach was followed in the anterior region of the maxilla, where a more favorable anatomy of the alveolar sockets was present. Implant osteotomies at post-extraction sockets were realized on the palatal side, avoiding any contact with the buccal wall of the socket and excessive buccal inclination.

Fig 11 Extraction of the residual maxillary teeth.
At the posterior sites, a full-thickness flap was elevated in order to guarantee better surgical access to sites where bone defects might be present. The elevation of the flap also allowed for a better detection of the sinus wall and facilitated the choice of inclination of the distal implants. After every drilling procedure, the walls of the distal implant sites were sounded out with a periodontal probe to avoid perforation of the sinus wall. A distal inclination of these implants also permitted more distal prosthetic support and avoided significant distal cantilevers.

Six Straumann Bone Level implants with SLActive surface were placed (Figs 13 and 14). Five Ø 4.1-mm implants and one Ø 4.8-mm implant were selected with lengths between 12 and 14 mm. All implants reached optimal primary stability (insertion torque above 35 Ncm) and were considered suitable for immediate loading.
The choice of bone-level implants was based on surgical and prosthetic considerations; the implant shape with a reduced distance between threads and a slight conical shape was considered ideal in order to reach an optimal primary stability. The use of multibase abutments should easily allow for the compensation of missing parallelism between different implants in order to realize a screw-retained prosthesis. Finally, the choice of a highly osteoconductive and rapidly osseointegrating SLActive surface was also related to the immediate loading protocol. An osteoconductive material (deproteinized bovine bone mineral, DBBM) was used to fill the gap between the buccal wall and the implants at post-extraction sites. The same material was used for ridge preservation at sites 12 and 22. The flaps were finally sutured with a 5-0 poly-amide suture.
After implant placement, six Multibase abutments (Ø 4.5 mm, height 4 mm) were connected to the implants and titanium copings were screwed on top of them (Figs 15 and 16).

![Fig 15 Connecting a multibase abutment.](image1)

The soft tissue was isolated with a U-shaped piece of rubber dam (Fig 17). After seating the temporary template, avoiding contact with the titanium copings and moving them to in a correct intermaxillary position, the template was connected to the titanium copings with autopolymerizing resin (Fig 18).

![Fig 16 Placement of titanium copings.](image2)
After polymerization, the copings were unscrewed and the template with the copings, was sent to the laboratory for refinement (Fig 19).
As a final step, the Multibase abutments were protected by screw-retained plastic caps (Fig 20) and the patient was discharged from the clinic.

**Laboratory Procedure for Fabricating the Temporary Full-Arch Bridge**

Six multibase analogs were connected to the titanium copings, and the temporary template (the same that had been previously utilized as a temporary template) was repositioned on the master cast by means of palatal and tuber supports (Figs 21 and 22). A new master cast was then obtained by adding some more plaster to secure the multibase analogs in place (Fig 23).
Fig 21 Temporary template with analogs.

Fig 22 Templates and analogs on the master cast.

Fig 23 The new master cast.
The temporary bridge was then refined on the new model, palatal support was eliminated, and a metal thread was added to reinforce it (Figs 24 and 25).

![Fig 24 Temporary bridge on the new model.](image)

![Fig 25 Temporary bridge, anterior view.](image)

**Delivery of the Immediately Loaded Maxillary Bridge**

After 24 hours, the provisional screw-retained bridge was delivered to the patient after the application of a chlorhexidine digluconate gel. Swelling was reduced, and the patient had no significant pain. The temporary bridge was screwed in place using light manual force after verifying its passive seat. The intraoral and extraoral appearance of the temporary rehabilitation was considered adequate (Figs 26 to 27). The occlusion was checked in order to obtain uniform and well-distributed contacts with the opposite arch. A
panoramic radiograph confirmed the correct adaptation of the temporary prosthesis (Fig 28). An antibiotic (for 6 days postoperatively), chlorhexidine digluconate mouth rinses (for 14 days postoperatively), and a soft diet (for the first 4 weeks after loading) were prescribed.

Fig 26 Temporary restoration, anterior view.

Fig 27 Patient’s smile with the temporary restoration in place.
Surgical Procedure and Immediate Loading in the Mandible

After 6 weeks of healing, a new wax-up for the mandible was obtained to improve the vertical dimension and perioral soft-tissue support (Fig 29). The surgical and prosthetic treatment plan for the mandible included the placement of four implants between the mental foramina, followed by an immediately loaded temporary prosthesis.

Following administration of local anesthesia, surgical access to the mandible was obtained with a mid-crestal incision and a median-releasing incision. The
mental foramina were exposed in order to use all available space to distribute the implants and to increase the anteroposterior spread of the future fixed rehabilitation (Fig 30). Distal implant sites were tilted mesio-distally to facilitate a more distal emergence, above the mental foramina (Fig 31).

Fig 30 Exposed mental foramina.

Fig 31 The distal implant beds were tilted to facilitate a more distal emergence.

Four Straumann Bone Level implants (Ø 4.1 mm, length 12 mm) were inserted after tapping the implant sites (Figs 32 and 33). All implants reached optimal primary stability, and immediate loading was possible. The choice of implant type and surface (SLActive) was guided by the same considerations as in the maxilla.
Before suturing, the multibase abutments were checked by means of the Crossfit Plan temporary planning abutments. Two 25° abutments were selected for distal implants to obtain a good parallelism between the four implants (Figs 34a-b). The implant position was recorded with a transparent resin template obtained from the mandibular wax-up, following the same procedure as in the maxilla. Titanium copings placed on top of the multi-base abutments were connected to the template with autopolymerizing resin (Figs 34c and 35). The multibase abutments were protected with plastic cover screws (Fig 36), and the patient was discharged from the clinic.
Fig 34a Crossfit Plan temporary planning abutments.

Fig 34b Two of the abutments selected were 25° abutments.

Fig 34c Titanium copings on top of the abutments.
Fig 35 Template connected with autopolymerizing resin.

Fig 36 Multibase abutments protected with plastic cover screws.

**Delivery of the Mandibular Provisional FDP Loading the Implants Immediately**

The same laboratory procedures were followed to realize the temporary mandibular fixed rehabilitation (Figs 37 and 38a), which was connected to the implants after 24 hours (Fig 38b). A passive seat of the bridge was confirmed, and the bridge was screwed using light manual force. The occlusion was carefully checked to obtain uniform and well-distributed contacts with the opposing arch. The patient was provided with the same postoperative instructions she had received after maxillary surgery and loading.
Fig 37 Cast and analogs.

Fig 38a Temporary mandibular fixed restoration.

Fig 38b The temporary restoration connected to the implants after 24
Final Prosthetic Rehabilitation

After complication-free healing of 6 more weeks, osseointegration of all maxillary and mandibular implants was confirmed by percussion; the soft tissues appeared healed. The final rehabilitation was planned as a one-piece cemented ceramically veneered zirconia bridge in the maxilla and a hybrid screw-retained prosthesis with distal cantilevers in the mandible. Once the multibase abutments were removed, the final procedure was started with a definitive open-tray impression at implant level in both the maxilla and mandible using a polyether material (Figs 39a-b).

Fig 39a Impression posts in place.

Fig 39b Open-tray impression.
Since the esthetic and functional parameters of the temporary prosthesis were considered adequate after a face-bow registration, the temporary prostheses were screwed onto the definitive master casts and used to define (at chairside) the correct 3-D intermaxillary positions (Figs 40a-b) at the second prosthetic visit.

![Screwing the temporary prostheses onto the master casts.](image)

**Fig 40a** Screwing the temporary prostheses onto the master casts.

![Articulated casts without the temporaries.](image)

**Fig 40b** Articulated casts without the temporaries.

At the third prosthetic visit an intraoral resin try-in of the final maxillary and mandibular frameworks was performed. Esthetics, phonetics, and occlusion were verified and small adjustments realized (Fig 41a-c). Based on the available space previously determined, the laboratory prepared the wax-ups of titanium abutments for the CAD/CAM procedure (Figs 42a-b). After the CAD/CAM production of titanium abutments (etkon/Straumann), a
segmented resin duplicate of the final cemented framework was prepared to be tested in the oral cavity (Figs 43a-b).

*Fig 41a Intraoral try-in.*

*Fig 41b Small adjustments can be made at this stage.*
At the fourth prosthetic visit, the definitive titanium abutments were screwed onto the maxillary implants. The segmented try-in resin framework was inserted and connected using small amounts of autopolymerizing resin (Figs 44a-c). The metal framework of the mandibular hybrid prosthesis was also
tried in at the same appointment. In the mandible, multibase abutments were used for the final rehabilitation (Figs 45a-b). The length of the distal cantilevers was based on a very conservative approach to avoid overloading the distal implants (the length of the distal cantilever was less than 1.0 times the anterior-posterior (AP) spread (the maximum accepted value is 1.5 times the AP spread).

Figs 44a-c Intraoral try-in of the segmented resin framework.

Figs 45a-b Inserting multibase abutments for the final mandibular rehabilitation.
The definitive design of the zirconia framework was carried out by the laboratory (Figs 46a-b) and sent to the Straumann milling center that produced the zirconia structure (Fig 47).

![Figs 46a-b Aspects of the CAD framework design.](image1)

![Fig 47 The completed Straumann CAM framework.](image2)

After a further try-in of the final frameworks at prosthetic visit 5—where occlusion esthetics, and phonetics were rechecked—the ceramic and resin veneering was completed, and the final rehabilitations were prepared for delivery at the sixth prosthetic visit (Figs 48a-c).
Customized titanium abutments and multibase abutments were screwed in and tightened to a 35 Ncm torque. The passive fit was verified, and the ceramic-zirconia bridge was cemented with a temporary cement. The hybrid mandibular prosthesis was screwed onto the multi-base abutments at a torque of 15 Ncm. The screw access holes were sealed with cotton and a temporary resin filling material.

After cement removal, the patient was once again instructed about oral hygiene procedures and advised to use specific oral-hygiene tools (Super-Floss Oral-B and interproximal microbrushes).

The patient felt comfortable and was fully satisfied with the esthetics (Fig 50), phonetics, and function of the implant rehabilitation.
Figs 49a-b Final appearance of the completed maxillary and mandibular rehabilitations after delivery.

Fig 50 Patient’s smile upon completion of the treatment.

A panoramic radiograph confirmed the correct insertion of the definitive frameworks (Fig 51).
Fig 51 Panoramic radiograph confirming the correct insertion of the definitive frameworks.

Follow-up visits and professional oral hygiene were scheduled every 4 months and a radiographic control once a year.

Figs 52a-d Clinical and radiographic follow-up after 12 months of loading demonstrates stability of the soft and hard tissues around the implants.

Acknowledgments

Laboratory Procedures
Carlo Pedrinazzi – Milan, Italy
Roberto Colli – Milan, Italy

6.2.6 Immediate Loading of Eight Implants in the Maxilla and Six Implants in the Mandible and Final Restoration with Three-Unit and Four-Unit FDPs

G.O. Gallucci, J.P. Bernard, U.C. Belser
Extensive scientific evidence has confirmed that immediately loaded implants with fixed full-arch provisional restorations can osseointegrate with success rates similar to conventionally or delayed loaded implants. A number of immediate-provisionalization techniques for edentulous jaws have been described. Some protocols differ when it comes to prefabricated provisional templates versus complete denture conversion; intrasurgical impressions versus direct relining; and cemented versus screw-retained provisional restorations. In this context, complete-denture conversion has been proposed for either intrasurgical impressions or direct relining. Another possibility is the utilization of a prefabricated provisional to be adapted either in the mouth (by direct relining) or in the laboratory (on a working model obtained from an intrasurgical impression).

Although a considerable amount of information exists on immediate implant-loading approaches, this prosthodontic step represents only the provisional phase in the treatment of edentulous patients with fixed rehabilitations. Comprehensive planning should include the diagnostic phase, the provisionalization phase and, most importantly, the final rehabilitation and its design.

The following case report describes the treatment of a 57-year-old male patient wearing maxillary and mandibular overdentures who sought a fixed solution.

Diagnostic Planning

The patient selection and diagnostic phases play an important role in planning a fixed implant-supported rehabilitation in fully edentulous patients.

During the diagnostic phase, the feasibility of the desired outcome was evaluated. Regardless of the immediate provisionalization technique used, the clinical, surgical, prosthetic, occlusal/functional, and esthetic aspects were clinically assessed before proceeding. Consequently, a diagnostic wax-up or set-up was fabricated to evaluate all the above-mentioned parameters (Figs 1a-g).
Fig 1a Initial radiographic exam.

Fig 1b Maxillary wax-up relationship.

Fig 1c Maxillary wax-up.
Fig 1d Flangeless wax-up, anterior view.

Fig 1e Esthetic planning.

Fig 1f Set-up/ridge.
Special attention was given to adjusting the prosthetic acrylic-resin teeth to the cast without waxing up a vestibular flange to establish the appropriate emergence profile for a fixed rehabilitation (Figs 1c-d). The palatal and lingual aspects were created in the same way as for a complete denture (support and retention of prosthetic teeth; Figs 1b-c). This diagnostic wax-up was then used to assess the clinical occlusion, esthetic parameters, and the relationship between the teeth and the alveolar ridge (the emergence profile; Figs 1d-g). Furthermore, before proceeding with the treatment, patient approval was obtained, especially with regard to esthetic aspects.

**Immediate Implant Loading**

After assessing extraoral and intraoral parameters, the diagnostic wax-up was duplicated for the fabrication of a provisional template and a surgical guide (Figs 2a-f). This replication of a provisional template and a surgical guide from the diagnostic wax-up allowed the retrieval of pertinent information at each stage of the treatment.

*Figs 2a-f Surgical and provisional templates duplicated from the diagnostic wax-up.*
Fig 2a Maxillary surgical template.

Fig 2b Mandibular surgical template.

Fig 2c Maxillary provisional template.
Fig 2d Mandibular provisional template.

Fig 2e Upper provisional without buccal flanges.

Fig 2f Lower provisional without buccal flanges.
Surgical templates were used during implant-bed preparation to control the axes with paralleling gauges. Straumann Standard implants were strategically distributed according to the final rehabilitation design. While keeping the placement devices attached to the implants, the parallelism can be checked against the surgical guide (Figs 3a-i).

**Fig 3a** 3.5-mm paralleling gauges.

**Fig 3b**
Fig 3c Parallelism checking.

Fig 3d

Fig 3e Implant placement.
Fig 3f

Fig 3g Implant axes.

Fig 3h
Since all the implants were placed and controlled with the surgical guide (the duplicate of the wax-up), the perforations on the provisional template matched the implant position (Figs 4a-i). Subsequently, sterilized screw-retained titanium provisional copings for bridges were connected to each implant. Rubber-dam sections were adequately pierced and placed over the copings to protect the wound area. The template perforations were sufficiently widened to avoid any contact with the titanium copings and thus to achieve only mucosal support on the palatal/lingual aspects. While the provisional template was manually held in place, acrylic resin was used to bond the template to the coronal part of the titanium copings. The provisional template was retrieved for laboratory finishing after the pick-up of the titanium copings. The remaining gaps between the titanium copings and the provisional template were filled in with acrylic resin, creating an appropriate emergence profile at each abutment site. Once the titanium copings were completely fixed to the provisional, the palatal/lingual part of the template could be cut off.

*Fig 3i Radiographic exam after implant placement.*
Fig 4a Copings in place.

Fig 4b Adapted provisional.

Fig 4c Protection of the wound area.
Fig 4d Bonding.

Fig 4e Retrieved template.

Fig 4f Laboratory finishing.
Fig 4g Immediate provisional.

Fig 4h Upper and lower immediate provisionals.
The screw-retained provisional was now ready to be seated and the marginal adaptation of the titanium copings could be checked on a panoramic radiograph (Fig 4i). This approach provides the patient with a fixed implant-supported provisional restoration the same day.

In summary, this pick-up technique relies on the palatal/lingual part of the provisional templates as a repositioning element and avoids both intrasurgical impression and direct relining, but it also permits the preservation of the selected tooth location and occlusion.

**Final Rehabilitation**

After four months of functional loading, final impressions were taken with a perforated customized tray and screw-retained impression posts (Straumann Dental Implant System, Straumann, Basel, Switzerland). Occlusion recorder devices (ORDs) were prepared on both the upper and lower working casts. For the occlusal record, the full arch provisional restoration was split between the central incisors. Next, both the upper and lower ORDs were inserted on one side of the mouth, while “half-provisionals” were left on the contralateral side (Figs 5a-f). So while both the vertical dimension and centric relation were maintained by the half-provisionals on one side, the ORDs were bonded with acrylic resin on the contralateral side. Subsequently, the remaining upper and lower half-provisionals were replaced by ORDs, and the vertical
dimension was now maintained by the previously bonded ORDs. The occlusal registration was completed by repeating the same procedure on the contralateral side. The upper and lower bonded ORDs were then utilized for mounting the master cast in the laboratory.

Fig 5a ORDs in place.

Fig 5b Bonded ORDs.
Fig 5c Contralateral-side ORDs.

Fig 5d Occlusal record completed.

Fig 5e Retrieved bonded ORD.
This approach of a split-mouth occlusal record using an alternating half-provisional technique was extremely effective in maintaining the vertical dimension and centric relation.

The definitive abutments were for both laboratory and clinical procedures. After casting and finishing, the frameworks were tried-in and the passive fit was appraised. The definitive segmented restoration consisted of four fixed partial dentures in the maxilla and three in the mandible (Figs 6a-e). The morphology, texture, and color of the final restoration were reproduced using a stratification technique, and the last occlusal and esthetic adjustments were made during the biscuit bake try-in. For the final seating of the definitive prostheses, solid abutments or synOcta cementing abutments were definitively transferred from the master cast to the mouth and then tightened to 35 Ncm. The final restorations were cemented with temporary cement. A fixed segmented rehabilitation design, supported by six to eight anterior-posterior implants, was proposed for the treatment of the fully edentulous patient.
Fig 6a Solid abutment insertion.

Fig 6b Segmented final restoration.

Fig 6c Esthetic outcome.
Summary
Comprehensive diagnostic planning was needed to assess the treatment feasibility and to provide reproducible information throughout the entire prosthetic treatment. An immediate loading approach can be used for edentulous patients with an excellent long-term prognosis. However, a reproducible provisionalization technique should allow same-day delivery of an immediately loaded provisional. Strategic implant placement and provisional fabrication should ideally converge to result in a final rehabilitation design with the envisioned reliable long-term results (Fig 7).
Fig 7 Final rehabilitation at the 5-year follow-up.

Acknowledgments

Surgical Procedures
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Prosthodontic Procedures
Dr. German O. Gallucci and Prof. Urs C. Belser – Geneva, Switzerland

Laboratory Procedures
Dental Technician Michel Bertossa – Geneva, Switzerland

6.2.7 Immediate Loading of Six Implants in the Mandible and Six Implants in the Maxilla and Final Restoration with Full-Arch CAD/CAM Metal Framework FDPs Involving Digital Planning and Guided Surgery

A. Tahmaseb, R. De Clerck, D. Wismeijer

Immediate loading of dental implants is increasingly popular with clinicians and patients. The idea of delivering a restoration directly after implant insertion, combined with a less invasive procedure (flapless protocol), has made treatment protocols involving dental implants more accessible to dentists and patients. However, immediate-loading concepts require sophisticated and exact planning.

To facilitate this, conventional panoramic tomographs and periapical
radiographs are often taken with the patient wearing a radiographic template simulating the preoperative prosthetic design. However, these radiographs do not provide all the necessary information. In addition, some protocols call for conventional surgical templates fabricated on the diagnostic cast. These will inform the bone drilling points and drill angles, but do not reference the underlying anatomical structures or provide exact 3-D guidance.

To overcome these limitations, considerable effort has been directed at developing techniques that provide optimal 3D implant positions with respect to postoperative prosthetic and anatomical parameters. An important achievement has been the introduction of computed-tomography (CT) 3-D implant-planning software and computer-aided design/computer-aided manufacturing (CAD/CAM) technology into implant dentistry. Digital CT images (Fig 1), including cone-beam computed tomography (CBCT) images, of patients wearing the prosthetic set-ups (Fig 2) can be converted to virtual 3-D models (Fig 3) of the treatment area.

Fig 1 Cone-beam computed tomography (CBCT).
These models provide a realistic view of the patient’s bone anatomy, permitting “virtual surgery” in a precise and prosthetically driven manner.

Different approaches have been introduced to transfer this information to the clinical situation.

**Static systems** determine implant positions prior to implant surgery and transfer this information to the operating field using surgical stents or templates. Static systems also called template-based systems (Fig 4).

A CT scan provides image data to obtain three-dimensional guidance for
implant placement. The surgical stent informs the movements and positioning of the implant osteotomy.

Mechanical positioning devices or automatic drilling units convert the radiographic template to a surgical template using a transformation algorithm. Other approaches include CAD/CAM technology to generate stereolithographic drilling templates.

**Dynamic systems** include similar diagnostic and planning functions and transfer the selected implant positions to the operating field using visual imaging tools on a computer monitor, rather than rigid guides. The surgeon may alter the surgical procedure and implant position using the available anatomical information. Since the surgeon can see a drilling “avatar” in a 3-D relationship with the patient’s anatomy during surgery, modifications can be accomplished based on significantly more data. In essence, the navigation system provides a virtual, modifiable surgical stent or template.

Bur tracking allows intraoperative real-time drill tracking according to the planned trajectory. Surgical navigation systems (Fig 5) visualize the current position of the surgical instrument on the reconstructed 3-D image data on a chairside screen using real-time anatomical matching.

![Fig 5 Computer navigation (dynamic approach).](image)

Use of these computer-assisted guided technologies is often restricted to the surgical aspects of implant treatment. Prosthetic treatment still has to be carried out following conventional protocols.
As many of the above-mentioned techniques are already established or are on the way to being established as routine clinical techniques, we found it logical to include a case in this Treatment Guide based on this technique. We do wish to emphasize that the body of literature that supports this and similar techniques is limited and that further research is necessary before it can be advocated as evidence-based.

**Table 1 Treatment schedule**

<table>
<thead>
<tr>
<th>Day</th>
<th>CLINICIAN</th>
<th>LAB</th>
<th>CAD/CAM</th>
</tr>
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<tbody>
<tr>
<td>Day 1</td>
<td>Mini-implant placement and impression</td>
<td>Working and master casts</td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>Prosthetic phase, bite registration</td>
<td>Wax set-up, prosthesis</td>
<td></td>
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<tr>
<td>Day 3</td>
<td>Try-in set-up</td>
<td>Fabrication of CT set-up in barium sulfate resin, using the flag complex to attach to mini-implant</td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>CT scan with the patient wearing the CT set-up attached to the mini-implants using the flag complex</td>
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<tr>
<td>Day 5</td>
<td>Importing the dicom file into the planning software</td>
<td></td>
<td></td>
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<tr>
<td>Day 6</td>
<td>Exporting the planning data for the CAD design</td>
<td></td>
<td>Designing the survival template and the framework of the superstructure</td>
</tr>
<tr>
<td>Day 7</td>
<td>Importing the design images into the planning software for a virtual check</td>
<td>Exporting the designs for dentist approval</td>
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<tr>
<td>Day 8</td>
<td>Delivering approved designs to milling center for the production</td>
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<tr>
<td>Day 9</td>
<td>Finishing the framework of the superstructure</td>
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<tr>
<td>Day 10</td>
<td>Implant insertion and prosthesis delivery</td>
<td>Final prosthesis is ready</td>
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**Case Report**

This case describes a modified concept in guided surgery based on CT scan images and computer processing to create a digital, non-stereolithographically milled surgical stent using mini-implants as references to transfer the information from the computer to the patient. This 3-D imaging in conjunction with a diagnostic transfer on (mini-) implants allows digital case planning and design, the fabrication of a surgical stent, and eventually the final superstructure to be placed at the time of the surgery.

A 65-year-old fully edentulous male patient presented with moderate ridge resorption (Cawood class VI) due to a long history of edentulousness. He was referred for a consulting session at University of Amsterdam Dental Clinic (Fig 6).
Fig 6 Male patient, edentulous upper and lower jaws, complete denture upper and lower, low smile line.

The clinical and medical anamnesis confirmed his good health. The problem with the removable prosthesis included a lack of comfort and stability, an inability to function normally, and, most of all, the psychological impact and uncertainty associated with the idea of wearing removable dentures.

Based on and clinical observations and the panoramic radiograph (Fig 7) as well as the articulated study casts, a fixed implant-retained restoration was recommended for both jaws.

Fig 7 Panoramic radiography shows moderately resorbed upper and lower jaws.

The six reference implants (mini-implants, Ø 3 mm, length 6 mm), three in
each jaw, were inserted transgingivally in a flapless procedure 3 weeks before the actual implant surgery (Figs 8 to 10).

**Fig 8** Insertion of reference mini-implants in a flapless approach.

**Fig 9** Insertion of the mini-implants in the upper jaw.
The triangular distribution of the mini-implants, placed so as not to interfere with the future final implants, ensured the stability of the coming surgical template. The maxillary mini-implants were placed at the midline and in the tuberosities, while those in the mandible were placed at in the midline and in the retromolar regions. These positions were determined on the study cast made during the patient’s first visit. Impressions were taken with a polyether impression material using impression copings, directly after the insertion of the mini-implants. A master cast (stone) was fabricated using the mini-implant analogs (Fig 11).

The prosthetic procedure was undertaken in the following phases:
- Bite-registration procedure
- Intraoral occlusal registration
- Wax-up set-up, esthetic and functional evaluation
- Copying the ideal set-up using a silicon wraparound

A CT set-up was delivered using a resin containing barium sulfate (VivoTAC/OrthoTAC, Ivoclar Vivadent, Schaan, Liechtenstein).

This diagnostic CT set-up represented the future final restoration. The fixed CT template allowed a correct evaluation of esthetics, function, and occlusion. The CT template was screwed to the mini-implants during the CT recordings using a specially designed screw complex (Fig 12).

Fig 12 Scan denture in barium sulfate resin copied from the prosthetic setup, fixed on the mini-implants, using calibration flags to adjust CT errors.
The screw complex was not only to stabilize the CT template but also to calculate the compensation for CT errors. Reports state that with CT images one must expect metal-induced image distortion and an error margin of 0.5 to 1.0 mm. The screw complex has known dimensions and a radio-opaque gutta-percha mark on top. This is visualized on the CT images; it allows adjusting for errors and circumventing distortions caused by the titanium mini-implants. Before the CT scan, the template had been connected to the mini-implants using the screw complex. The CT data was processed to create multiple cross-sections and 3-D images using the planning software (Exe-Plan Software, Brussels, Belgium).
Twelve Straumann Standard implants, six in each jaw, were virtually inserted, taking the available bone, the future final restoration, and the underlying anatomical structures into consideration. The planning data was exported to the CAD software, where the surgical templates and the frameworks of the future superstructure were designed using the same data as the planning software (Figs 15 to 17). The designed structures were imported back into the planning software, where the fit was checked virtually. Utilizing the same data for planning the surgery and for designing the surgical stent and superstructure eliminates the transfer errors that can otherwise occur when data have to be transformed or scanned.

**Fig 15** Cross-section of implants with attached superstructure.

**Fig 16** CAD model of the superstructure.
After approval of the implant planning and the design of the structure, the data was sent to the production site (ES Tooling, Beringen, Belgium).

A simultaneous five-axis milling device fabricated the surgical templates (PEEK composite) and the titanium frameworks.

The dental laboratory (Van de Bijl TTL, Tilburg, Netherlands) created the final restorations on the titanium frameworks, using the same master casts as at the beginning of the treatment (Figs 18 and 19).
The patient received local anesthesia using lidocaine (Alphacaine SP, Oral Hygiene Center, Netherlands), beginning in the maxilla. The surgical template was connected to the mini-implants using gold screws. The drilling stent was extremely stable due the good internal connection of the mini-implants, which is similar to the connection of Straumann Standard implants, and the triangle distribution (Fig 20).

The drilling sequence was executed for each implant, starting with the punch and ending with the last drill. The implants were inserted using the appropriate implant drivers (Figs 21 and 22).
The drilling sequence includes three different drill diameters, with length increasing by 2 mm per drilling step to prevent any extreme torques during the osteotomy.

Fig 21 The osteotomy through the surgical stent with complete guidance.
The diameter of the guide segment is the same for all drills, precisely fitting the drilling stent. The stop on each drill determines the depth of the osteotomy.

Another detail contributing to more precise implant placement is the so-called precision pin, which pushes through the implants so that they are positioned exactly at the depth previously determined (Fig 23).
Fig 23 The precision pin verifies the final position of the implant at the predetermined depth.

The procedure was repeated for each maxillary implant (Figs 24 to 26).

Fig 24 Two implants in position.
Fig 25 Insertion of a posterior implant.

Fig 26 All implants in position.

After placement of the last implant, the surgical template was removed by removing the gold screws (Fig 27).
The procedure was finally repeated on the mandible (Figs 28 to 31).

Fig 27 Surgical stent removed, flapless approach.

Fig 28 Securing the surgical stent in the lower jaw.
Fig 29 Osteotomy in the lower jaw.

Fig 30 Implant placement guided and controlled by the precision pin.

Fig 31 All implants are inserted.
Immediately after implant insertion, the final restorations were screwed directly onto the implants, without interlocking abutments (Figs 32a-c).

Fig 32a Superstructures were placed directly on the implants without abutments.

Fig 32b Maxillary superstructure.
The mini-implants were removed. Prior to the insertion of the superstructure the fit was evaluated on a panoramic radiograph (Fig 33), and the occlusion was checked. Minor occlusal adjustments were carried out (Figs 34 to 36).

Fig 33 Panoramic radiograph of the implants and superstructure after placement.
Fig 34 Occlusion (left aspect).

Fig 35 Occlusion (right aspect).

Fig 36 Smile line.
The patient was followed up and examined at 2 weeks, 6 months, and 1 year (Figs 37 to 39a-c).

Fig 37 One-year follow-up radiograph immediately after reinsertion. The dorsal implants in the right posterior maxilla had to be tightened.

Fig 38 Periapical radiograph, post-torque, correct position (right maxillary).
Fig 39a Maxillary radiograph, left side.

Fig 39b Mandibular radiograph, right side.
2 weeks:

- No postoperative pain or discomfort
- Eating and chewing possible
- Satisfactory esthetics and comfort
- Occlusal screw access points covered with composite

6 months:

- High satisfaction, no discomfort
- Minor acrylic chipping in the mandible

12 months:

- The superstructures were disconnected and Ostell and probing depth measurements executed – RSQ values were between 70 and 80
- The acrylic chippings were repaired and the structures reinserted

**Acknowledgments**

**Prosthetic Procedures**
A. Tahmaseb

**Laboratory Procedures**
Dental lab vld Bijl – Tilburg, The Netherlands
7 Complications Following Implant-Prosthetic Rehabilitations in Edentulous Patients

P. Casentini, D. Wismeijer, M. Chiapasco, G.O. Gallucci

Implant treatment of edentulous patients has become a proven and very predictable treatment option. However, complications associated with implant treatment are not rare. Such complications cannot always be avoided, even if the clinician is well-trained and experienced; nor can long-term biological and mechanical complications always be predicted. For this reason, inserting implants implies the necessity of a strict aftercare regime. After the superstructure has been inserted, patients are expected to report back for periodic inspection of the peri-implant tissues and the superstructure itself. Once the clinician has evaluated the patient and a steady state has been reached, an individual patient-based recall regime can be installed. Systematic and continuous monitoring of the condition of the peri-implant tissues for disease is recommended. Implant superstructures also require continuous monitoring on an individual schedule. The following clinical and radiographic parameters should be evaluated at recall visits:

- Peri-implant tissues
- Plaque and calculus
- Bleeding
- Recession
- Bone loss (probing)
- Radiographs

- Superstructures Occlusion/articulation
- Wear of occlusal surface
- Denture retention
- Attachment loosening
- Abutment status (with the superstructure removed)

Regular monitoring of the peri-implant tissues is strongly recommended to facilitate early diagnosis of any peri-implant disease. Plaque and calculus
must be removed, and sometimes patients will have to be remotivated. Bleeding on probing is evaluated, and probing depths around implants are recorded. Bone loss can be evaluated by probing and the evaluation of periapical radiographs. Such radiographs must be taken every two years, since bone loss can proceed rapidly even in apparently healthy patients. A routine recall visit of a patient treated with an implant-supported overdenture is presented in Figs 1a-f.

Figs 1a-f Scheduled follow-up of a patient wearing a mandibular implant-supported overdenture. The bar has been disconnected from the implants for cleaning. The peri-implant soft tissues are evaluated by
probing with a plastic probe. Plaque and calculus, if present, are removed from the implant surface with plastic or Teflon manual or ultrasonic curettes. In this case, only limited plaque deposits were present, and the peri-implant tissues appeared healthy. A radiographic control confirms the absence of peri-implant bone loss.

The main types of complications are:

- Soft-tissue complications
- Maintenance problems
- Failure of the retentive system
- Fracture of the dental prosthesis
- Bone loss due to peri-implant infection
- Bone loss due to overload or absence of a passive fit
- Implant fractures
- Complications due to insufficient planning

7.1 Soft-Tissue Complications
Implants supporting overdentures must be surrounded by a cuff of keratinized tissue. While its presence may have little influence on the long-term prognosis of the implants, it does seem to play an important role for patient comfort. As described in Chapter 3, the absence of keratinized tissue can result in peri-implant pain, which can adversely affect the patient’s oral hygiene and in the long term even lead to the destruction of soft and hard tissues around the implants (Figs 2a-b and 3a-b). The treatment plan must therefore provide for inserting the implants such that the keratinized tissue heals in contact with the implants or keratinized tissue is in place after a grafting procedure. Hence, if no keratinized tissue is present, surgical correction by means of a tissue graft is often required (Fig 4a-g).
Figs 2a-b Lack of keratinized tissue around the ball attachments.

Figs 3a-b Absence of keratinized tissue around four implant abutments supporting a bar.
Figs 4a-g Absence of keratinized tissue around two of four implant
abutments supporting a bar. The lack of keratinized tissue was associated with horizontal bone loss and exposure of the rough implant surface. The patient was complaining about painful oral hygiene procedures. A graft of keratinized tissue harvested from the palate was combined with remodeling of the implant surface to assist in oral hygiene.

Soft-tissue hyperplasia is sometimes observed beneath overdentures. There are several possible explanations for this phenomenon, including insufficient oral hygiene and insufficient space between the bar and tissue. A comprehensive treatment approach is based primarily on plaque control (Figs 5a-b). In some cases, however, the tissue will have to be reduced surgically and the design of the superstructure modified to prevent recurrence.

Figs 5a-b Hyperplasia of the soft tissues under a maxillary implant-supported overdenture, before and after treatment. There was no bone loss. Treatment consisted of removing the superstructure, cleaning the implant surfaces, and positioning a flap.

7.2 Maintenance-Related Issues

The design of a superstructure must always allow for adequate dental hygiene. The dental technician must design the superstructure to facilitate access with standard oral-hygiene tools. Sufficient interimplant distance must also be ensured. The pontic areas must be based on the ovate pontic design concept, and no inaccessible concave areas must be present. A ridge-lap design must be avoided wherever possible (Figs 6, 7a-b).
Fig 6 An extremely difficult-to-clean fixed dental prosthesis in an Angle class III patient with a poor periodontal status.

Figs 7a-b Too little distance between implants at the central and lateral right incisor sites may compromise the esthetic result and oral hygiene.

Figs 8a-b Adequately distributed and spaced implants are important for oral hygiene.
7.3 Failure of the Retentive System
Over time, the retentive devices of an overdenture will exhibit wear due to use. When clips and matrices loosen, patients will complain about a loss of retention. However, specific instruments can be used to activate the retentive devices (Figs 10a-c).
Figs 10a-c If necessary, gold matrices can be activated or deactivated to
adapt their retention.

With the introduction of Locator attachments, retention has become adjustable to the patient’s needs by simply replacing the plastic matrices (Figs 11a-c).
Figs 11a-c Locator retentive devices can be activated by replacing the
plastic component of the matrix.

However, there comes a time when the matrices have to be replaced. In most cases, this can be implemented by relining procedure. The matrix is removed from the denture and an impression is made of the denture-bearing area including the abutments. In the dental laboratory, the new matrices are then polymerized into the denture. The matrices must be absolutely parallel, otherwise the clips in the matrix will be bent when the denture is inserted and their retention will deteriorate rapidly. The procedure can also be performed at chairside (Figs 12a-f). However, this is not the preferred approach, as it is very difficult to position the matrices in parallel with this procedure. There is also a risk of resin polymerizing under the matrix, making it difficult if not impossible to remove the denture without causing damage to the soft tissues or to the denture itself. This approach should only be used in an emergency.
Figs 12a-f A gold matrix in a mandibular denture was reattached directly in the oral cavity. The gold matrix was repositioned on its anchor with a new Teflon ring and isolated by a small piece of rubber dam. Then the prosthesis was perforated to check the three-dimensional position of the matrix and subsequently relined with autopolymerizing resin and refined.

A relining procedure can also be used when replacing the retaining clip of a bar. When the clip must be replaced, the superstructure is detached from the abutments. The clip is removed from the denture and the bar is repositioned using the plastic clips that fit through the screw holes and click in place in the
abutment thread. An impression is made with the overdenture, and the bar is collected. At the dental laboratory, the technician can place a new clip in the existing denture (Figs 13a-c).

![Figs 13a-c Reattachment of a retention clip. The clip is removed from the denture, and sufficient space is created to take an impression of the bar. The bar is then held in place on the abutments by plastic impressions clips. Finally, an impression is taken with the denture in order to capture the correct position of the bar. The impression is then sent to the dental laboratory, where implant analogs are placed over the clip and a master model can be fabricated.](image)

The following case (Figs 14 and 15) was that of an 87-year-old patient who had received an overdenture on two implants with ball attachments. The original complication was caused by a combination of implant overload and infection, but the case essentially constituted malpractice. The restorative dentist had relined the denture directly in the mouth using autopolymerizing resin. When he was unable to remove the denture after the procedure, he gave the patient an appointment for 3 days later. Still unable to remove the denture at that point, he sent the patient home after telling her she now had a fixed
dental prosthesis and to keep it clean. The patient was referred to the implant clinic 2 years later.

![Fig 14 Radiograph of the non-removable denture and fixtures.](image1)

We managed to remove the denture without causing the mandible to fracture. The implant was still attached to the matrix when we took the denture out. After cleaning the wound, the patient was advised not to wear the denture for 4 weeks. The mandible did not fracture, and it was decided that she could continue to wear the denture on the one remaining implant.

### 7.4 Fracture of the Dental Prosthesis
Fabricating a bar-supported overdenture for an edentulous jaw requires adequate space within the denture for the retentive mechanism. This may weaken the denture and make it prone to fracture. If the denture has been optimally designed and the retentive system functions well but tends to fracture often, it might be advisable to insert a metal mesh in the acrylic. This will give the denture additional strength and might be sufficient to prevent the recurrence of this problem (Figs 16a-c).

Figs 16a-c A metal mesh was added to this maxillary overdenture retained by four Locator attachments to give the structure adequate
Tooth abrasion in overdentures can be explained in several ways. Acrylic teeth in an overdenture might wear faster than in a conventional denture due to the potentially greater occlusal and articulation forces during function. Bruxism might also be a complicating factor. This problem is more evident if the opposing arch consists of natural teeth or a fixed prosthesis with metal-ceramic teeth. Composite teeth, which are less prone to wear and have the same abrasive characteristics as natural teeth, might be advisable in these cases. On the other hand, if a patient exerts excessive forces on a denture, composite teeth may fracture. The fracture of ceramic teeth in an overdenture may also sometimes be traced to an inadequate occlusal concept. This problem can often be avoided by a bilaterally balanced occlusion.

Tooth fractures in a screw-retained hybrid prosthesis are easy to repair. The prosthesis is detached from the implants, and an impression of the antagonistic teeth is made and presented, together with an intermaxillary registration, to the dental laboratory, which will replace the fractured teeth. Tooth detachment can usually be prevented if the metal structure of the prosthesis includes metal pins to support each tooth (Figs 17a-c).
Figs 17a-c The framework design of a mandibular hybrid denture should include supports for each dental unit in order to reduce the incidence of acrylic tooth detachment or fracture.

If the access hole for the holding screws of a hybrid cantilever prosthesis is in an unfavorable position, this can weaken the structure of the acrylic teeth, causing them to fracture. A possible solution to this problem is to mask the access hole with a single cemented crown (Figs 18a-b). However, this makes removing the structure from the implants more difficult when repairs become necessary.

Figs 18a-b A single cemented crown is used to seal the area of the access hole. The position was unfavorable for direct access through the acrylic tooth.

When a metal-ceramic fixed dental prosthesis is the treatment of choice, the risk of ceramic fracture must be considered. If the fracture involves a minor part of the ceramic, an adhesive procedure probably represents the easiest repair method. However, this may give the patient the feeling of wearing a second-rate prosthetic device.

In case of major fractures, the prosthesis must be removed, and in most cases, the entire ceramic veneer must be removed and the framework re-veneered. There is a risk of torsion in the metal superstructure on reheating the metal framework during repair, compromising its fit.

A revision can be much easier if the rehabilitation is segmented. When a complex rehabilitation has to be realized in one piece, a possible solution can be metal-ceramic single crowns or bridges cemented on a screw-retained framework. In case of ceramic fracture, the affected part of the framework can be easily removed and repaired (Figs 19a-d).
Figs 19a-d In this complex full-arch rehabilitation, a one-piece screw-retained metal framework supported four three-unit metal-ceramic bridges. Fissures were added on the palatal side to facilitate bridge removal, and the soft tissues were executed in composite resin. With this design, a revision—as in the case of a ceramic fracture—does not represent a problem.

7.5 Bone Loss Due to Peri-Implantitis
A regular recall of implant patients is obligatory. If patients fail to show up for their regular recalls, they might run the risk of developing severe peri-implantitis.

If implants fail beneath a restoration, the entire rehabilitation is jeopardized. Implant loss might lead to loss or complete revision of the superstructure.

Peri-implantitis can be defined as an inflammatory process affecting the tissues around an osseointegrated implant in function, resulting in a loss of supporting bone. Peri-implantitis represents an irreversible process involving bone loss, as opposed to “peri-implant mucositis,” which can be defined as a
reversible inflammatory change in the peri-implant soft tissues without associated bone loss.

It has been demonstrated that peri-implantitis has a microbial etiology and that the responsible pathogens are almost identical to those encountered in pockets with advanced periodontitis.

![Fig 20 Orthopantomograph showing excessive bone loss in a patient who has not presented herself for recall for 5 years.](image)

The effect of insufficient oral hygiene can be potentiated by local contributory factors such as untreated periodontitis around the residual teeth, smoking, implant overloading, the absence of keratinized tissue, inadequate fit of the implant-supported prosthesis, or cement residue left in the implant sulcus after cementing the crown.

Peri-implantitis can be clinically associated with the presence of plaque and calculus, bleeding on probing, increased probing depth (compared to baseline), suppuration, and radiographically evident bone loss. The diagnosis of peri-implant disease in this chapter will be based on an evaluation of these clinical parameters.

As stated at the beginning of this chapter, an individualized program of maintenance care based on recall visits at regular intervals is obligatory for implant patients. Continuous monitoring will allow prevention or at least early diagnosis of peri-implant disease.

Based on the Proceedings of the 2nd and 3rd ITI Consensus Conferences, the Cumulative Interceptive Support Therapy (CIST) protocol is
recommended for the treatment of peri-implant disease.

CIST is based on four treatment modalities that can combined and used in sequence based on the clinical situation:

- Mechanical debridement
- Antiseptic treatment
- Antibiotic treatment
- Regenerative or access/resective surgery

Untreated peri-implantitis will lead to continuous bone loss with implant failure and may jeopardize the entire implant-supported rehabilitation.

The implant at site 42 presented recurrent inflammation after 8 years of function. At a previous stage, mechanical cleansing was combined with the administration of a chlorhexidine digluconate gel and metronidazole following the CIST protocol. The infection appeared resolved, but at the following follow-up visit, the patient commented on discomfort in the treated area again. The implant involved showed an increased probing depth (6 mm) associated with suppuration and bleeding on probing. The radiograph showed a typical crater-like defect. Mechanical debridement was again performed and combined with chlorhexidine digluconate gel and antibiotics. After treatment of the acute infection, it was decided to correct the defect surgically. A more superficial reshaping and smoothening of the TPS threads was combined with a regenerative approach in the deeper part of the defect. The implant surface was treated with gauze soaked alternately in chlorhexidine digluconate and saline. The deeper part of the defect was filled with a mixture of autogenous bone chips and deproteinized bovine bone mineral (DBBM) and covered with a collagen membrane. Soft tissues were reshaped and repositioned by means of 5-0 polyamide sutures. One year after surgical treatment, the site showed a reduced probing depth (3 mm), and bleeding on probing and suppuration were absent.
7.6 Bone Loss Due to Overload or Absence of a Passive Fit

Bone loss related to overload and the absence of a passive fit have also been reported.

Mechanical overload is not easy to diagnose. A passive fit of the superstructure is of great importance. If the superstructure does not fit passively, it must be removed and the problem has to be addressed. Possible solutions include segmenting the structure and reconnecting the parts or fabricating a new superstructure in the dental laboratory. If the problem is not resolved, internal stress is introduced into the bone/implant interface, which might lead to bone loss. Another possible consequence of the absence of a passive fit can be abutment or screw fracture. Other explanations for this phenomenon include material fatigue and “off-centric occlusal overload.”
Figs 22a-c Cervical bone loss around the implants due to a lack of
passive fit. This case shows a patient who was referred back as he presented an unusual amount of bone loss around the implants 6 months after insertion of the superstructure. The bar was unscrewed, and it immediately became clear that there was no passive fit. Figs 21b and c show the implant after the bar was loosened. The treatment consisted of removing the clip from the denture, taking a new impression of the abutments and redoing the bar. A new clip was inserted into the denture.

Occlusal overloading of individual implants due to bruxism or the choice of an inappropriate occlusal concept might also lead to bone loss and possibly even to implant loss or implant fracture. For this reason, implant-supported prosthetic designs should not include excessive cantilevers (Figs 23a-j).
Figs 23a-j Loss of osseointegration due to overloading. The original rehabilitation of this patient included four mandibular implants connected with a bar and an implant-supported overdenture. The patient’s history was positive for bruxism, and previous loss of the two right implants to fracture was reported. The two residual implants remained in function, but loading with a U-profile bar resulted in excessive load and loss of osseointegration. Signs of infection were absent, the peri-implant soft-tissue appeared normal, but the implants were mobile and surrounded by a continuous radiolucency. Before implant removal, two new implants with a rapidly osseointegrating surface were placed and then loaded with a less rigid connector. The final design of the new rehabilitation will include placement of two additional implants to replace those that failed.

In patients with severe bruxism, occlusal splinting is recommended.

7.7 Implant Fractures
Implant fractures can be related to implant overloading. This can have a deeper cause in an inadequate implant design, an incorrect indication, an incorrect occlusal concept, bruxism, or inadequate passive fit.

The referring dentist had planned implant treatment of the edentulous maxilla with the insertion of four implants in the anterior maxilla. The patient anamnesis was positive for bruxism. The clinician placed four Regular Neck implants (∅ 3.3 mm) in the residual bone. All the implants seemed to osseointegrate and were loaded with Locator attachments and an overdenture without palatal coverage. The two distalmost implants lost osseointegration and failed a few months after loading. The two remaining implants remained in function but fractured after 6 months due to overloading and metal fatigue. After only one year of function, complete failure was recorded. Splinting reduced-diameter implants with a bar is strongly recommended. The re-treatment of this patient was planned as followed: removal of the fractured implants and simultaneous bone augmentation with a bilateral sinus lift in order to place six implants supporting a fixed prosthesis.
Figs 24a-c Fractured reduced-diameter implants.
Fig 25 Two implant fractures caused by overloading of the superstructure by the opposing dentition. It is advised to insert four implants in the edentulous mandible if maxillary natural teeth are still present.

7.8 Complications Due to Insufficient Planning

Before undertaking any implant treatment, the clinician should be familiar with and adequately trained in clinical assessment, treatment planning, and in the surgical and restorative techniques associated with dental implants. Solid and current knowledge of the surgical anatomy of the edentulous maxilla and mandible is a fundamental prerequisite for correct implant placement with respect to relevant anatomical structures. While surgical skills represent the foundation of correct implant placement, they are not sufficient to realize a correct prosthetic rehabilitation.

Implants must be placed according to a precise plan that is prosthetically driven and dictated by the structure of the future prosthetic framework or frameworks. Finally, the dentist planning an implant case should also be familiar with the technical aspects of superstructures and their biomechanical design and possible shortcomings. If such a treatment is undertaken without sufficient experience and training, complications will occur, possibly compromising the treatment as a whole.

Finally, re-treatment of cases that failed due to insufficient planning or to surgical and prosthetic complications usually represent a complicated and stressful procedure both for the patient and for the clinician and exposes the
patient to more invasive and expensive procedures.

Fig 26 An implant displaced into the maxillary sinus due to insufficient bone volume.

Fig 27 Possibly due to an insufficient design of the case (no implant replacing the canine in the third quadrant), biomechanical overload caused the abutment screws to fracture.
Figs 28a-c Mandibular implants placed to support an overdenture require sufficient parallelism. In this case, a lack of parallelism caused...
the matrix to detach from the prosthesis and made the overdenture unstable. The CT scan shows that the implant axis was not correct in relation to the residual bone anatomy. It was decided to remove the implants and to insert new ones.

Acknowledgments

Surgical Grafting Procedures
Figs 4a-g:
Dr. Pietro Fusari – Milan, Italy
8 Conclusions

D. Wismeijer, G.O. Gallucci

The selection of the appropriate treatment protocol for edentulous patients is influenced by a myriad of clinical and patient-related factors. Throughout this Volume 4 of the ITI Treatment Guide, different parameters involving treatment planning and execution for the edentulous patient were developed and illustrated.

A number of general conclusions can be drawn; these are summarized for the reader in the present chapter.

8.1 Proceedings of the 4th ITI Consensus Conference
Definitions of the terms applicable to the carious loading protocols:

- When dental implants are allowed a healing period longer than 2 months after implant placement without connecting the abutments, this is termed conventional loading.
- When dental implants are connected to the prosthesis between 1 week and 2 months after implant placement, this is termed early loading.
- Immediate loading has been defined as the situation where dental implants are connected to the prosthesis within 1 week after implant placement. It was also decided that delayed loading should be included in the definition of conventional loading.

Scientific and/or clinical validation was categorized according to four groups covering a range from clinically insufficiently documented to scientifically and clinically validated. The highest level of scientific and clinical validation was found for conventional loading with mandibular overdentures and maxillary fixed dental prostheses. Insufficient scientific or clinical documentation/validation was found to immediate loading of maxillary overdentures as well as for immediate loading of immediately placed implants combined with fixed or removable dental prostheses in either jaw.
The treatment risk for the protocols highlighted in red or yellow (see also Chapter 2) is increased, especially when the variability in outcome homogeneity is taken into account.

*Table 1 Validation of loading protocols for different prosthodontic treatments in the edentulous mandible or maxilla.*

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<th>Removable</th>
<th>Fixed</th>
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<td></td>
<td>Maxilla</td>
<td>Mandible</td>
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<tr>
<td><strong>Conventional loading</strong></td>
<td>CWD</td>
<td>SCV</td>
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<tr>
<td><strong>Early loading</strong></td>
<td>CD</td>
<td>CWD</td>
</tr>
<tr>
<td><strong>Immediate loading</strong></td>
<td>CID</td>
<td>CWD</td>
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<tr>
<td><strong>Immediate loading of immediately placed implants</strong></td>
<td>CID</td>
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*SCV: scientifically and clinically validated – dark green; CWD: clinically well-documented – light green; CD: clinically documented – yellow; CID: clinically insufficiently documented – red*

### 8.2 Patient Considerations

The assessment of a patient’s goals and his or her motivation to undergo implant treatment is essential. Patients will often have to be guided to an understanding of the difficulties and limitations related to implant treatment for the edentulous jaw. In this context, patients must be informed of the degree of compromise that may be required to meet their expectations. In order to achieve this, clinicians should ideally consider the best treatment option for a given patient and provide adequate information regarding the advantages and limitations for the proposed implant therapy. Thus, a fixed implant-supported restoration in a resorbed edentulous ridge can be more demanding in terms of implant placement, prosthetic design, maintenance, and cost/benefit ratio for the patient. Conversely, an overdenture may result in a straightforward or advanced procedure for most patients. The cost/benefit analysis for implant-supported restorations in edentulous patients represents an important factor that influences the patient’s treatment preference.
Selecting a successful treatment is the result of a proper diagnosis, treatment planning including the patient’s chief complaints, and ultimately an implant/prosthetic design for which scientific evidence supports that both removable and fixed implant rehabilitations can significantly improve an edentulous patient’s quality of life.

8.3 Treatment Difficulty – SAC Classification

In 2009, the ITI published the SAC classification for implant dentistry based on a consensus meeting held in early 2007. Different clinical situations have different levels of difficulty and different degrees of risk for aesthetic, restorative, and surgical complications. The SAC classification was developed to assist clinicians in evaluating the degree of difficulty for individual patient cases.

When evaluating edentulous patients, implant-supported overdentures in the mandible are often classified as straightforward. Implant-supported overdentures in the maxilla are normally classified as advanced. However, a greater number of supporting implants leads to a more complex treatment protocol, meaning that the SAC classification will shift to advanced for the mandible and to complex for the maxilla. A fixed full-arch dental prosthesis in the edentulous patient is normally classified as advanced or complex. Modifying factors of the SAC classification concern available restorative space, access, esthetic risks, provisional restorations during healing, occlusal parafunction, and finally the loading protocol itself. The increased complexity and risk of immediate-loading protocols in edentulous patients normally entails a SAC classification of complex.

Table 2 SAC decision matrix for the maxillary rehabilitation.

<table>
<thead>
<tr>
<th>Edentulous Maxilla - Fixed</th>
<th>Notes</th>
<th>Straightforward</th>
<th>Advanced</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-arch</td>
<td>Refers to the distance from proposed implant restorative margin to</td>
<td></td>
<td></td>
<td>Space restricted for</td>
</tr>
<tr>
<td>distance opposing occlusion. Note: hybrid bridge restorations will need more space</td>
<td>Average adequate restoration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>Good Restricted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading protocol To date immediate restoration and loading procedures are lacking scientific documentation</td>
<td>Conventional or early Immediate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esthetic risk Refer for ERA (Treatment Guide 1)</td>
<td>Low Moderate/high</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provisional restorations during healing</td>
<td>Removable Fixed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occlusal para-function Risk of complication is to the restoration, not implant survival</td>
<td>Absent Present</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occlusal scheme issues</td>
<td>Anterior guidance No anterior guidance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3 SAC decision matrix for the mandibular rehabilitation.**

<table>
<thead>
<tr>
<th>Edentulous Mandible - Fixed</th>
<th>Notes</th>
<th>Straightforward</th>
<th>Advanced</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refers to the distance from</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Inter-arch distance

proposed implant restorative margin to opposing occlusion. Note: hybrid bridge restorations will need more space

Average

Excessive (Mechanical leverage issues) or restricted (space for components)

Loading protocol

To date immediate restoration and loading procedures are lacking scientific documentation

Conventional or early

Immediate

Esthetic risk

Refer for ERA (Treatment Guide 1)

Low

Moderate/high

Provisional restorations during healing

Removable

Fixed

Occlusal para-function

Risk of complication is to the restoration, not implant survival

Absent

Present

Occlusal scheme issues

Anterior guidance

No anterior guidance

8.4 Future Developments

As stated in Chapter 2, the use of CAD/CAM techniques for the fabrication
of frameworks and abutments is not based on a large body of scientific evidence. However, preliminary evidence appears promising, and it may be expected that the role of CAD/CAM in implant planning, superstructure design, implant placement, and superstructure and abutment fabrication will become more and more prominent within implant treatment protocols. It is expected that more and more scientific evidence will support this new technology in the near future.

Further clinical trials assessing implant-supported rehabilitations for the edentulous patients should ideally consider different loading protocols in relation to well-differentiated prosthetic protocols. In addition, calculating implant survival rates alone should no longer be considered as a standard of evidence. Future clinical research in this field should include the calculation of overall success rates, where implant, hard- and soft-tissue and prosthetic parameters are correlated in long-term follow-up studies.
Literature/References


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Removable and Fixed Implant/Prosthodontic Options for the Edentulous Mandible

Two free-standing implants with ball or Locator attachments. See pages 38, 65, 76, 85, 205

Bar design over two splinted implants with optional cantilevers. See pages 38, 39, 65, 93, 125, 208, 215

Four free-standing implants with Locator or telescopic crown attachments. See pages 65, 200, 217

Bar design over four splinted implants with optional cantilevers. See pages 39, 65, 199, 201, 204, 212

Full-arch prosthesis on five to six anterior implants with two-unit bilateral distal cantilevers. See pages 67, 100, 203.

Full-arch prosthesis on six anterior-posterior implants in one piece. See pages 44, 67, 187.

Full-arch prosthesis on six anterior-posterior implants segmented into three FDPs. See pages 57, 177.

Removable and Fixed Implant/Prosthodontic Options for the Edentulous Maxilla

**Removable**

1. **Four free-standing implants with Locator or telescopic crown attachments.** See pages 61, 209
2. **Six free-standing implants with Locator or telescopic crown attachments.** See pages 46, 51

**Fixed**

1. **Bar design over four splinted implants with optional cantilevers.** See pages 47, 61
2. **Bar design over six splinted implants.** See pages 47, 61, 202
**Fixed Implant Prosthetics**

- **Full-arch prosthesis on four anterior implants with two-unit bilateral distal cantilevers.** See pages 48, 62, 219

- **Full-arch prosthesis on six anterior implants with one-unit bilateral distal cantilevers.** See pages 48, 62, 139, 187, 211

- **Full-arch prosthesis on six anterior-posterior implants.** See pages 50, 62, 118, 151, 161, 203

- **Full-arch prosthesis on eight anterior-posterior implants segmented into four FDPs.** See pages 56, 62, 108, 177

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C: canine, PM: first premolar, LI: lateral incisor, M: first molar
- : optional bar segment, ←→: cantilever, ←→: segmentation area