Introduction to Implant Prosthodontics

A case-based Clinical Guide

Stefanos G. Kourtis

with contributions
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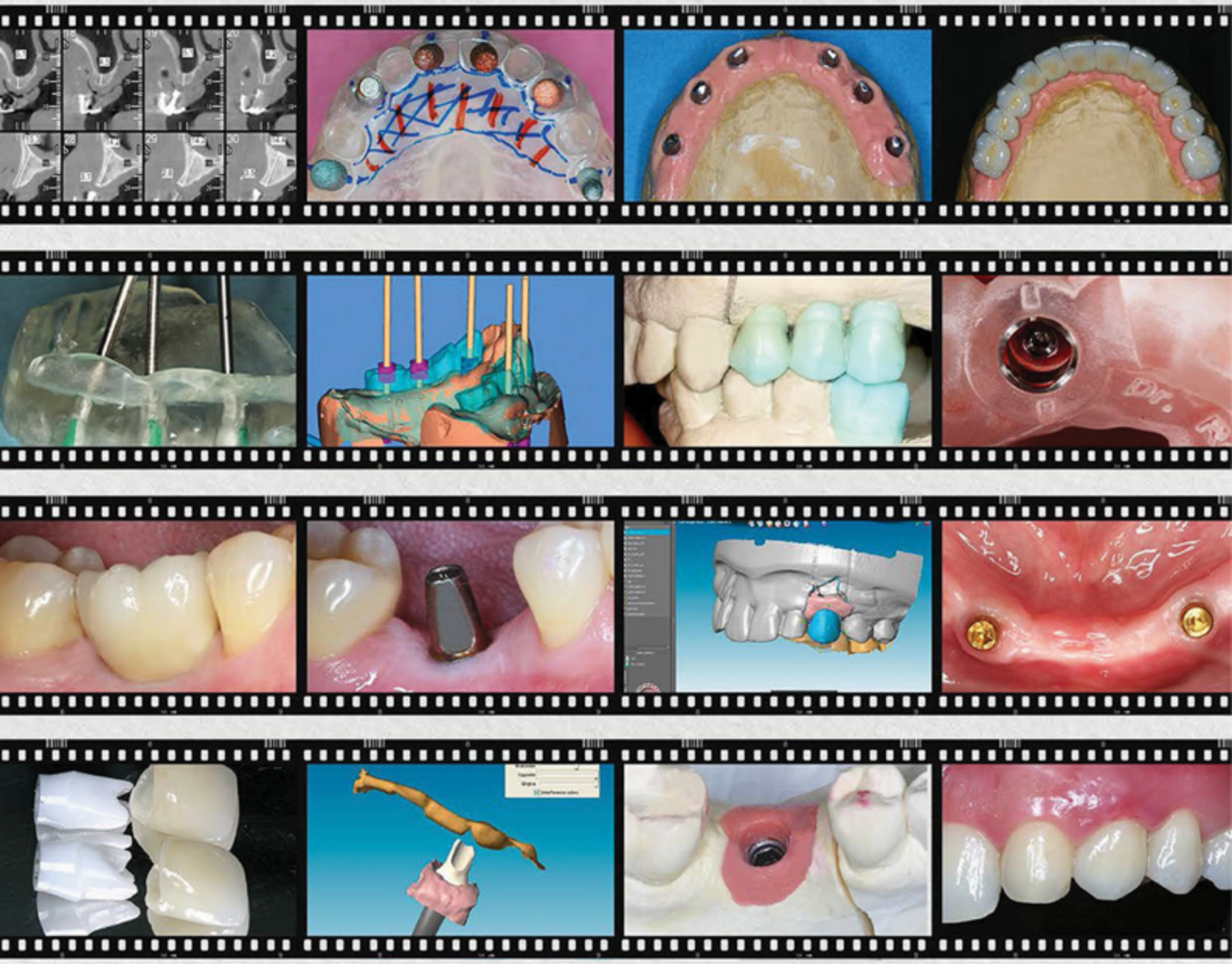

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Abbreviations used in the text

CAD/CAM	Computer Aided Design / Computer Aided Manufacturing
CBCT	Cone Beam Computed Tomography
CT	Computer Tomography
DICOM	Digital Imaging and Communication in Medicine
FDP	Fixed Dental Prosthesis
IOS	Intra-Oral-Scanning
OHRQoL	Oral Health Related Quality of Life
PEEK	Poly-Ether-Ether-Ketone
PMMA	Poly-Methyl-Methacrylate
STL	Standard Tesselation Language

Prologue

Writing a textbook is always a challenge for any scientist. The main question that arises after the author has come up with the initial idea is *"...What should I write about?"* or *"...What is new? What have all previous authors not reported or explained?"* These questions are a difficult task to answer and keep bothering the author before starting writing, during the whole procedure and even at the final stages. Sometimes only the acceptance can justify the effort and the time needed to write a book.

Dental implants have been an established treatment option for partially and completely edentulous patients for decades. In the first years of their clinical use, the theoretical background on Osseointegration and Implant Prosthodontics was covered by few textbooks that had been characterized as "classical" and any research results were reported in scientific papers. Over the years, the evolutions in Implant Prosthodontics have led to a continuing introduction of innovations in prosthetic components and treatment options.

Clinicians are informed on these innovations from research papers and seminars. However, each of them is focused on a specific topic, a single innovation or technique.

The purpose of this book is to offer a thorough introduction to current Implant Prosthodontics by combining theory and practice in an easy-to-read manner. In each chapter, the needed theoretical background and principles are reported, and the techniques are presented with clinical examples in step-by-step manner. The aim is to guide the dentist in their practice by combining the needed knowledge with its clinical application and relevance. For this reason, this book can be characterized as *"A case-based Clinical Guide."* To make the text easier to read and comprehend, the theoretical parts are marked with a green title while the clinical cases are marked with a blue one.

Clinicians, on their part, are always concerned about the stages or steps required in each technique, and for this reason, special emphasis has been placed on the detailed description of each case as it is followed by a critical discussion on the selection of each specific treatment option.

Concluding the prologue, I need to sincerely thank my co-authors for their contributions, both in writing the text and in sharing their clinical cases. I would also like to express my thanking to all the colleagues who have entrusted me with their clinical cases, which have been used to underline the theoretical part and are followed by a special reference to every contributor.

As mentioned above, it remains to the reader to evaluate if the effort was worthwhile.

Stefanos Kourtis

Athens 2022

CHAPTER 1

Diagnostic Elements for Treatment Planning in Implant Restorations

Stefanos Kourtis

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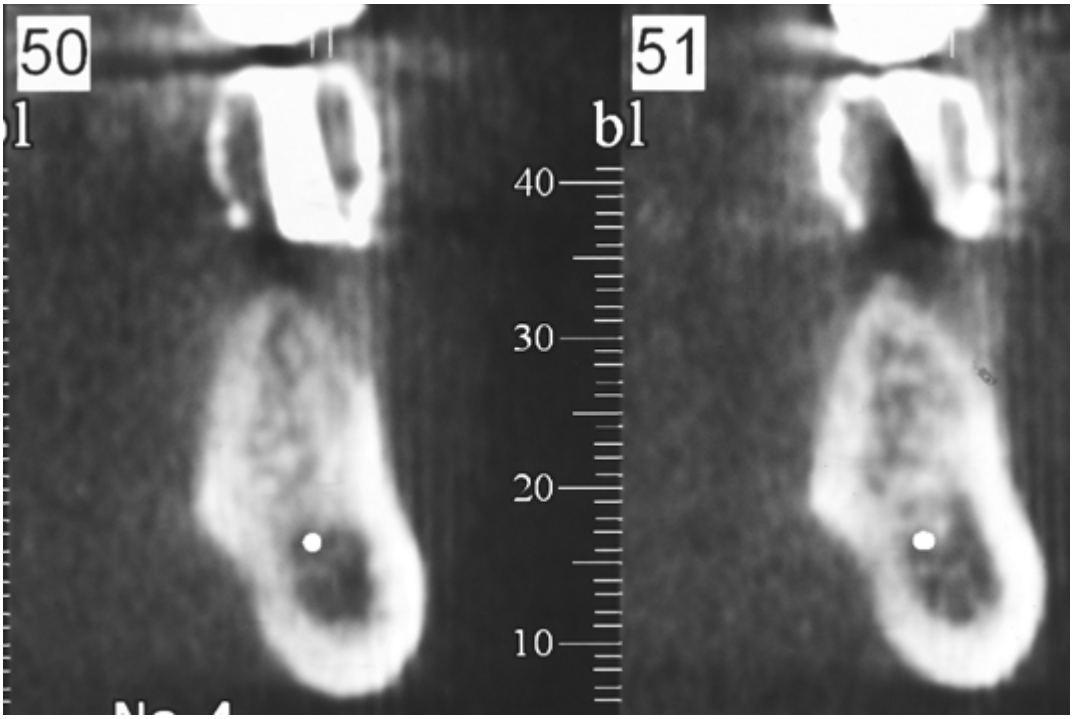

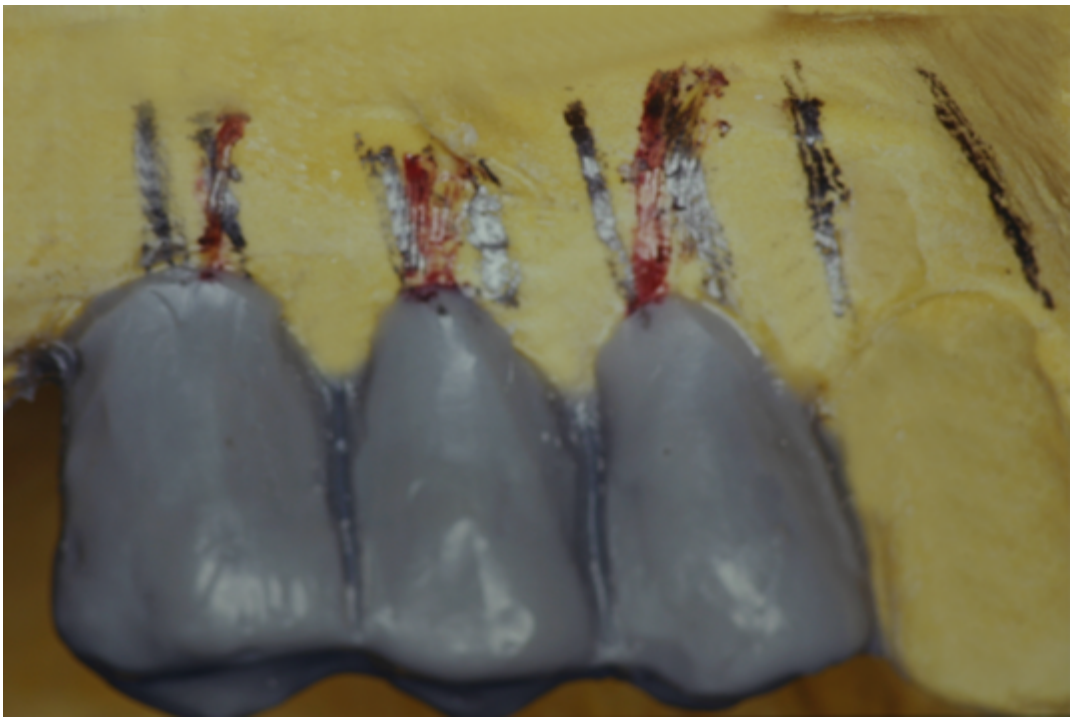

Abstract

In the early days of clinical application of osseointegration, implants were placed where adequate bone was available. The evolution of prosthetic components and the technique of Guided Tissue Regeneration have offered increased possibilities in implant restorations. Proper presurgical diagnosis is essential for a detailed treatment plan in implant restoration. The diagnostic elements that are essential for the diagnosis and treatment plan in implant restorations include the panoramic radiography, the tomographic imaging (as CT or CBCT), the study casts and the diagnostic wax-up. The aim of this chapter is to focus on comprehensive presurgical planning taking under consideration all case-specific details.

Knowledge background

To understand the content of this Chapter, the reader must be familiar with the basic principles of treatment planning for prosthetic restorations on natural teeth.

1.1 Introduction

In the early days of clinical application of osseointegration, implants were placed where adequate bone was available, and the prosthetic restoration was a screw-retained Fixed Dental Prosthesis (FDP). The evolution of prosthetic components and the technique of Guided Tissue Regeneration have offered increased possibilities in implant restorations. Proper presurgical diagnosis remains, however, a crucial stage when planning an implant restoration (**Arlin, 1990; Wolf, 1994; Callan and Strong, 1995; Buck, 1996**). Moreover, the increased need for predictability mandates a close cooperation between the clinician and the dental technician to plan and predict a functional and esthetic outcome (**Jansen and Weisgold, 1995; Lang, 1998**).

The treatment planning should define the kind and extent of the prosthetic restoration, which will dictate the number, position, and inclination of the needed implants. For this reason, presurgical planning must be accomplished in detail using all available means that contemporary technology may offer. Numerous techniques have been proposed for the fabrication of radiographic and surgical guides (also referred to as templates, splints, or stents) using various radiopaque materials as markers (**Takeshita et al., 1997; Israelson et al., 1992; Solow, 2001; Ku and Shen, 2000; Forbes-Haley and King, 2013; De Kok et al., 2014; Kourtis et al., 2014**).

1.2 Aim

The aim of this chapter is to focus on comprehensive presurgical planning taking into consideration all case-specific details. The presented cases were selected because each one had one or more complicated stages that could be recognized during the planning phase avoiding further complications.

1.3 Diagnostic elements

The diagnostic elements for the presurgical evaluation and treatment planning in implant restorations include:

- Detailed and thorough medical and dental record with a special interest in medications and existing medical conditions.
- Detailed intra- and extraoral examination.
- Periapical radiographs of the region(s) of interest or a panoramic radiograph in large edentulous areas for an initial assessment.
- Study casts mounted on a semi-adjustable articulator.
- Detailed wax-up / set-up.
- Fabrication of a radiologic guide.
- Tomographic imaging, preferably Cone Beam Computed Tomography (CBCT) or Computed Tomography (CT) in the absence of CBCT.
- Fabrication of a surgical guide.

If the presurgical examination is not detailed, the clinician may encounter unexpected difficulties during

treatment, either in the surgical or in the prosthetic phase.

Tomographic imaging (CBCT or CT) is considered nowadays a standard procedure for precise and detailed examination of the bone substrate prior to implant placement. It should be combined with the use of a radiologic guide with proper radiopaque markers and followed by an appropriate image reconstruction to produce accurate cross-section images of the examined region (**Ganz, 2011; Angelopoulos and Aghaloo, 2011; Jacobs et al., 2018**).

The following cases represent some indicative examples that emphasize the need for careful examination and planning. Beside the zone of implantation, a thorough intraoral examination is necessary to assess the entire area of the planned restoration. Anatomical structures, interarch relationship, occlusal situation in the whole dental arch should be carefully evaluated before initiation of the treatment. In certain cases, an extra oral examination may also reveal some factors that have to be taken into consideration during the treatment planning.

The clinician should always combine the information from all the above mentioned presurgical means of examination to establish a solid and predictable treatment plan that focuses on the difficulties of each case and also includes alternative treatment options. The initial steps of the presurgical diagnosis are analyzed with clinical examples at the beginning of this Chapter. Selected clinical cases are presented underlining the diagnostic value of each step and showing how the combined information can and should be evaluated before any irreversible treatment step is undertaken.

1.4 Panoramic Radiography and Computed Tomography

Panoramic radiography has been used for the initial evaluation of the implant patient from the early years of clinical application of implants. It is a valuable diagnostic tool as it allows an overall view of the existing teeth, the supporting hard tissues and relevant anatomical structures, all in one diagnostic image. Its main role, along with complimentary periapical radiographs, is that of a gross assessment of the edentulous spaces, the status of existing teeth and possible dental pathology as well as anatomical limitations for implant placement.

The panoramic radiograph is a magnified diagnostic image and it is essential that the induced magnification be recognized on the film (**Batenburg et al., 1997; Scarfe et al., 1998; Gomez-Roman et al., 1999; Stramotas et al., 2002**). The magnification factor is variable among different panoramic machines and ranges between 1,18-1,33. A fixed magnification (the one provided by the manufacturer of the machine) is achieved when the patient is ideally positioned in the machine and, thus, initial measurements may be accurately performed. When positioning errors occur, which is not rare, the panoramic image is distorted (different magnification in different areas of the image) which makes it unsuitable for accurate bone height estimation.

Contemporary digital panoramic machines provide automated magnification correction tools which may be useful when the radiograph is made without patient positioning errors and no distortion has been induced. It must be emphasized, however, that automated magnification correction function will not correct possible induced distortions, and measurements rendered should be verified and confirmed by the clinician as shown in the presented clinical case (**Case A**). In any case, current digital panoramic machines in the hands of knowledgeable operators and proper patient positioning may minimize distortion and allow acceptable accuracy for the initial evaluation of the bone substrate in height (**Vazquez et al., 2013**).

Beyond that, there is a general agreement in the literature that surgical planning even in simple cases should be accomplished with a tomographic study (CT or CBCT examination). Both CT (with the proper dental scan protocols) and CBCT allow a precise evaluation of the hard tissue substrate and the anatomical points of interest in all three dimensions (**Jacobs et al., 2018**). CBCT stands out as an imaging modality which is readily available nowadays and at advantage in comparison to CT because of the lower radiation (**Angelopoulos and Aghaloo, 2011; Mandelaris et al., 2018**). It is nowadays considered an absolute prerequisite for a safe and precise presurgical planning with safety in every case, even when the initial panoramic shows no need for additional diagnostic imaging as shown in **Case B**. The CT and CBCT images have no magnification and allow precise measurement of the bone substrate in height and width by means of the software. In this way, the presurgical planning can be accurate and detailed, minimizing the risk of hurting any vital anatomic structure or fenestration.

1.5 Study casts/diagnostic wax-up

Study casts are an essential element in presurgical planning. They are the reference point to every stage of the

treatment and allow a precise evaluation of the intraoral situation even after the end of clinical examination. The study casts should always be mounted on a semi-adjustable articulator and be kept even after the end of the treatment for reasons of documentation. The mounted casts allow the evaluation of the occlusal relationship of the maxillary and mandibular arch and the prosthetic space. They are also necessary for a detailed wax-up and the fabrication of a radiographic and surgical guide, which correlate the radiographic images with the clinical conditions.

The role of study casts and the wax-up in the presurgical diagnosis and planning for implant restorations is clearly shown in **Cases C and D**. In complicated cases, all diagnostic elements should be used and taken into consideration to make a detailed treatment plan with all the possible points of difficulty, as shown in **Cases E, F and G.**

1.6 Case A (Figs. 1.1 to 1.4)

In this clinical case (Case A), the patient had received several implants in the maxilla and the mandible some years ago. For the recall appointment a panoramic x-ray was needed, and the patient was referred to a radiologist. On the panoramic x-ray, however, where a 1:1 magnification was marked, the implants appeared longer and wider than their original dimensions, which were recorded in the patient's file (***Fig. 1.1***). For example, in regions #27 and 36 a D 5,5/L 15 mm implant had been inserted (***Figs. 1.2 and 1.3***). The superimposition of the plastic transparent sheet showing the implants in their exact dimensions revealed that the panoramic x-ray had a severe magnification. This finding was confirmed by periapical x-rays in region 36 and the superimposition of the transparent sheet (***Fig. 1.4***).

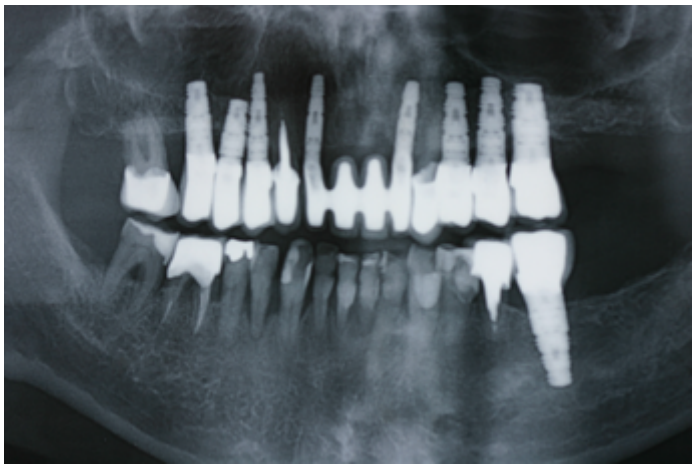

Fig. 1.1 *Case A: Panoramic radiography of a patient at a recall appointment. The implants appear longer and wider.*

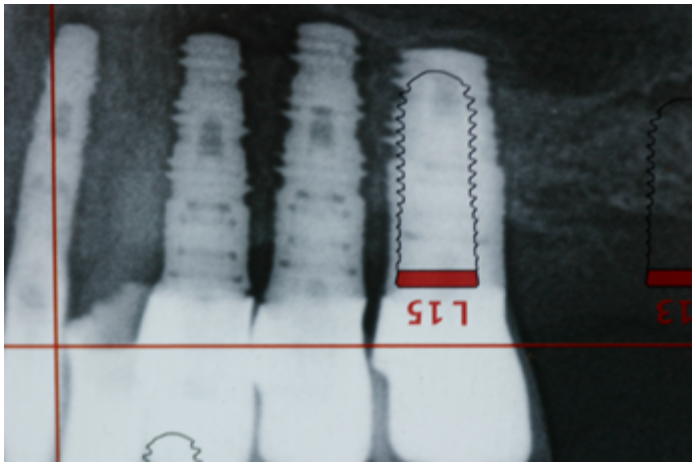

Fig. 1.2 *Superimposition of a measuring plastic transparent sheet on the panoramic film in region #27.*

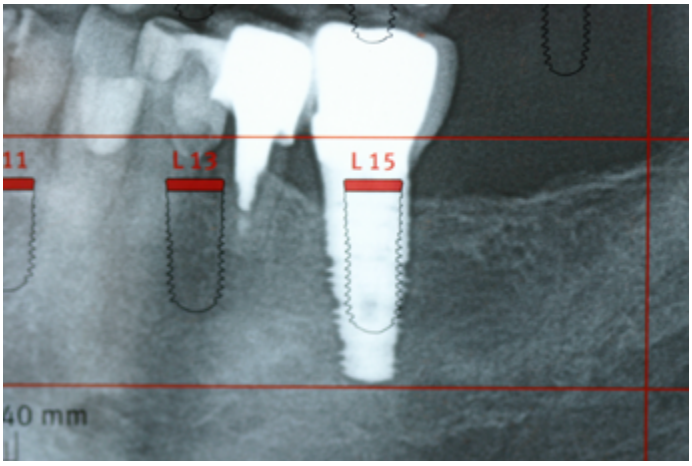

Fig. 1.3 *Superimposition of a measuring plastic transparent sheet on the panoramic film in region #36.*

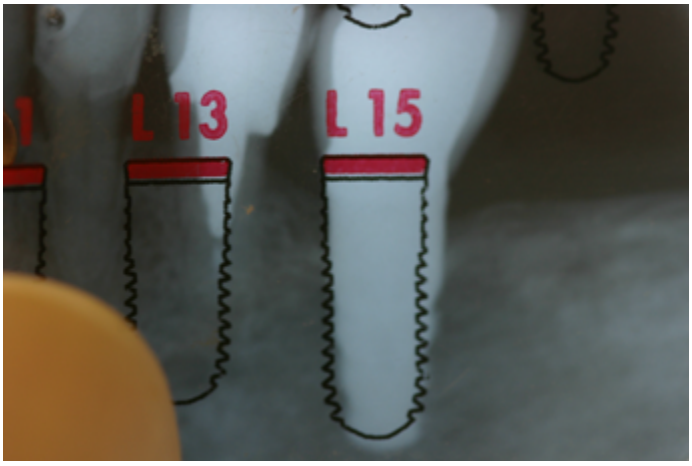

Fig. 1.4 *Superimposition of a measuring plastic transparent sheet on the periapical film in region #36.*

1.7 Case B (Figs. 1.5 to 1.8)

In Case B, the panoramic x-ray of a patient is presented upon the initial clinical examination (***Fig. 1.5***). The initial treatment plan in this case was a fixed restoration with four implants in the mandibular interforaminal area. The bone substrate in this area appears adequate in height and the alveolar crest has usually also adequate width. Even if the alveolar crest is sharp and narrow on its peak—with sufficient height—it can be usually grinded and flattened to create a plateau to allow implant placement. In the Computed Tomography of this case, however, the alveolar crest appeared extremely narrow and consisted practically of a labial and lingual cortical plate without any spongious bone. In some areas, it could be characterized as an "8-shaped mandible" (***Figs 1.6-1.8***). Based on the findings of the Computer Tomography, an augmentation technique for lateral increase of the width should be performed prior to the insertion of implants or the treatment plan could be modified accordingly.

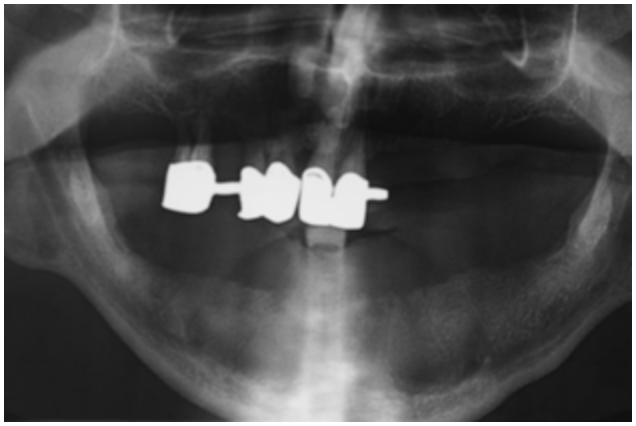

Fig. 1.5 *Case B, initial panoramic radiography of the patient.*

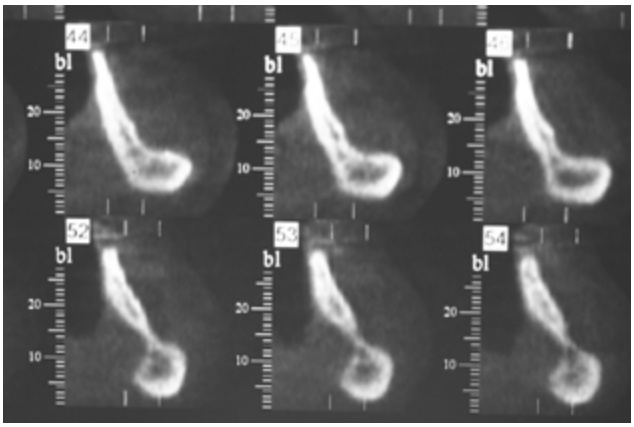

Fig. 1.6

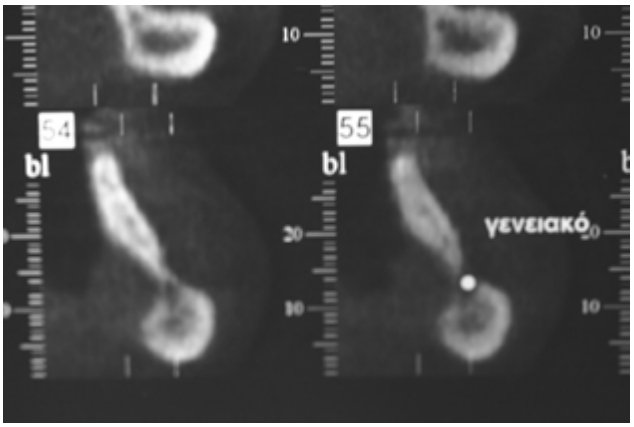

Fig. 1.7

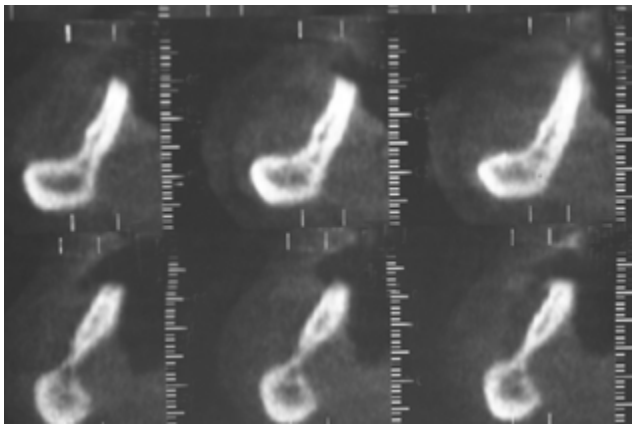

Fig. 18

Figs. 1.6, 1.7 and 1.8 *Cross-section images of the Computed Tomography of the mandible. Extremely absorbed alveolar crest and "8-shaped" mandible.*

1.8 Case C (Figs. 1.9-1.16)

The patient presented for restoration of the mandibular left quadrant. The patient wished a fixed restoration instead of the existing Removable Partial Denture. The initial clinical and radiographic examination revealed an alveolar crest reduced in height and severely absorbed in width (***Figs. 1.9-1.12***). The occlusal relation was found acceptable without any need for excessive occlusal corrections except for the canine areas #23/33.

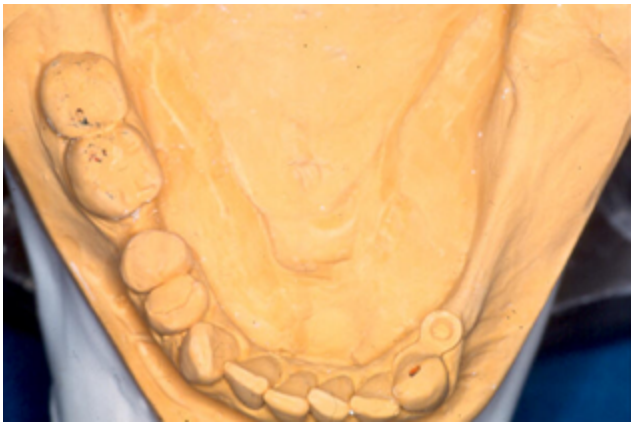

Fig. 1.9

Fig. 1.10

Figs. 1.9 and 1.10 *Case C: Study casts of the patient. Bone resorption is obvious, both in height and width.*

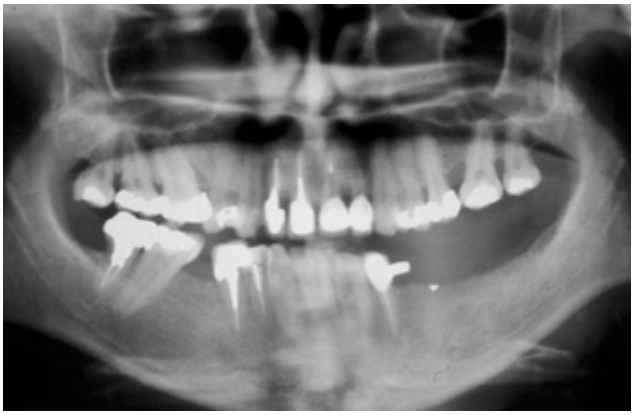

Fig. 1.11

Fig. 1.12

Figs. 1.11 and 1.12 *Panoramic radiography of the patient. The height of the alveolar ridge allows insertion of implants with adequate length.*

The Computed Tomography showed that a bone augmentation technique was necessary on the labial side of the alveolar to allow placement of the implants, as there was minimal spongy bone between the cortical plates (***Figs. 1.13 and 1.14***). Before any treatment procedure, the patient was carefully examined to verify the extent and expected efficacy of the augmentation procedure on the planned restoration. The needed surgical steps and the time needed for the implant restoration were explained to the patient, who wished to avoid extended surgical procedure.

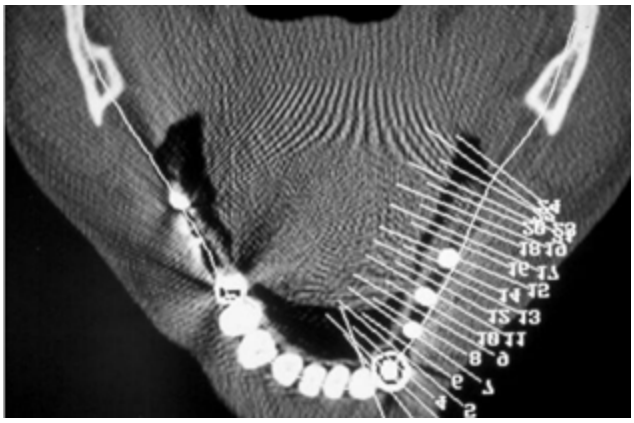

Fig. 1.13

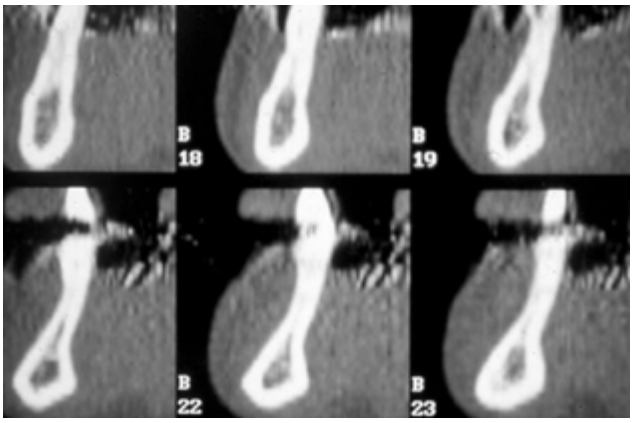

Fig. 1.14

Figs. 1.13 and 1.14 *Computer Tomography of the patient. The alveolar ridge is severely resorbed in width, and lateral augmentation is needed.*

1.9 Case D (Figs. 1.15-1.22)

The patient presented for treatment of the missing teeth #26, 36 and 37 (***Fig. 1.15***). The initial clinical examination revealed a normal alveolar crest with minimum absorption both in height and width for the mandibular posterior region. The patient expressed an intense wish to maintain her remaining teeth. On the panoramic x-ray (***Fig. 1.16***), several endodontic and periodontal problems of teeth #27 and 28 were recognized.

Study casts were fabricated and mounted on a semi-adjustable articulator (***Figs. 1.17 and 1.18***). On the study casts, severe overeruption of the maxillary molars was obvious protruding from the occlusal level. The prognosis of the molars was doubtful to poor due to the periodontal condition that included furcation involvement. If the teeth #27 and 28 would be maintained—according to the patient's wish—extensive periodontal treatment including bone surgery would be necessary and their prognosis would remain doubtful. Additionally, new root canal treatment and crown restoration would be necessary for both teeth #27 and 28, while their prognosis would remain doubtful.

Fig. 1.15

Fig. 1.16

Figs. 1.15 and 1.16 *Case D, initial clinical situation and panoramic radiography of the patient.*

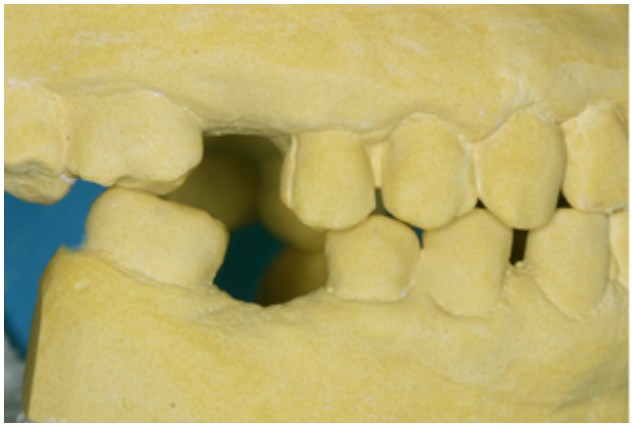

Fig. 1.17

Fig. 1.18

Figs. 1.17 and 1.18 *The study casts mounted on the articulator.*

Based on these findings, a treatment plan was made that included extraction of both maxillary molars and insertion of two implants in areas #26 and 27. As these teeth were over-erupted, the bone absorption following the extractions with minimum osteoplastic surgery could create adequate interarch space in the area. On the other side, the maxillary implants would have a better prognosis compared to the existing teeth in the present situation. Soft tissue surgery to reduce gingival thickness was also decided for the left distal side of the mandible that could be accomplished simultaneously to implant insertion.

The treatment plan was presented to the patient with details in all aspects. The patient consented for extraction of the teeth and insertion of two implants in the maxilla and two in the mandible. The case could be accomplished