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THE IMMEDIACY CONCEPT

Treatment Planning from Analog to Digital

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Contents

Foreword

In the past 50 years, modern implant dentistry—based on the concept of osseointegration—has made tremendous and constant progress to the benefit of patients. Osseointegration was first described by the two research groups of Prof P-I Brånemark from the University of Gothenburg and Prof André Schroeder from the University of Bern. In the 1980s and 1990s, the basic surgical principles were defined, the clinical indications expanded from fully edentulous to partially edentulous patients, the submerged versus nonsubmerged healing modalities were examined, and new microrough implant surfaces were tested, which initiated a paradigm shift in the dental implant market.

Since the millennium change, we have been in a phase of routine application of dental implants. In the past 20 years, many efforts have been made to improve the attractiveness of implant therapy for patients by reducing the surgical invasiveness, pain and morbidity, and healing and treatment periods required. Various placement protocols with immediate, early, and late implant placement postextraction were defined at an ITI Consensus Conference in 2003. In addition, the different loading protocols with immediate, early, and conventional loading and restoration were defined 5 years later.

The present textbook is edited by Dr Edmond Bedrossian, a gifted oral and maxillofacial surgeon and very experienced implant specialist. He was able to invite additional talented authors for contributions to the book, resulting in an excellent and very comprehensive textbook on the concept of immediacy. The first two chapters present the biologic basis of this concept, followed by relevant implant design aspects and biomechanical principles in chapters 3 and 4. Chapter 5 discusses the concept of nonsubmerged tissue-level implants, including the latest development with the TLX implant (Straumann). Chapters 6 to 9 then present the latest developments of the digital workflow in various clinical situations, which has had a tremendous positive impact for these implant treatments. The second half of the book deals with the treatment of fully edentulous patients, in particular the edentulous maxilla, where the immediate loading protocol is a tremendous service for patients for obvious reasons. The book then concludes with case presentations on all clinical situations described throughout to showcase everything that has been learned and how it can be applied.

The clinical chapters clearly show not only the great progress made with these treatment modalities, but also that these treatments are challenging for the clinician and complex in nature. Therefore, these procedures should only be carried out by skilled and experienced implant surgeons. Besides that, case selection based on well-defined selection criteria is very important to select the most appropriate treatment option in a given situation.

In conclusion, this is an excellent, clinically oriented textbook about the concept of immediacy in implant dentistry, and the reader will highly profit from the content. I congratulate Dr Edmond Bedrossian and the other authors. This book can be highly recommended to colleagues with an interest in this topic.

Daniel Buser, DMD, Dr med dent
Prof Emeritus, University of Bern

Preface

The emphasis of this book is that the preservation of alveolar hard and soft tissues is more predictable using the immediacy concept than is the reconstruction of the hard and soft tissues using the traditional delayed approach. Implant treatment is the most physiologic treatment offered to patients missing a single tooth, several teeth, and even their entire dentition. Internal loading of the alveolar bone with an implant-supported prosthesis maintains the alveolar bone volume after loss of teeth.

"Preservation is more predictable than reconstruction."

Treatment of patients with missing teeth has evolved over the past three decades from two-stage delayed loading of implants placed in healed extraction sites to immediate implant placement with immediate provisional restoration placement at the time the teeth are removed. On the other hand, the rehabilitations of the terminal dentition patient and the existing fully edentulous patient have also evolved from delayed placement and delayed loading to immediate placement, which can be performed both in the maxilla and the mandible. What was the motivation for this dramatic change?

- Improved patient comfort and satisfaction
- Shortened treatment time
- Greater treatment acceptance

The vast body of published literature on this subject has allowed for many systematic reviews that clearly support immediate implant placement, fabrication of immediate provisionals, and immediate loading in appropriate clinical settings. Even in extreme cases of alveolar resorption, immediate implant placement with the use of tilted and/or zygomatic implants for the rehabilitation of the edentulous maxilla with a fixed prosthesis has also demonstrated success rates of over 97%. These published success rates are consistent with the 97% to 98% success rate expected with the traditional two-stage delayed loading protocols.

This book presents up-to-date information from discussion of the fundamental (analog) prosthetic and surgical treatment planning protocols to the integration and use of available digital workflows that complement everyday clinical practice. I am confident that readers will appreciate the journey through this book. The authors of every chapter underscore the fundamental scientific facts essential for predictable treatment planning with the practical presentation of clinical protocols for positive short- and long-term outcomes. This patient-centric approach results in the most contemporary and up-to-date information for our colleagues and their patients in every single chapter. The first chapter begins with a comprehensive discussion of distance and contact osteogenesis. Later chapters present the implant micro and macro design features necessary for achieving immediacy. Fundamental analog surgical as well as prosthetic protocols are presented in subsequent chapters. The role of the digital workflow is comprehensively discussed, and its use for the treatment of missing single to fully edentulous cases is presented through the remaining chapters. The final chapters illustrate multiple case reports utilizing and executing the information learned in previous chapters.

Prof P-I Brånemark's sentiment stands true today as it did the day he stated it:

"No one should die with their teeth in a glass of water."

The chapters written by leaders in the field of implant dentistry intend to follow the simple but powerful objectives set by Prof Brånemark, which include interdisciplinary collaboration, simplification, and following science with well-established treatment planning and protocols. The messages from each of Prof Brånemark's objectives are as follows:

Interdisciplinary collaboration between the implant team, the restorative dentist, the surgeon, and the laboratory technician is critical in proper treatment planning, execution of plans, and the long-term maintenance of implant reconstructions. In cases of patients with congenital and/or acquired maxillofacial defects, collaboration with our medical colleagues is also vital.

Simplification refers to the comprehensive understanding of a subject or a procedure. In order to discuss a subject or to execute a procedure and have others respond by saying, "You make it look simple," the complete command of the subject or the procedure is necessary. Knowing the level of predictable outcomes by proper preoperative clinical evaluation and treatment planning leads to practical and predictable prognosis. Therefore, realistic appreciation of the difference between "optimal" and "adequate" treatment outcomes is critical.

Following science and having a comprehensive knowledge of well-established protocols are essential to prevent complications. Following these objectives will lead to treating our patients in the most predictable manner with predictable long-term prognoses. After all, the patient is paramount.

Enjoy the content of this textbook; I am confident that you will find the comprehensive and contemporary information as essential for your daily practice as I do in mine.

Acknowledgments

This textbook was made possible by collaboration between global leaders of implant dentistry, and this collaboration has been a privilege and the highlight of my career. Without their unselfish sharing of their years of experience and knowledge, this project would not have been possible. I am extremely thankful for Drs Larry Brecht and Armand Bedrossian, who have been invaluable as coeditors as well as contributors to various chapters in this book.

Dr Danny Buser, an icon in the field of dental implants and ITI, has graciously written the foreword for this textbook, further confirming that the authors have provided implant teams with the most current and contemporary scientific information to treat our patients in the best possible manner.

I would also like to thank Elizabeth Murdoch Titcomb of Iolite Biomedical Communications for the creative illustrations throughout this textbook, allowing comprehensive and clear communications of many anatomical and technical concepts.

I am humbled by the collaboration of so many of the globally renowned authors of this textbook and am confident that we have honored the objectives set forth by my mentor, friend, and the father of osseointegration, Prof P-I Brånemark.

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SECTION I

THE IMMEDIACY CONCEPT

Included topics:

- Osseointegration Demystified
- Biologic Principles and the Immediacy Concept
- Implant Design for the Immediacy Concept
- Biomechanical Principles for Immediate Loading
- The Tissue-Level Implant

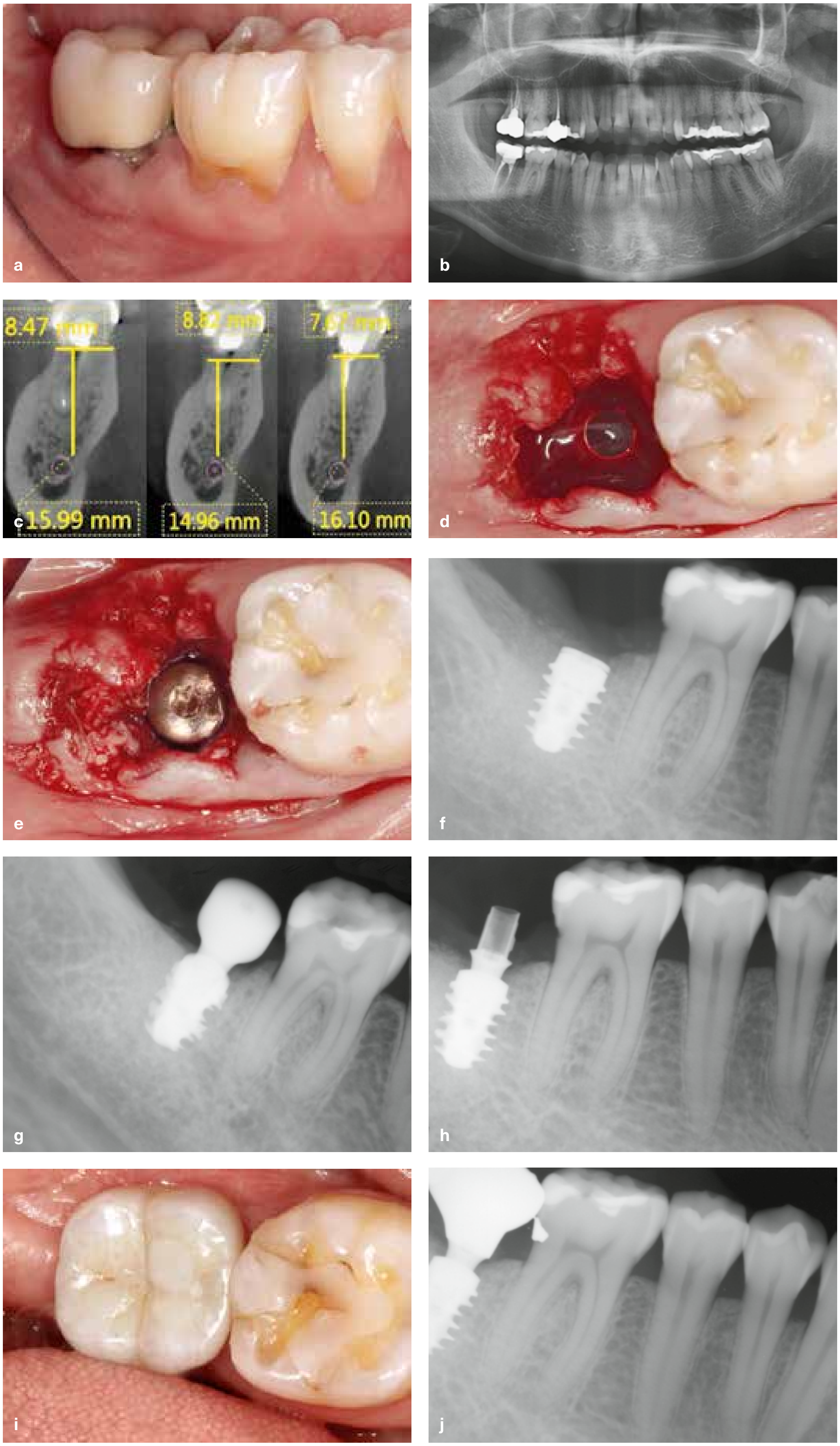
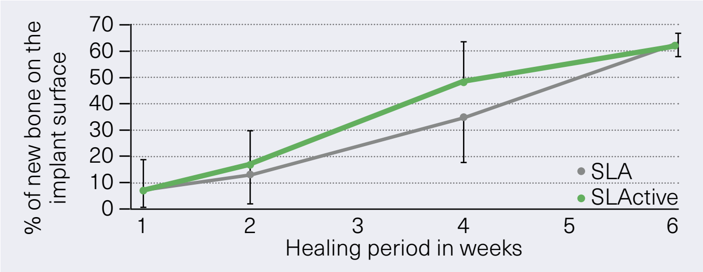


FIG 2-1 *(a to j)* Clinical and radiographic presentation of a nonrestorable second molar.



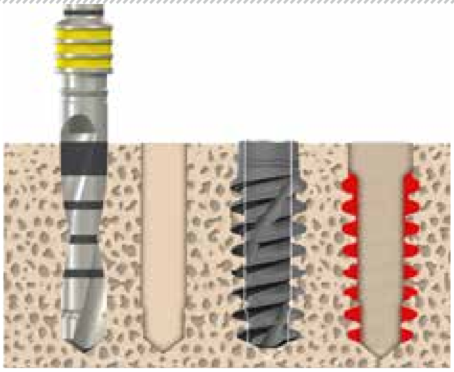


FIG 3-2 During the same healing period, implants with the SLActive surface enhancement show a higher BIC.

FIG 3-3 Atraumatic preparation of a narrower diameter osteotomy and the enlargement of the osteotomy by implant threads.

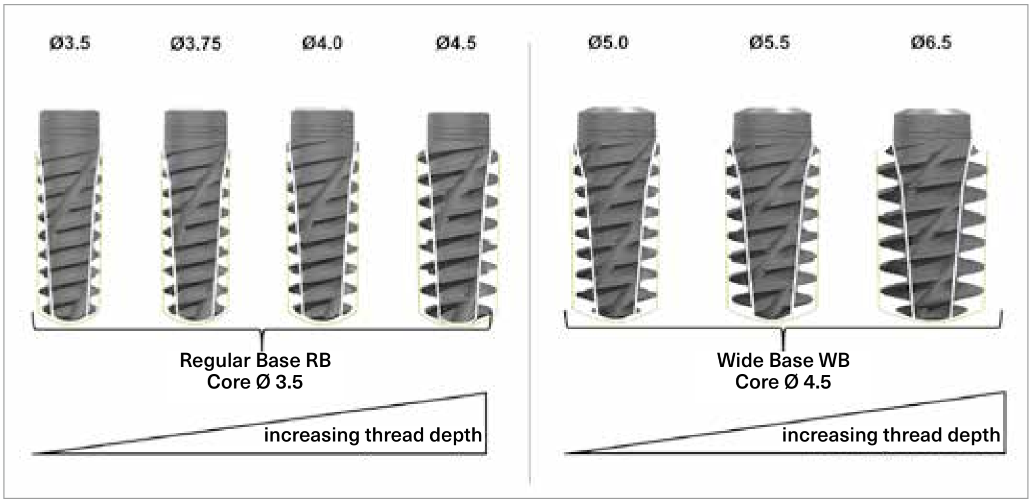


FIG 3-4 A tapered thread design allows for lateral compression of the cancellous bone, allowing initial stability to be achieved.

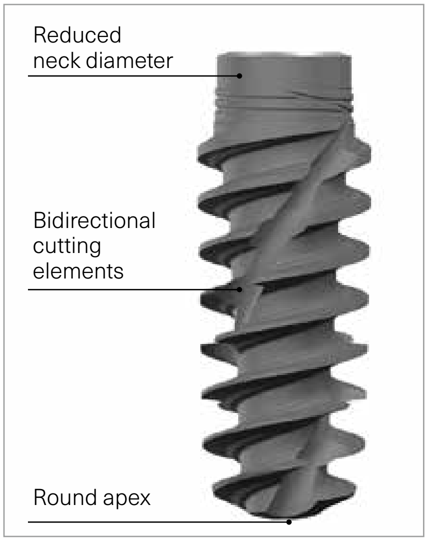
Implant core design

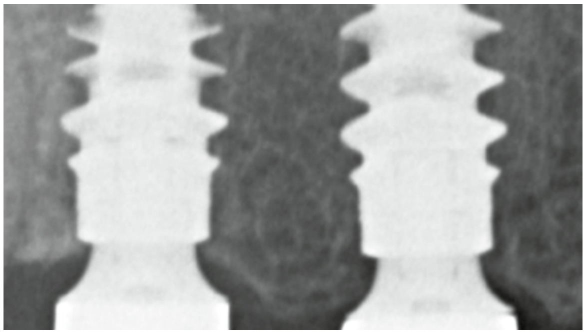
Limiting the diameter of the implant core allows for the preparation of a narrower osteotomy with decreased level of trauma to the alveolar bone. The cutting of the bone results in cellular apoptosis and therefore a potential increase in the catabolic phase of osseous remodeling, leading to development of soft tissues between the osteotomy and the implant. Wang and coworkers[22] described the advantages of limiting the cutting of the bone and increasing the compression of the bone instead in order to minimize the catabolic portion of the remodeling and therefore attain as well as maintain the initial stability of the implant at the time of placement (Fig 3-3).

During the insertion of the implant, initial stability is achieved by the thread design becoming progressively wider and thicker from the apical portion of the implant up to its platform. The tapered thread design, the favored geometry of most contemporary implant designs, allows for the progressive lateral as well as vertical compression of the surrounding trabecular bone (Fig 3-4). The resultant initial stability of the implant, especially in cases of limited bone following extractions and immediate implant placement, is very predictable.

Bidirectional cutting elements

The macro design of implant threads should facilitate forward as well as reverse cutting of the osteotomy during the insertion of the implant. The self-tapping design of an implant





◀ **FIG 3-5** An implant with a rounded tip may be less traumatic if in close proximity to vital structures.

▶ **FIG 3-6** The reduced-neck diameter avoids excessive compression of the cortical bone, stabilizing and preserving its position at the implant platform.

plays a significant role in the atraumatic insertion of implants, especially in undersized osteotomies. The ability of the surgeon to advance and reverse the implant during its insertion, especially in dense bone, allows for the enlargement of the osteotomy with simultaneous horizontal and vertical compression of the surrounding trabecular bone. The ability of the implant to behave like a "tap" drill allows the surgeon to achieve their desired initial stability.

Round apical tip design

At times, the apical portion of an implant is in close proximity to vital anatomical structures, including the following:

- The nasal floor in the anterior maxilla
- The floor of the maxillary sinus in the posterior maxilla
- The inferior alveolar nerve canal in the posterior mandible

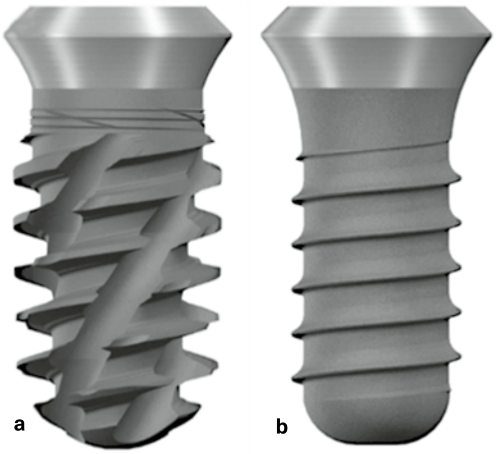
Surgeons generally allow 2 mm of distance between the apical portion of the implant and vital anatomical structures. However, in cases where closer relationships between the implant apex and the vital structures are present, a rounded or noncutting tip design of the implant may be beneficial (Fig 3-5).

Reduced neck diameter

Although a tapered geometry of an implant placed into an undersized osteotomy is advantageous for achieving initial stability, excessive compression of the cortical crestal bone by the widest portion of the tapered implant can lead to avascular necrosis of the bone surrounding the implant platform, resulting in crestal bone loss. Therefore, a reduced implant platform diameter (compared to the most coronal implant thread) limits excessive lateral stresses at the avascular cortical crestal bone, limiting potential crestal bone loss (Fig 3-6). This property of an implant design is important in the very dense cortical bone present in the mandible as well as the fragile and limited cortical bone thickness in the maxillary alveolar crest.

◀ **FIG 5-4** TLX implant *(a)* compared with TL implant *(b)*.

▶ **FIG 5-5** BIC is seen along the enhanced surface of the TLX implant.



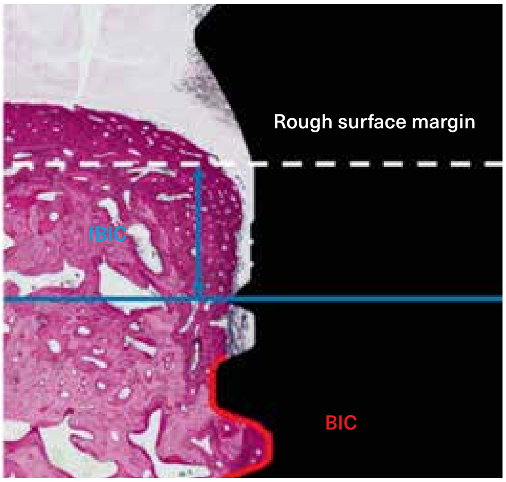
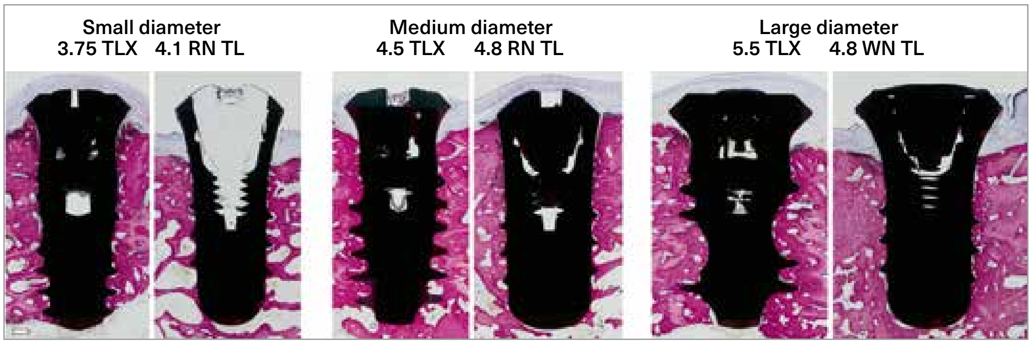


FIG 5-6 BIC is consistent and stable between the different diameters of the TLX and the TL implants.

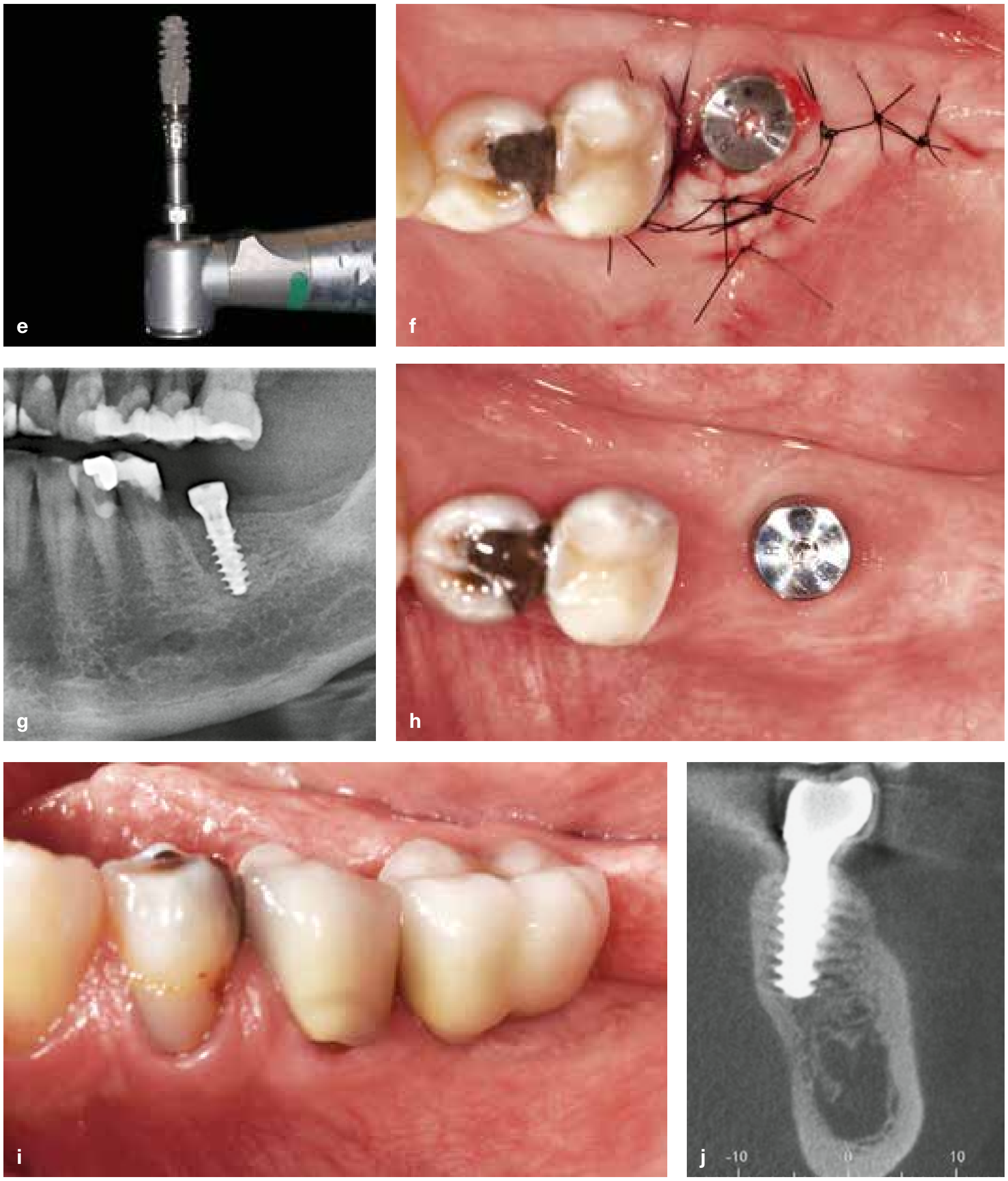


With the marginal bone level as well as the soft tissue benefits of the nonsubmerged, one-piece implant, the new generation of this type of implant is referred to as the TLX (Straumann). The TLX implant also has two different surface topographies. The intraosseous portion is enhanced with acid-etched technology, whereas the extraosseous soft tissue portion is machined titanium.

The TLX implant is very similar to its predecessor the TL implant (Fig 5-4). The implant threads are the same as the BLX implant (Straumann), which allow for better initial stability due to the fully tapered design with progressive widening as well as thickening of the threads from the apical portion upward to the last most coronal thread. The "neck" or platform of the implant is slightly narrower than the widest, most coronal thread, thereby reducing the lateral compression on the avascular crestal cortical bone as the implant base attaches to the platform-switching profile of the soft tissue portion of the implant.

El Chaar and colleagues, in a 2021 study, compared the one-piece TLX implant to the existing and well-documented Straumann Tissue Level implant[53] (Fig 5-5). They concluded that the adaptation of bone to the most coronal portion of the implant threads is predictable. Three different diameters of the TLX implant were compared to the TL implant, with equivocal results (Fig 5-6). Both implant types displayed noninferior and equivalent levels of osseointegration and bone height maintenance, while the test implants displayed significantly higher primary implant stability. The combination of observations indicates that the novel implant type is able to provide high levels of primary stability combined with a comparable osseointegration pattern to the benchmark TL implants.

FIG 5-7 *(cont)* *(e)* The 4.5-mm-diameter TLX implant. *(f)* Closure cap in place. *(g)* Immediate postoperative panoramic radiograph. *(h)* Proper healing of the soft tissues around the TLX abutment. *(i)* Definitive screw-retained crown. *(j)* Stable marginal bone levels.



Case 2: Guided TLX

A 64-year-old man presented with missing mandibular left first molar (Fig 5-8a). Guided surgery for the placement of a TLX implant was planned in the coDiagnostiX software (Fig 5-8b). A tooth-borne surgical guide as well as an immediate provisional restoration were printed in preparation for the procedure (Fig 5-8c). With the use of the tooth-borne implant guide (Fig 5-8d), a 4.5 × 14–mm TLX implant was placed at 50 Ncm insertion torque (Fig 5-8e).

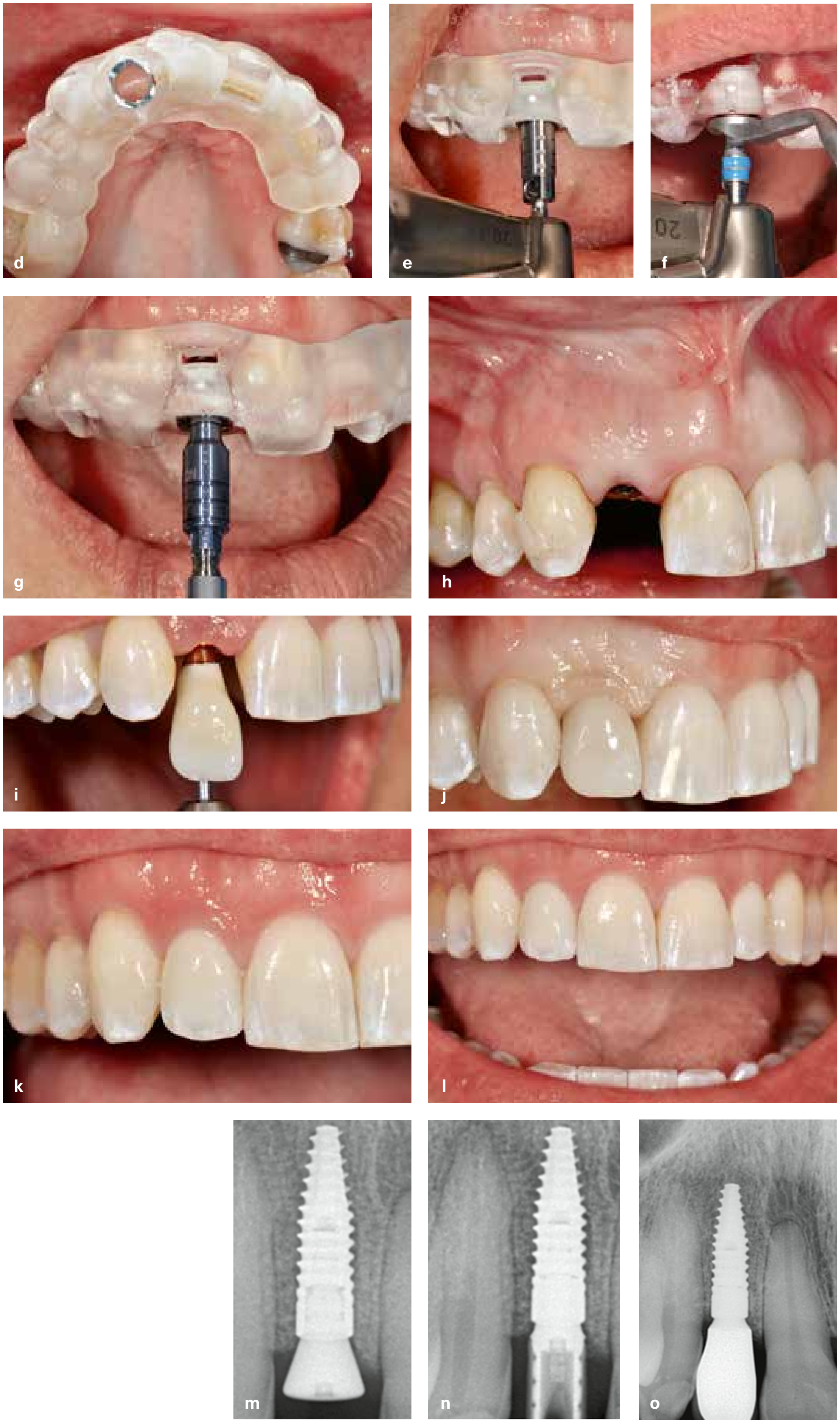


FIG 6-4 *(cont) (d)* Printed surgical guide with 5-mm-diameter master cylinder that will allow fully guided surgery, including implant placement. Note the four inspection windows that are used to confirm guide seating. *(e)* Guided tissue punch. Flapless surgery was planned because the zone and quality of marginal tissue was favorable and no bone grafting was planned. *(f)* Preliminary preparation of the osteotomy with a 2.2-mm-diameter, medium-length drill. Note that the drill guide will act as a vertical stop. *(g)* Guided implant placement. The lines on the driver marked H2/H4/H6 will define the depth of implant placement through the guide. This final step reduces deviation between planning and executed implant position. *(h)* Surgery completed. Healing abutment in place. *(i)* Provisional restoration delivery at 8 weeks of healing. The role of the provisional restoration is to develop the peri-implant marginal tissue architecture. *(j)* Note the initial tissue blanching. *(k and l)* Definitive restoration: intraoral and open-mouth views at 6 months postrestoration. *(m to o)* Radiographs on day of surgery, day of provisional restoration insertion, and 14 months postrestoration.

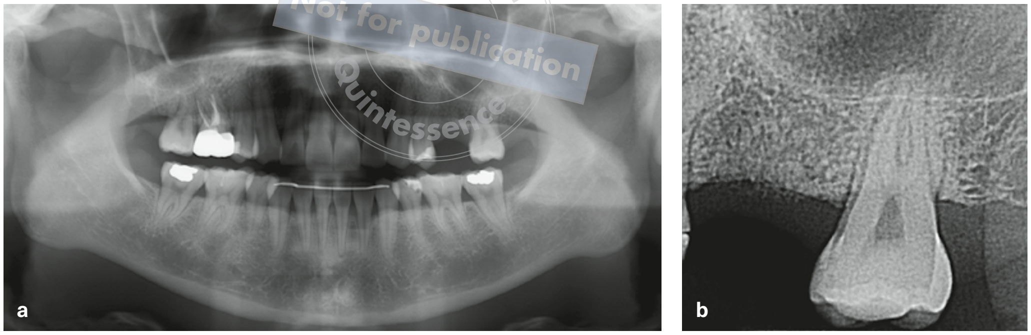


FIG 7-1 *(a)* Panoramic radiograph providing anatomical considerations and periodontal condition of the dentition. The vertical height of the partially edentulous maxillary alveolar bone can be identified, as can the location of the maxillary sinus. *(b)* Periapical radiograph providing a localized view of the sinus and available vertical bone height.

Materials, techniques, and workflows in dental treatment have changed over the years. Conventional methods related to alginate impressions for diagnostic casts, followed by wax-ups to aid in envisioning and planning dental implants were predictable but time consuming and labor intensive. As digital technology has been embraced in the dental field, the use of intraoral scanning and implant planning software has surpassed conventional techniques for a more contemporary method of data acquisition, planning, and dental implant treatment. The purpose of this chapter is to review the sequence of steps and records needed for digital implant planning and treatment.

Acquiring Data

For many years, extraoral and intraoral photography has been a powerful tool for patients, interdisciplinary treatment, and laboratory communication. Whether treatment is involving a single-tooth or full-mouth rehabilitation, gathering photographs with an outside-in approach (macro to micro)[1] has allowed for comprehensive planning in a 2D perspective. Furthermore, radiographs—panoramic and/or periapical—have allowed clinicians to evaluate the teeth, hard tissue, and anatomical landmarks necessary for dental and/or implant planning in a 2D view (Fig 7-1). These radiographs allowed the clinician to evaluate the amount of bone available vertically, permitting them to choose the proper implant length. Although 2D diagnostic information was and still is predictable for treatment planning, if a 3D view of both the hard and soft tissues were available, this would allow the clinician to choose the width of the implant, as well as envision any anatomical landmarks or limitations in a comprehensive manner.

As dentistry evolves, the implementation of digital technology increases in treatment workflows.[2] There are several methods to utilize digital technology in implant treatment, and a fundamental understanding of traditional "analog" techniques is imperative to optimize complete digital workflows. The innovations in digital technology have been increasingly adopted by the dental community, providing clinicians with the tools for comprehensive diagnosis, planning, and therapy.[3] With the evolution of 3D technology, such as CBCT and intraoral scans (IOSs), clinicians are able to evaluate and plan implant treatment.

The CBCT (Fig 7-2) may be an efficient tool to evaluate hard anatomical structures for implant therapy, as it has a relatively low acquisition time and patient dose as compared with a medical CT.[4–6] The digital imaging and communications in medicine (DICOM) file acquired from the CBCT can be utilized in various implant planning softwares, allowing the

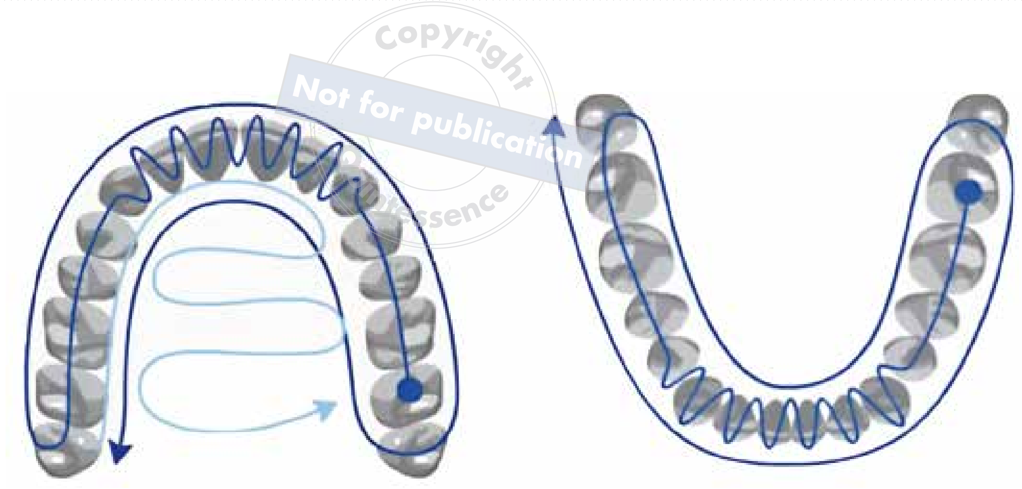


FIG 7-4 Each intraoral scanner has a manufacturer's scan path that should be followed to allow for the most accurate digital impression. These images depict the scan path for 3Shape's Trios 4 scanner.

reported improved laboratory communication can also be argued, due to the efficacy of communicating through traditional models before scanning had been introduced. As for the disadvantages, a proper impression technique with a dry field and tissue retraction is still imperative for accurate IOS.

The STL file provides digital raw data collected in the form of polygons or triangles representing the *x*, *y*, and *z* planes of the digitized surface. Each IOS has its respected scan acquisition workflow and scan path. For instance, the scan path for the Trios IOS by 3Shape (Fig 7-4) has been shown to provide the most optimal stitching of the images, providing an accurate acquisition of the diagnostic digital impression.

Superimposition of DICOM and STL

The acquisition of both DICOM and STL files allows the operator to predictably treatment plan the surgical placement of the implant, while also keeping in mind the planned prosthetic position. The most important step of the digital workflow is the alignment of both the DICOM and STL files in the implant software. If the superimposition is done incorrectly, implant planning and/or important anatomical considerations can be compromised.

Each software has its own methods of importing these files and digital planning. In this book, coDiagnostiX by Dental Wings, a subsidiary of Straumann, will be utilized for all digital planning and workflows. When starting a new case to plan, the initial step with coDiagnostiX is to import the CBCT DICOM files. Once imported, the DICOM file must be aligned with the coordinate system evaluating the sagittal, coronal, and axial position. Once set, the panoramic curve must be established, identifying the incisal point of the desired arch, in order to generate a series of panoramic views of the teeth and bone. If the mandibular arch is where the treatment is desired, identifying the inferior alveolar nerve is the subsequent step. Now the CBCT is imported and ready to accept an imported STL model scan.

The STL model scan can be imported and aligned to the CBCT. By identifying a minimum of three corresponding regions (Fig 7-5a) on both the CBCT and model scan, the software will confirm that both DICOM and STL files are superimposed accurately (Fig 7-5b). The presence of metal ceramic or zirconia prostheses may display scatter in the DICOM, which can make the alignment difficult. Once superimposed properly, implants can be selected from the digital library, which offers a multitude of implants provided in the market today.

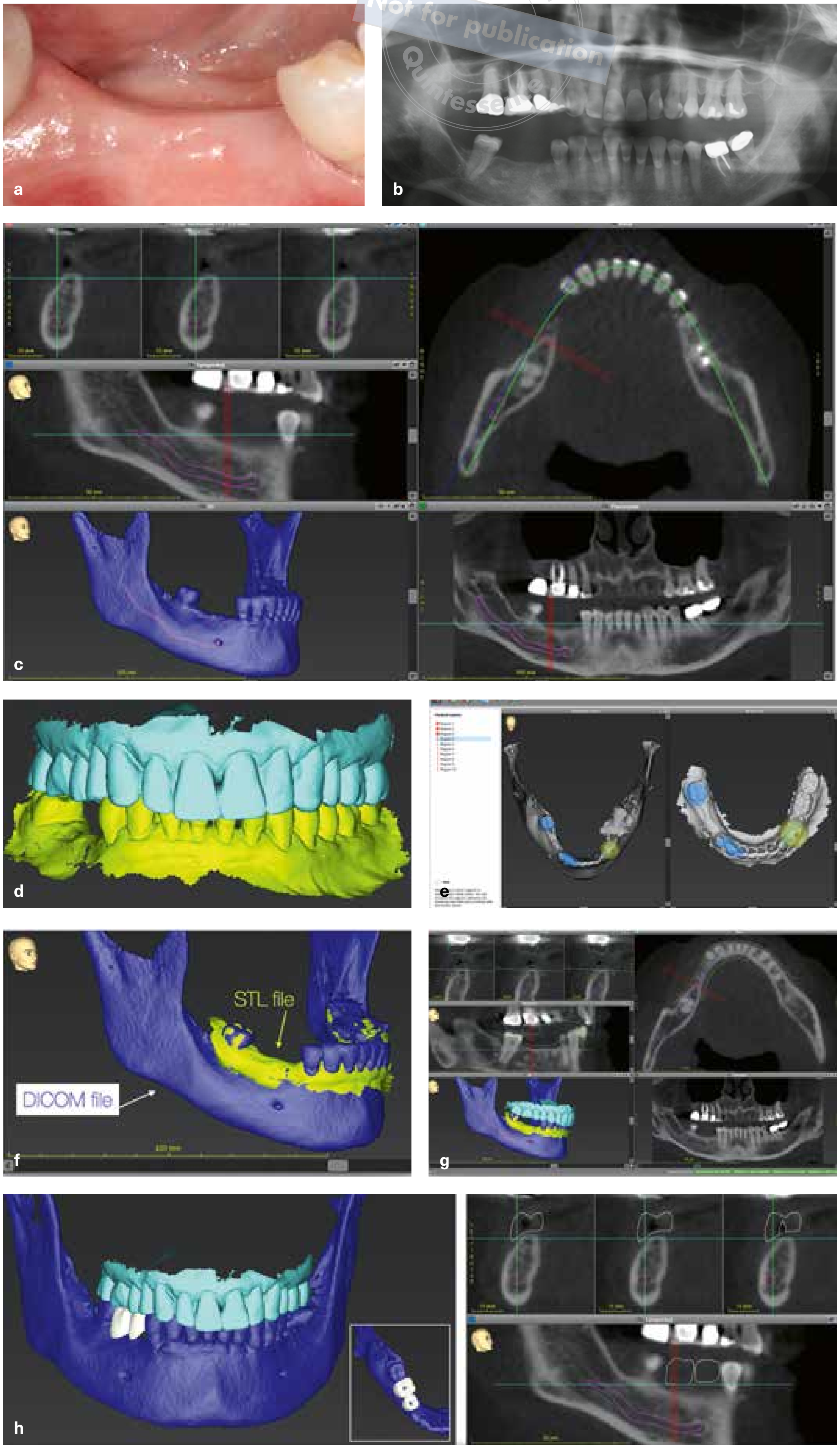


FIG 7-8 *(a)* Preoperative clinical presentation of the partially edentulous ridge for missing mandibular right premolar and first molar. *(b)* Preoperative 2D panoramic radiograph. *(c and d)* Acquisition of the DICOM and STL files. These two files are the first step for any digital planning for implant therapy. *(e to g)* Alignment of the DICOM and STL files in the coDiagnostiX implant planning software. A minimum of three points, cross-arch, are chosen on both files to align and superimpose the files accurately. *(h)* Digital teeth imported in the edentulous site for comprehensive prosthetic treatment planning. Utilizing the STL file of the opposing arch allows the clinician to position the planned teeth in the occlusal relationship prior to planning the implant positions.

FIG 7-8 *(cont)* *(i)* The implant sites were planned in coDiagnostiX for Straumann BLX implants. The alignment of the DICOM and STL file, as well as importing digital teeth, allows the clinician to surgically and prosthetically plan the implant position for predictable guided surgery. The tooth-borne guide was finalized in coDiagnostiX *(j)* and then printed *(k)*. The *arrows* indicate the design of the tooth-borne guide with inspection windows to ensure complete seating of the guide at the time of surgery. *(l and m)* The tooth-borne guide seated on the day of surgery. The inspection windows indicated by the *arrows* assure the clinician of complete seating of the guide. *(n to s)* Progressive drill sequence for the osteotomy preparations of the mandibular right second premolar and first molar sites. The sequence for the BLX guided kit is planned in the coDiagnostiX software, and the planned surgery can be printed and available for the surgeon. →

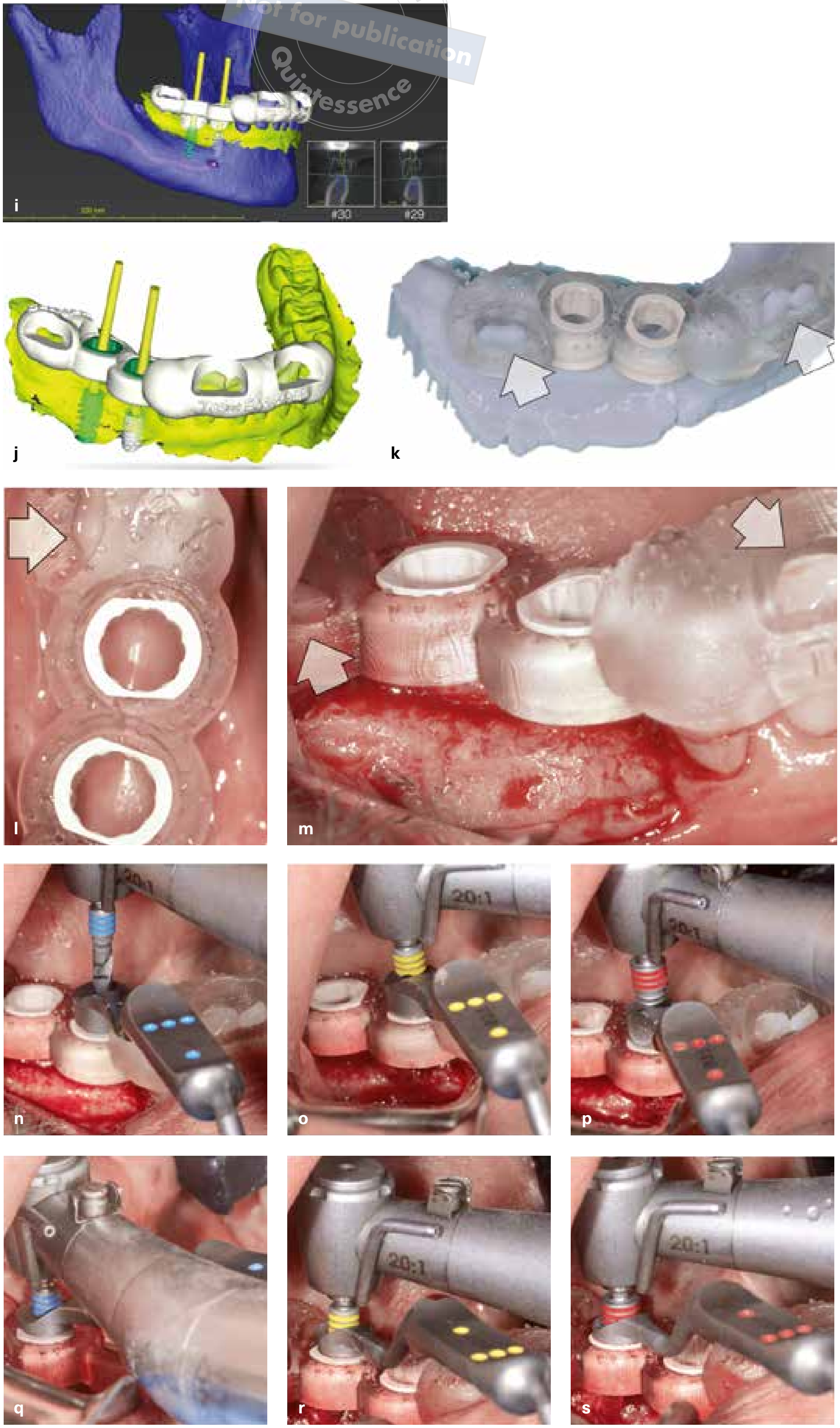


FIG 7-9 *(cont)* *(h and i)* Shade photos of the adjacent teeth taken prior to any restorative work to prevent desiccation, which could impair accurate shade communication with the dental laboratory. *(j)* The soft tissue and interproximal papillae are preserved by the immediate implant and immediate provisional treatment. This soft tissue emergence should be transferred to the laboratory to aid in designing the custom abutment and crown.

imperative when utilizing IOS for any restorative treatment. In this case, using the Trios 4 scanner, we followed the scan path indicated in Fig 7-4. The initial step is to scan the complete mandibular arch is captured with the implant provisional in place. This allows the clinician to capture the entire arch without concerns about the collapse of the soft tissue emergence. This is not as essential for posterior cases, as capturing the emergence is more essential for anterior esthetic situations. Once the entire arch is scanned, the provisional is removed and the scan body is placed and quickly scanned to capture the implant orientation and position. The software will then be able to align the scans to aid the laboratory with the implant position and occlusion, allowing for the design and fabrication of the definitive crown (Fig 7-9k). This scanning progression provides the clinician with more control of capturing the scan body's anatomy and soft tissue emergence (Figs 7-9l and 7-9m). At this time, the provisional can be placed back onto the implant, and the opposing arch and occlusal registration scans may be captured.

BOX 7-2

Steps for treatment planning utilizing a digital workflow

1. Data acquisition
   - DICOM files
   - STL file
   - Photographs
2. Superimposition
   - Import into implant planning software: coDiagnostiX software
3. Guided surgery
   - In-house 3D model and surgical guide printing
4. Definitive prosthesis
5. Digital impressions and CAD/CAM fabrication

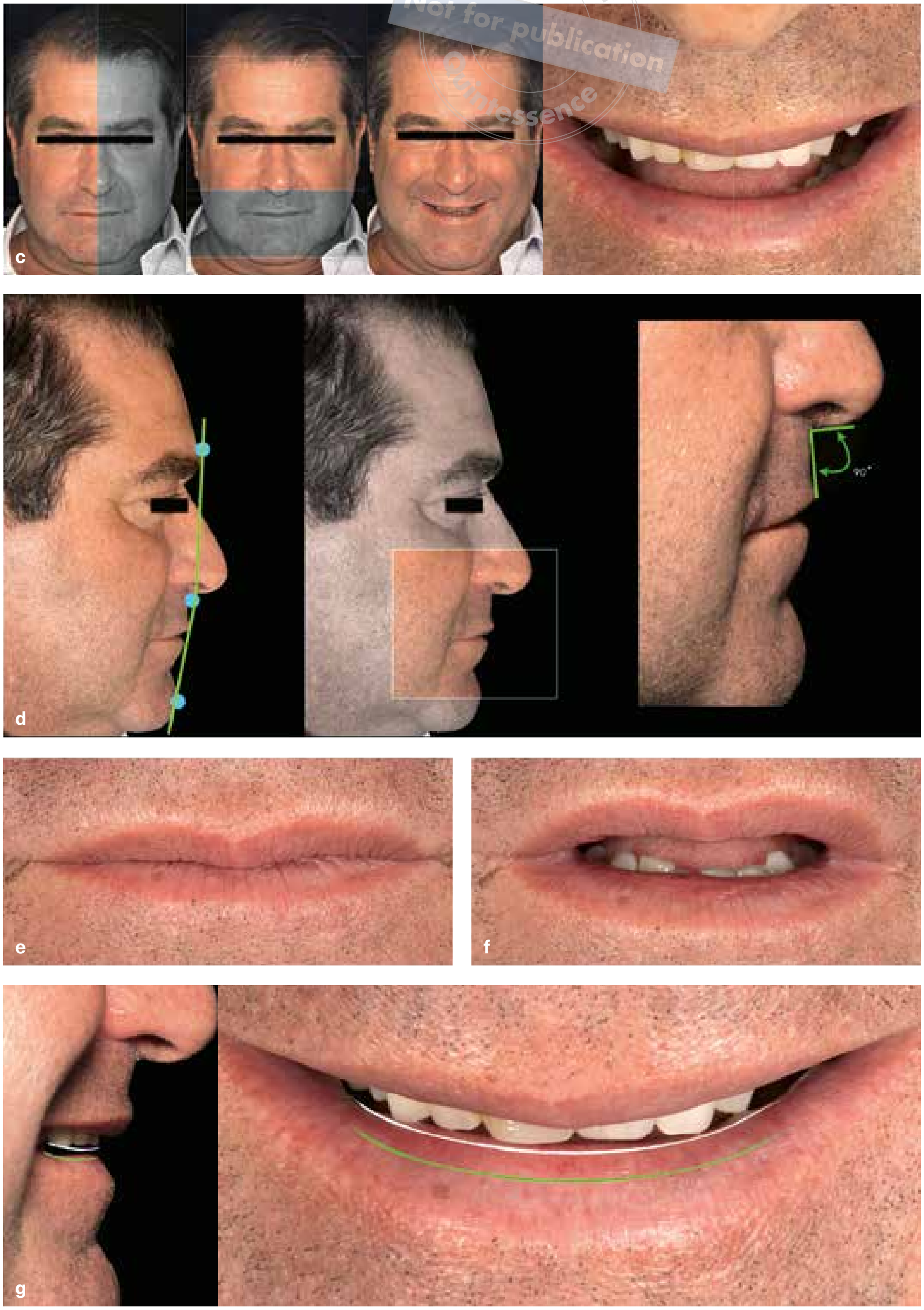
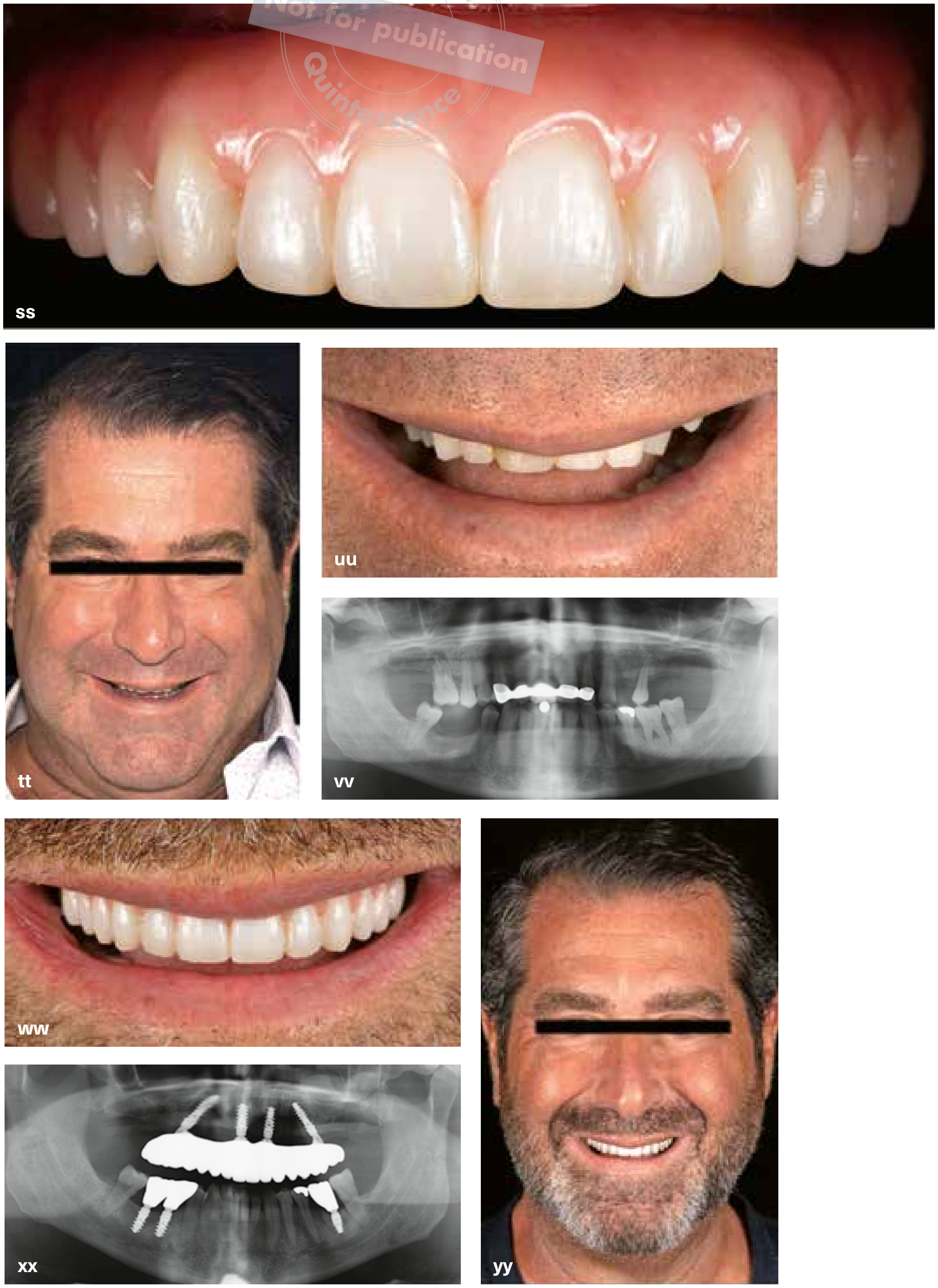


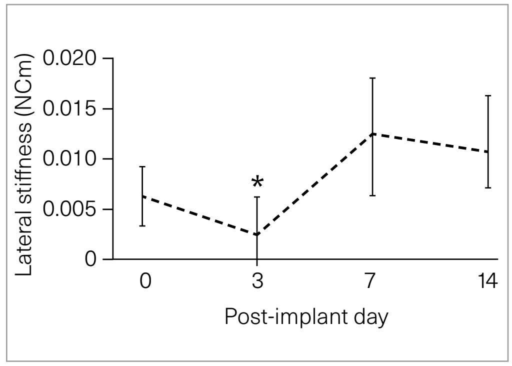
FIG 7-10 *(cont)* *(c and d)* The "macro" esthetics. *(c)* His frontal evaluation demonstrates that he has a symmetric face and an appropriate occlusal vertical dimension (OVD). Upon smiling, his dental midline is coincident with his facial midline. *(d)* His lateral profile demonstrates a slightly convex yet orthognathic profile. His nasolabial angle is appropriate, ensuring that the anterior positioning of his maxillary incisors provides adequate upper lip support. *(e to g)* The "mini" esthetics: These three photos are essential for evaluating a patient's smile. *(e)* Competent lip closure ensures that a patient may have appropriate OVD and can close his lips without strain. *(f)* The repose photograph is the most important, as it demonstrates no incisal display at rest position, implying that lengthening his incisors will need to be done and communicated with the laboratory to provide an esthetic outcome. *(g)* The smile evaluation demonstrates a guarded smile with minimal lip dynamic and tooth display. What it does imply is that the occlusal plane of the existing dentition is coincident with the lower lip curvature and should be followed for the denture setup.

As will be discussed in chapter 9, on full-arch treatment planning, a proper diagnosis is essential prior to treatment. When assessing the panoramic radiograph, as well as the CBCT analysis and clinical periodontal evaluations, the diagnosis for our patient was a composite defect (Figs 7-10i and 7-10j). A composite defect diagnosis, indicating the loss of hard and soft tissue, is appropriately restored with a fixed prosthesis 3 (FP-3), which

FIG 7-10 *(cont)* *(ss)* The monolithic zirconia prosthesis milled and delivered, improving the esthetics, phonetics, and function for the patient. The before *(tt to vv)* and after *(ww to yy)* of the maxillary zirconia prosthesis. The tooth proportions, display, and buccal corridors are filled to provide a uniform, symmetric, and esthetic result. The monolithic nature of the ceramic prostheses provides strength, while the liquid ceramic (MiYo by Jensen Dental) provides the color and texture for a natural appearance.



evaluate the esthetics, phonetics, OVD, and occlusion. Any adjustments necessary can be made to this prototype and sent back to the laboratory for comprehensive communication and replicated when fabricating the definitive zirconia prosthesis. The second is a pink and white PMMA prototype, delivered to the patient to "test-drive" the parameters mentioned, as well as receive feedback from friends and family prior to fabricating and delivering the definitive zirconia prosthesis.



◀ **FIG 9-2** Proper placement of the immediate implant with a mesio-buccal-distal space.

▶ **FIG 9-3** Implant stability quotient (ISQ) values consistent with the catabolic and anabolic phases of remodeling.

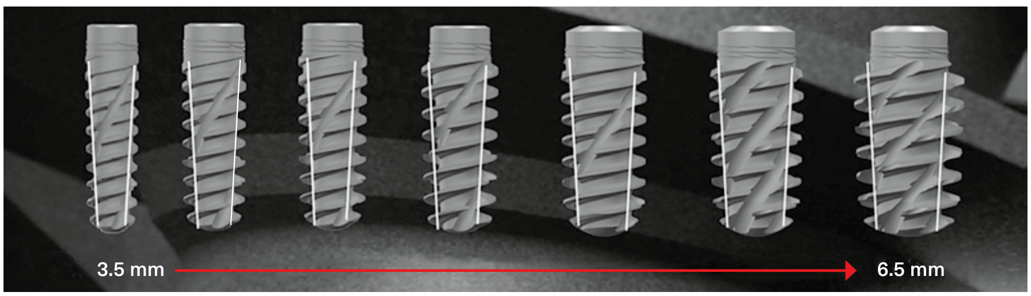


FIG 9-4 Narrow core of the BLX implant.

in an extraction site. The crestal dimension of the extraction site is much larger than the implant platform diameter, so the surgeon's ability to negotiate the existing walls of the extraction site for proper preparation of the osteotomy for stabilization of the implant is imperative (Fig 9-2).

For proper initial stability of an implant placed in a limited volume of bone, such as an extraction site, geometry of the implant for immediacy is critical. The design of the implant, the modification of the surgical technique, and limiting the amount of "cutting" of the residual alveolus all play a major role in the success of immediately placed implants.

Bone remodeling

The art of osseointegration is in limiting bone remodeling through the use of appropriate hardware and the adoption of a well-designed and atraumatic surgical technique. Upon initiation of the osteotomy, apoptosis, or the death of cells at the periphery of the osteotomy, occurs.[11] Once the bone is "traumatized" during the preparation of the osteotomy, the peripheral dying of cells and their replacement with new bone is referred to as the *remodeling process* and is responsible for the dip in stability seen in the first 6 to 8 weeks as described by Glauser et al[12] (Fig 9-3).

Implant geometry

Wang and colleagues[11] wrote that one approach to reducing the amount of osteocyte death, and thereby reducing bone resorption, is to limit bone cutting and instead attempt to deform the bone sufficiently to create space for an implant. An implant with a narrow core and progressively widening and thickened threads will result in the lateral as well as vertical compression of the cancellous bone, resulting in the atraumatic insertion of endosseous implants. The narrow core of the Straumann BLX implant reduces the need for cutting in order to enlarge the osteotomy for the placement of the implant (Fig 9-4). By limiting the cutting of the bone with the progressive use of larger and larger diameter drills, the surgeon relies on the ability to

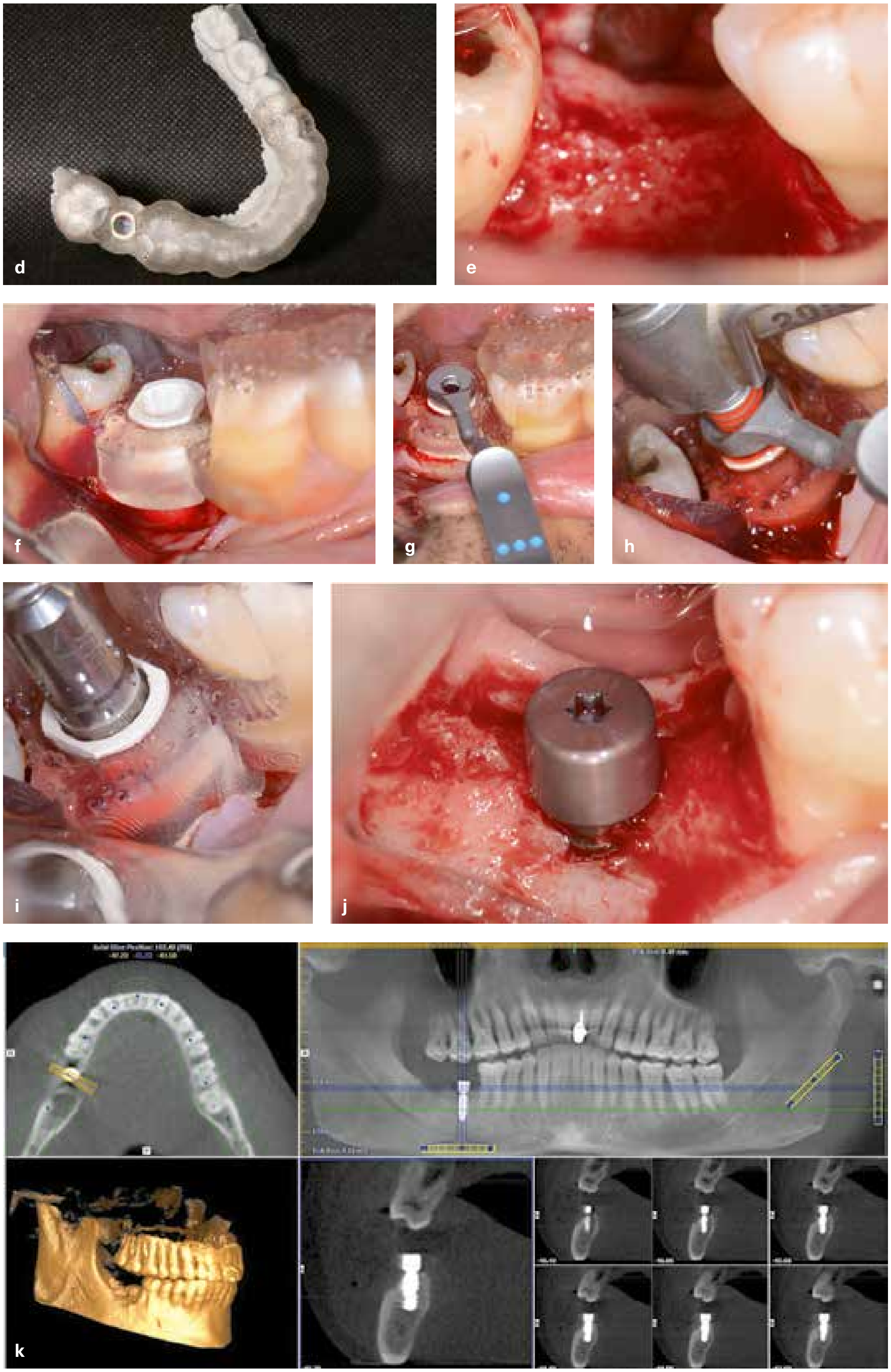


FIG 9-6 *(cont)* *(d)* Surgical guide printed with DLP. *(e)* Full-thickness flap exposing the surgical site. *(f)* Fully seated guide as confirmed by looking through the inspection windows. *(g)* Drill guides used per planning instruction protocol. *(h)* Fully guided drill. *(i)* Insertion of the implant through the guide. *(j)* Temporary healing abutment in place; the one-stage protocol. *(k)* Postoperative CBCT scan with implant position as planned.

TABLE 10-1
Implant placement protocol vs loading protocol

	Immediate restoration/ loading (Type A)	Early loading (Type B)	Conventional loading (Type C)
Immediate implant placement (Type 1)	Type 1A: CD	Type 1B: CD	Type 1C: SCV
Early implant placement (Types 2 and 3)	Type 2/3A: CID	Type 2/3B: CID	Type 2/3C: SCV
Late implant placement (Type 4)	Type 4A: CD	Type 4B: SCV	Type 4V: SCV

CD, clinically documented; SCV, scientifically and clinically valid; CID, clinically insufficiently documented.

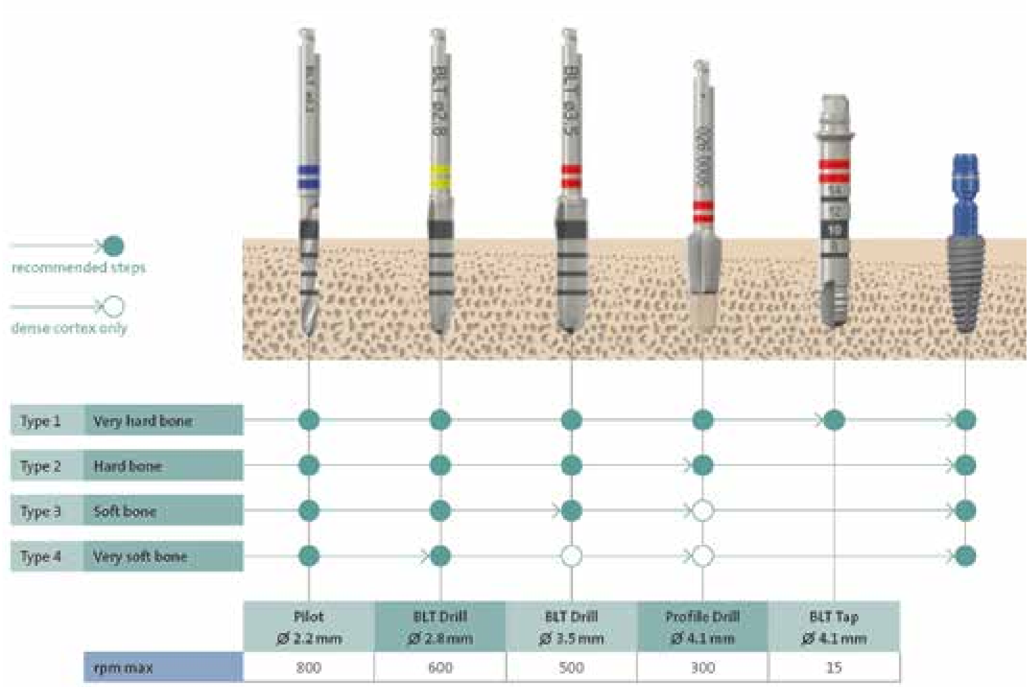


FIG 10-1 Drilling protocols should be customized according to bone density to optimize primary stability.

Technical Aspects of Immediacy

Bahat and Sullivan[12] listed factors that may affect implant loading positively or negatively. These factors included implant design, surgical technique, and implant finish. Stavropoulos et al[13] and Bedrossian and Bedrossian[14] listed important principles for consideration with regard to immediate loading. Undersizing the osteotomy, higher insertion torque, and the design of the implants being used are surgical principles for achieving the desired stability of implants for immediate loading[14] (Fig 10-1).

A specific drilling protocol should be used, according to the type and size of implant, and adapted to the bone density of the location where the implant is to be placed. Moreover, primary stability can be measured in different ways. Although scientific studies try to standardize measurement devices and protocols, in clinical reality, there is no consensus on what the best measurement device is or what measurement outcome is more appropriate to proceed with immediate loading. Insertion torque measured in Ncm and resonance frequency analyses (RFAs) are the most commonly cited protocols to measure primary stability.[15] In clinical use, insertion torque seems to be more widely used, since all implant placement devices can measure the insertion torque in Ncm. An insertion torque of 40 Ncm is considered a good primary stability of the implant in order to allow for immediate loading.

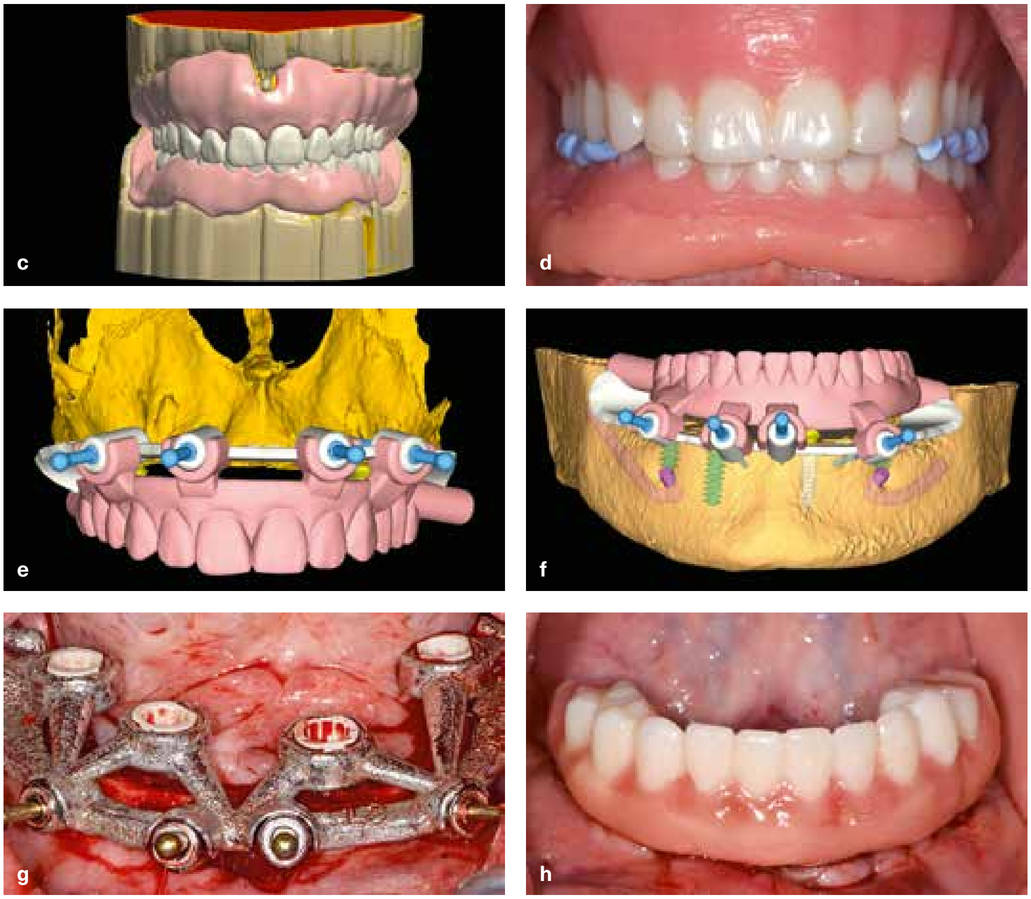


FIG 10-4 *(cont)* *(c)* Virtual wax-up of definitive prosthesis. *(d)* Try-in of interim prosthesis. Teeth were extracted in a staged procedure. *(e)* Virtual surgical planning of maxillary bone reduction and implant placement with Straumann BLX implants. *(f)* Virtual surgical planning of mandibular bone reduction and implant placement, also with Straumann BLX implants. *(g)* Intraoperative view of mandible with stackable metal printed guides for bone reduction and implant placement. *(h)* Immediate loading of the mandibular prosthesis.

teeth, which is critical for proper and esthetic soft tissue drape. Other considerations included interarch prosthetic space requirements for the fabrication of a fixed immediate-load provisional as well as the planned definitive zirconia prosthesis. Proper number and distribution of implants was planned to allow for the maximum anteroposterior (AP) distribution, minimizing to eliminating posterior cantilevers (Figs 10-4e and 10-4f).

The guided surgery followed the "stackable" guide concept protocol. The bone-reduction templates were positioned using occlusal interdigitation and horizontal stabilizing pins. Subsequent to the planned ridge reduction, the implant positioning templates were positioned using support designed into the bone-reduction templates (Figs 10-4g and 10-4h). All templates were printed in base metal alloy, allowing for the minimization of bulk and facilitating access for irrigation.

Four BLX implants (Straumann) were positioned in each arch. Primary stability of all implants was considered to be excellent, between 35 and 40 Ncm. Screw-retained abutments were placed on all implants and torqued to 35 Ncm without any rotation of the placed implants, confirming appropriate initial stability to consider immediate loading. Titanium nonengaging provisional abutments were positioned on all implants and torqued to 15 Ncm. Prefabricated provisional prostheses, designed to be implant supported, were oriented by stabilization with fixation pins to the bone-reduction guide (Figs 10-4i to 9-4k). The provisionals were indexed to the temporary titanium cylinders using autopolymerizing methyl methacrylate resin.

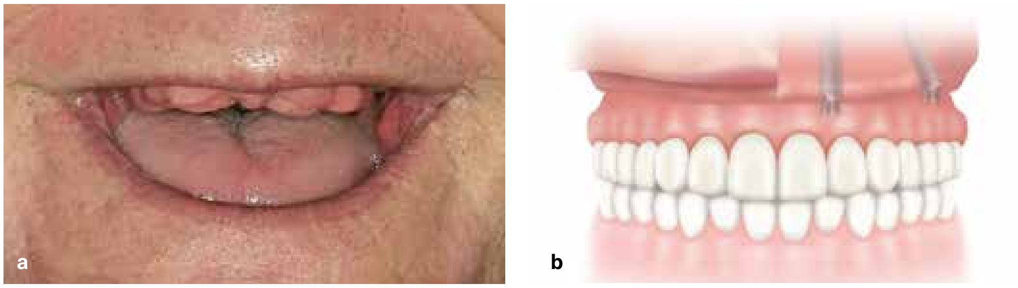


FIG 11-8 *(a)* Visible edentulous maxillary crestal soft tissues in maximum smile. *(b)* A visible transition line results in an unesthetic outcome. (Part *b* copyright E. M. Titcomb 2022.)

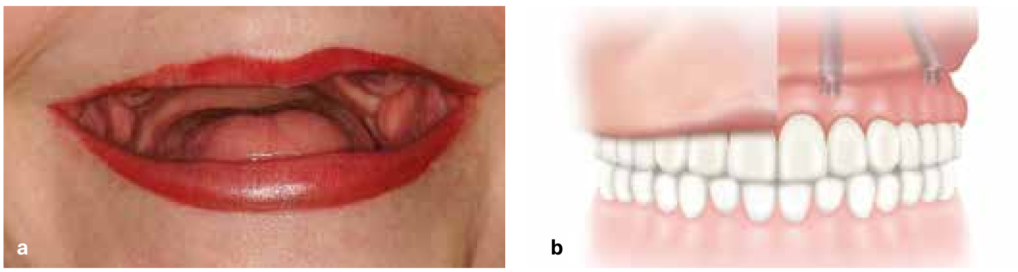


FIG 11-9 *(a)* Hidden edentulous maxillary crestal soft tissues. *(b)* A hidden transition line results in an esthetic outcome. (Part *b* copyright E. M. Titcomb 2022.)

◀ **FIG 11-10** Terminal dentition with potential visible transition line.

▶ **FIG 11-11** Terminal dentition with a hidden transition line.

For patients with terminal dentition, the same evaluation protocol applies. If the patient displays their free gingival margins as well as the buccal alveolus in maximum smile (Fig 11-10), the potential for the exposure of the transition line of the final hybrid prosthesis with an unesthetic outcome is predictable. However, if the patient does not display their maxillary alveolus during maximum smile (Fig 11-11), then the transition line of the final hybrid prosthesis will be hidden and therefore result in an esthetic outcome.

If the transition line (ie, the crestal soft tissue) is visible in the preoperative evaluation, two possible final prosthetic designs are possible: the fixed hybrid prosthesis or the implant-supported overdenture. If a fixed hybrid prosthesis is planned, alveoloplasty, reducing the height of the alveolus at least 2 to 3 mm apical to the lip line during maximum smile, is indicated. If an alveoloplasty is not performed or is not possible due to large pneumatized maxillary sinuses, an implant-supported overdenture with a flange that overlaps the alveolus would be indicated.

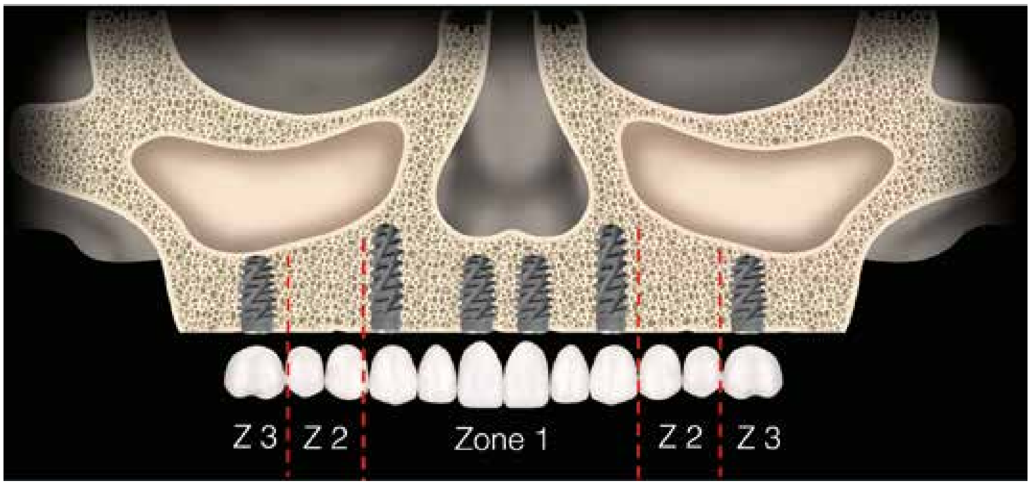


FIG 11-14 Presence of all three zones with axial implants along the arch length. (Copyright E. M. Titcomb 2022.)

support are placed in the axial or tilted trajectory. The same applies if the zygomatic implant is planned for posterior support as well as in cases where the quad-zygoma treatment concept is planned.

For an edentulous ridge, a minimum of four implants should be considered, although placing more than four implants may also be an option, depending on the available bone volume and other functional considerations.[5,6] The distribution of the implants should be planned to eliminate the need for cantilevered teeth distal to the terminal implants in the provisional as well as the definitive prosthesis. As a general principle, presence of cantilevers on a fixed maxillary restoration should be avoided or minimized to a maximum of one tooth to avoid unfavorable load transfer to the prosthetic components, the alveolar bone, and the existing implants.[7,8]

Presence of zones 1, 2, and 3

For patients with alveolar bone present in all three zones of the edentulous maxilla, four to six conventional implants in an axial trajectory may be placed along the arch length (Fig 11-14). Four implants would allow for a favorable AP distribution of implants. The placement of additional implants in the canine positions helps in the distribution of forces along the prosthesis under function in lateral excursive movements.[9,10]

Presence of zones 1 and 2; absence of zone 3

For patients lacking bone in zone 3 due to large pneumatized maxillary sinuses, inclining the posterior implants in front of and parallel to the anterior maxillary sinus wall allows for an adequate AP distribution of implants to support a fixed restoration while avoiding the need for grafting (Fig 11-15). Use of tilted implants has been shown to be successful with immediate loading procedures of the completely edentulous maxilla[5,6,11–16] and therefore a sound treatment option in this group of patients.

However, an alternative to the use of inclined implants in patients with limited bone in zone 2 as well as lacking bone in zone 3 is sinus grafting, followed by simultaneous or delayed implant placement (Fig 11-16). When extensive sinus grafting is performed, a staged approach is considered due to lower survival rate when implants are loaded in newly grafted

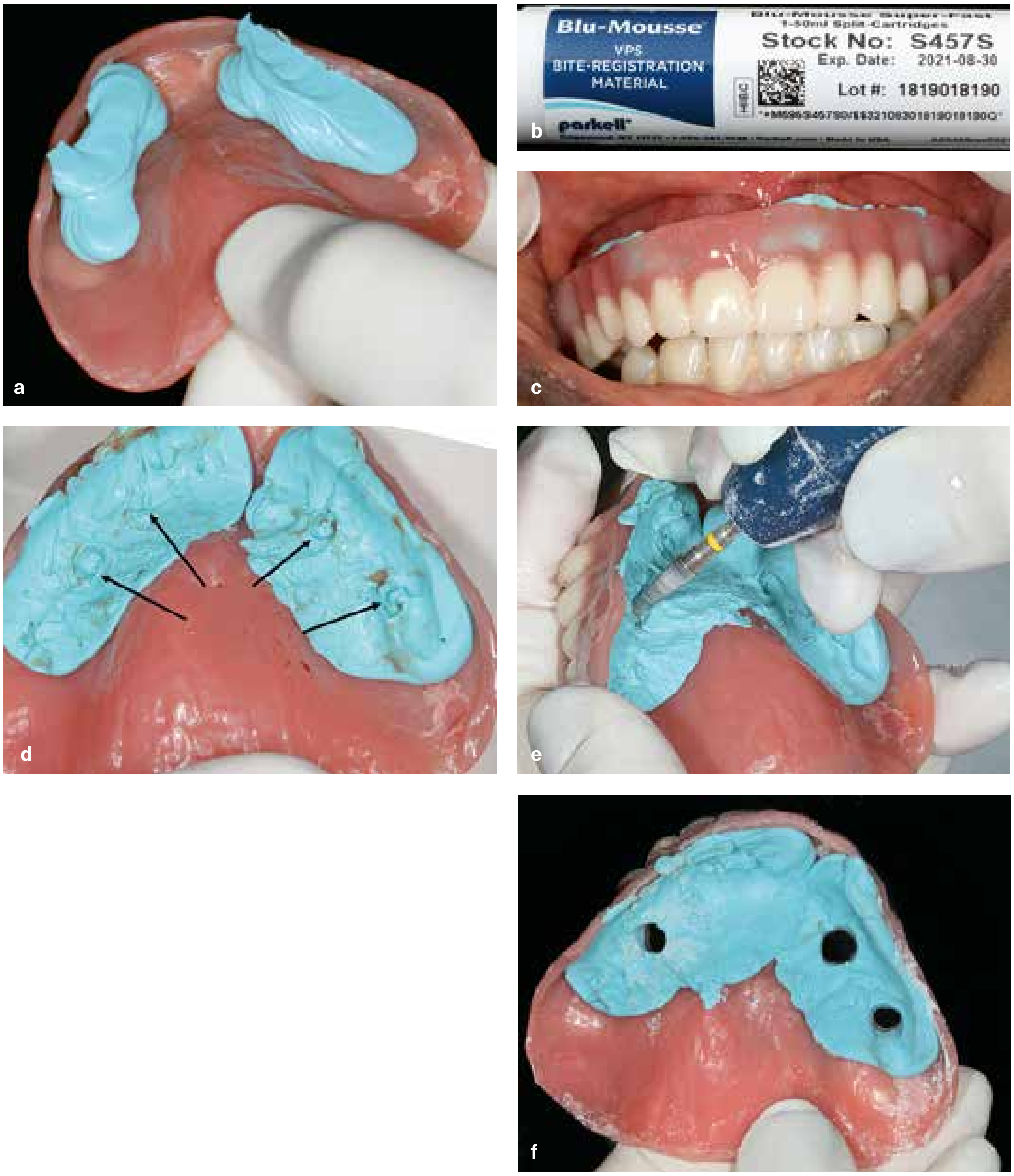


FIG 14-6 *(a and b)* Quick-setting bite registration material is placed inside the removable prosthesis to register the position of the SRAs. *(c)* The removable prosthesis with the bite registration material on the tissue surface is seated fully into place against the intact palate. *(d)* The position of the SRAs is located in the bite registration material *(arrows)*. *(e and f)* Holes are placed in the conversion prosthesis in the locations of the SRAs.

As the prosthesis is being seated over the temporary cylinders, care is taken to make sure that the prosthesis is able to again fully seat into place over the palate in the maxilla, or over the retromolar pads and/or external oblique ridges in the mandible. It is often helpful to shorten the temporary cylinders from their original length to facilitate passing the removable prosthesis over the cylinders when they are all in place. This is especially true if the cylinders are at widely divergent angles. If needed, the holes in the removable prosthesis should be widened appropriately at this point to ensure that the prosthesis fully clears the temporary cylinders and is allowed to seat fully on the tissues.

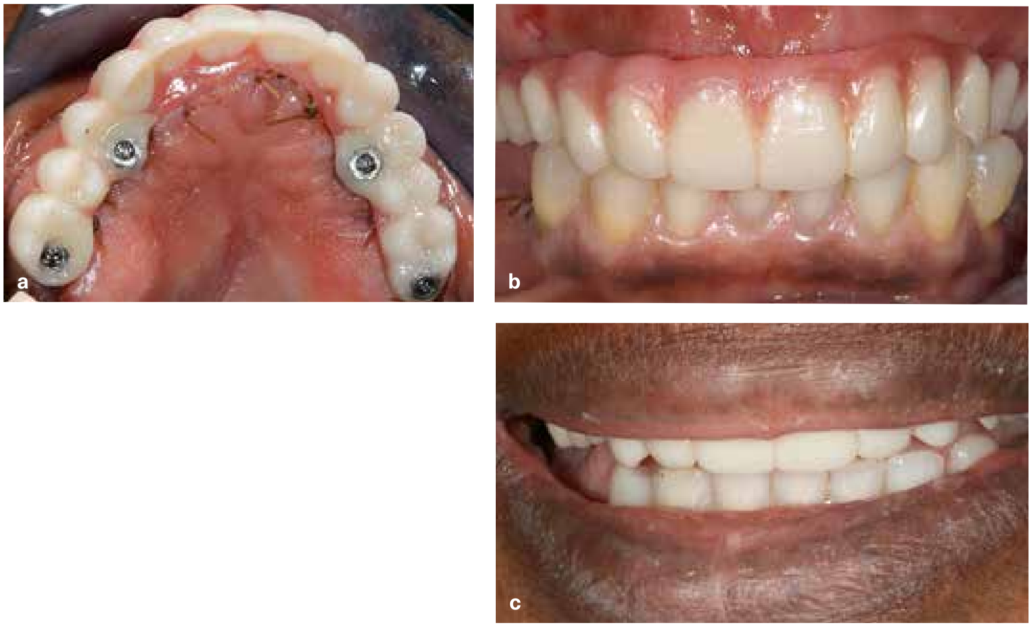


FIG 14-9 *(a)* The conversion prosthesis is returned to the patient and the occlusion checked and adjusted if indicated. Note that no posterior cantilevers are present in the acrylic immediate-load conversion prosthesis. *(b and c)* The now screw-retained fixed conversion prosthesis is checked for speech, esthetics, and comfort. The patient is instructed on oral hygiene protocols to maintain the health of the supporting tissues.

The recontoured conversion prosthesis is now returned to the patient and seated over the implants and on the SRAs. The occlusion is examined to ensure that there are even contacts. Contacts should be as close to over the implants in a vertical axis as possible. Contacts on cuspal inclines should be minimized. Most importantly, there should be no cantilevers on the conversion prosthesis[8] (Fig 14-9a).

During the healing phase, while bone is forming on the surface of the implants, cantilevers magnify the forces on the terminal implants that could result in a failure of successful osseointegration.[9] Once the conversion prosthesis has been checked for comfort, speech, and appropriate occlusal contacts, the prosthetic screws are tightened to 10 Ncm (Figs 14-9b and 14-9c).

The titanium temporary cylinders are sealed with PTFE tape packing and Fermit (Ivoclar Vivadent) or composite. Postsurgical instructions are reviewed for hygiene, diet, and avoidance of any habits. The patient is dismissed and seen in follow-up 7 to 10 days later. If at all possible, the fixed conversion prosthesis is not removed for 3 months in the maxilla and 2 months in the mandible.[10,11]

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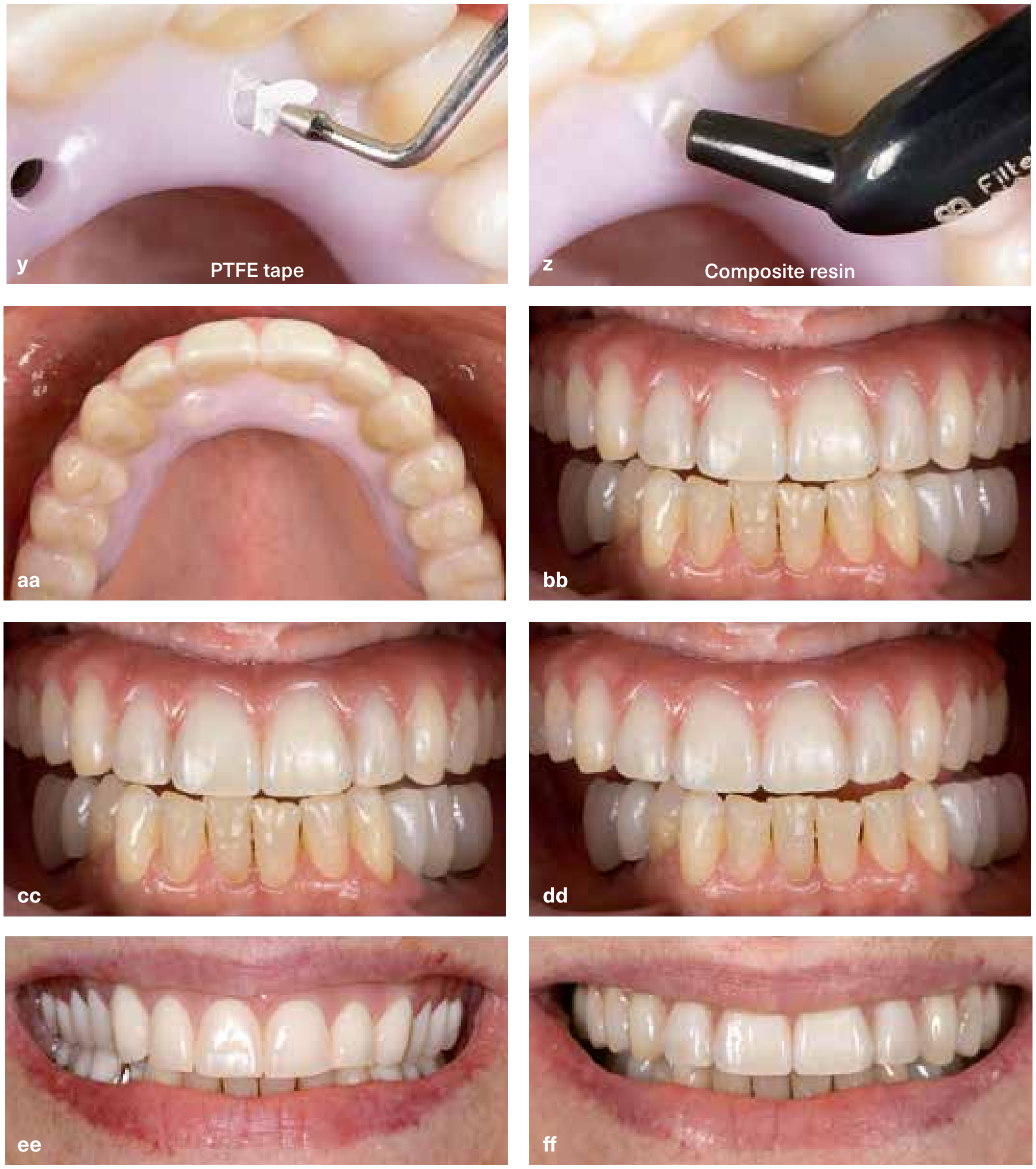


FIG 15-11 *(cont)* *(y to aa)* The prosthesis is seated, prosthetic screws hand tightened, PTFE tape placed to protect the head of the screws, and the screw access openings sealed with composite resin. *(bb to dd)* The occlusal scheme was set for bilateral simultaneous contacts, shallow anterior guidance, and canine guidance, eliminating all nonworking interferences in eccentric movements. The before *(ee)* and after *(ff)* of the maxillary zirconia prosthesis. The occlusal cant and buccal corridors are filled to provide a uniform, symmetric, and esthetic result. The monolithic nature of the ceramic prostheses provides strength, while the MiYo liquid ceramic provides the color and texture for a natural appearance.

and canine guidance, eliminating all nonworking interferences in eccentric movements (Figs 15-11bb to 15-11dd). Annual maintenance appointments should consist of ensuring cross-arch rigidity of the maxillary fixed prosthesis and the occlusal scheme maintained. The final result (Figs 15-11ee and 15-11ff) demonstrates the before and after of the maxillary monolithic zirconia prosthesis. Our patient was very happy with the esthetic result.

What makes these prostheses biomechanically successful is the cross-arch rigidity maintained by the prosthetic screws, which are recommended to be hand-tightened. The American College of Prosthodontists recommends that if the restoration is in function and free of mechanical complications (ie, fracture), there is no indication for removal and/or replacement of these prosthetic screws.[39] They also recommend that radiographs should be taken once every 1 to 2 years to ensure there is no pathology or abnormal findings with the implants. Finally, an occlusal guard (Fig 15-12) is recommended to protect the prosthesis from any complications that may occur due to severe clenching and/or bruxism.

FIG 16-6 *(a)* The patient presents with a fractured denture tooth in the canine position. *(b and c)* The tooth was repaired by adding acrylic (salt and pepper technique) and bonding it in place. *(d)* Patient's condition after multiple repairs over the years. *(e)* Side-by-side comparison of the hybrid prosthesis and the new zirconia prosthesis. *(f and g)* Occlusal view of the definitive zirconia prosthesis on the master cast and facial view with improved esthetics. *(h)* Zirconia prosthesis intraorally.

FIG 16-7 *(a)* Frontal pictures of the day of insertion of a full-arch layered zirconia implant-supported prosthesis on the maxilla and a hybrid implant-supported prosthesis on the mandible. *(b)* Five years after insertion, the patient fractured the buccal porcelain on the central incisors and right lateral incisor. *(c)* Close-up view of the fractured porcelain with a black contrastor. *(d)* The prosthesis was removed and analyzed in the master cast. No damage was observed in the zirconia framework or any other area of the prosthesis. *(e)* Traditional veneer preparations were performed in the central and lateral incisors. Note that a layer of porcelain was left purposely on the surface to improve bonding to the future veneer. A polyvinyl siloxane (PVS) impression was made, and both the impression and prosthesis were sent to the laboratory for veneer fabrication. *(f)* Porcelain veneers were fabricated. Meanwhile, the patient was using the prosthesis that had been saved in the patient's box as a "spare tire." →

Chipping of Overlying Ceramics

Chipping ceramics may occur in one or multiple teeth, and the treatment can be handled either directly or indirectly. In some cases, minimal chipping of a posterior tooth in a non-esthetic area may be treated by just polishing the area to eliminate any rough surfaces. Depending on the extension and location of the fracture, these can be treated either with a composite restoration or a ceramic veneer.

The patient in Fig 16-7 had been treated with a zirconia framework and ceramic layered implant-supported fixed solution in the maxilla. After uneventful performance for 5 years, the patient presented with chipped incisal edges of the four maxillary anterior teeth. The prosthesis was unscrewed and removed, and the patient was given the previous prototype as a provisional restoration. It is worth pointing out that part of the conventional restorative protocol entails utilizing a prosthetic prototype as the infallible communication device between dentist and patient and between dentist and technician because it allows the team to evaluate both the esthetic parameters as well as functional parameters (occlusion). Because this prototype will be literally replicated to become the definitive restorative solution, it is

CASE 2 / Analog workflow for single anterior implant crown *(continued)*

FIG 3 Shade photographs captured with shade tabs prior to any treatment to prevent desiccation of the teeth, which can alter the shade. *(a)* Vita 3D shade tabs taken of the adjacent teeth. *(b)* Vita 3D shade tabs taken with polarized filters. *(c)* Stump shade taken of veneer preparation stump.

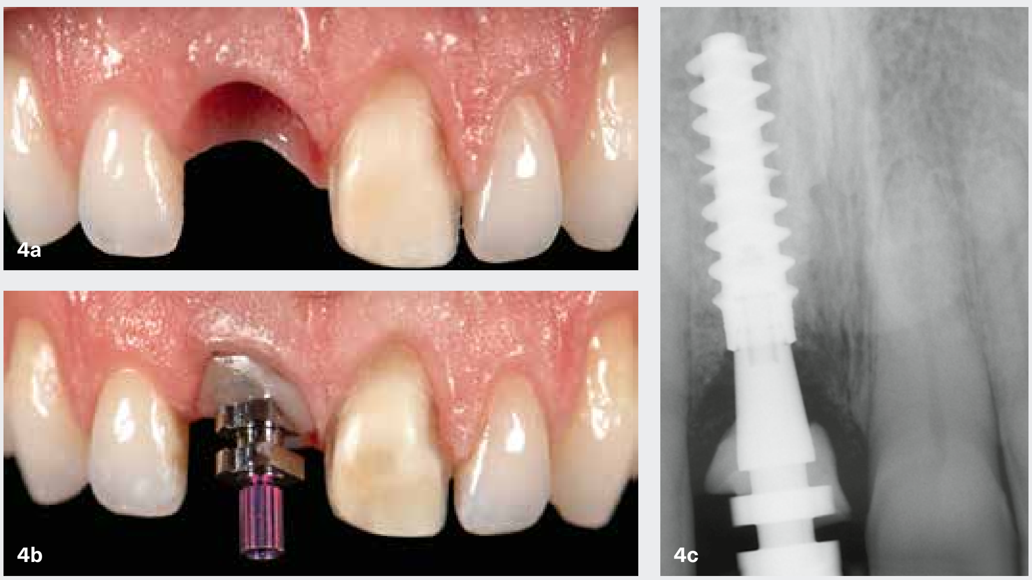


FIG 4 *(a and b)* Customized open-tray impression coping with composite resin to scaffold and capture the soft tissue emergence profile prior to impression taking. *(c)* Radiographic confirmation of complete seat of the impression coping.

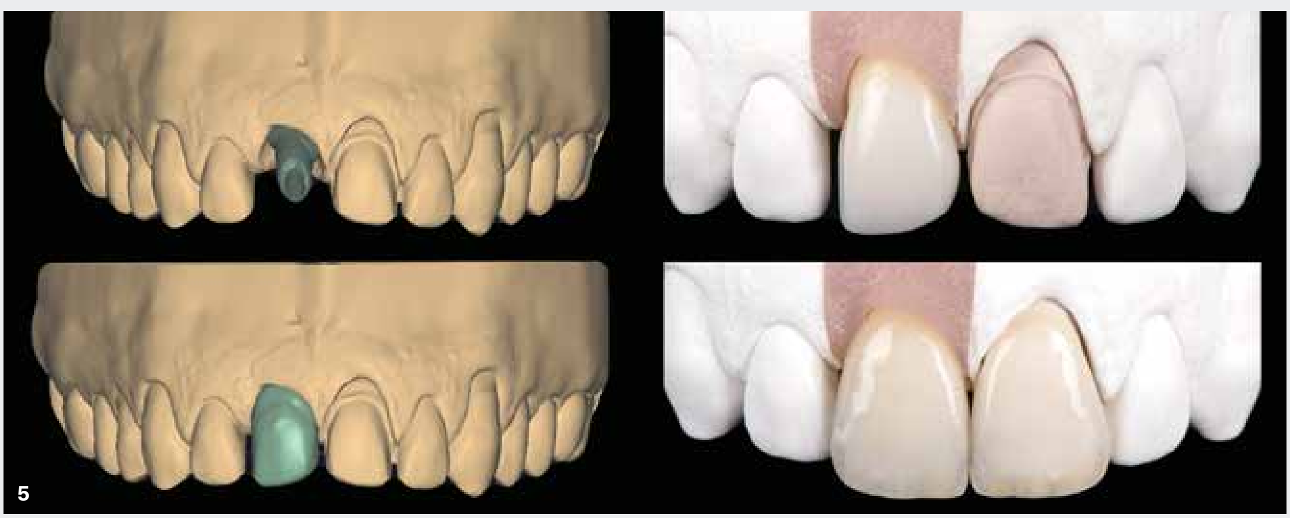
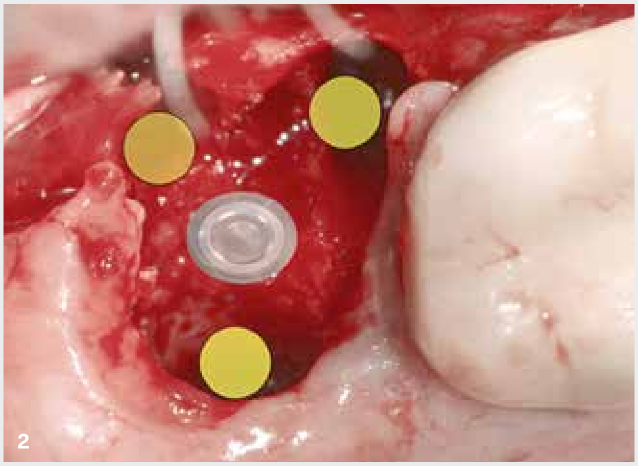
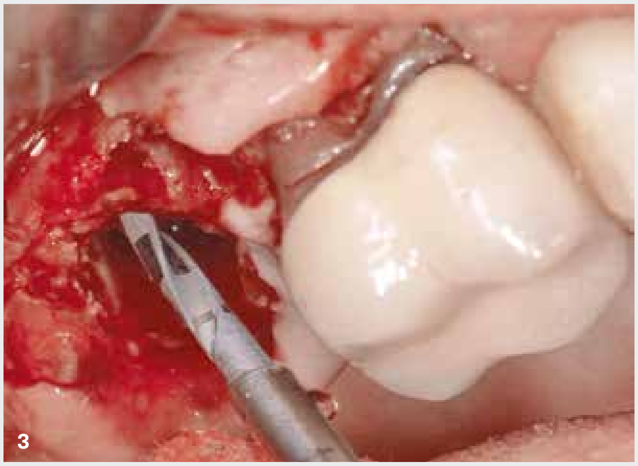
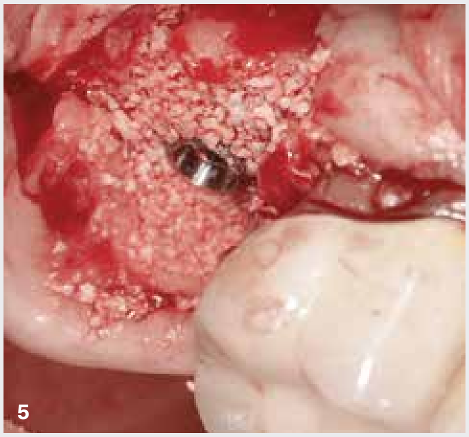


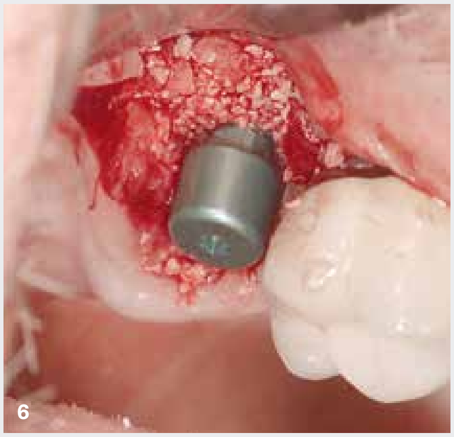
FIG 5 Digitization of the master cast for zirconia abutment design. The zirconia substructure was also designed to mimic the adjacent veneer preparation in both Stumpf shade and shape. This allows the laboratory technician to control the porcelain thickness and shade matching. (Laboratory work performed by James Choi, CDT.)

CASE 6 / Analog workflow *(continued)*









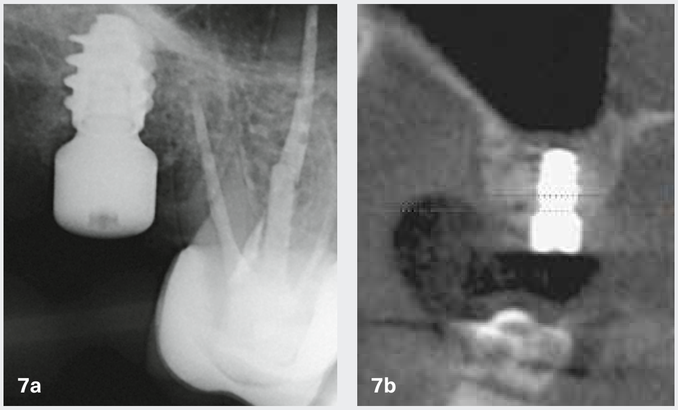


FIG 2 Intact root sockets allow for the positioning of the osteotomy in the central portion of the extraction socket.

FIG 3 The spade drill is centered in the extraction socket.

FIG 4 The trajectory of the osteotomy is evaluated.

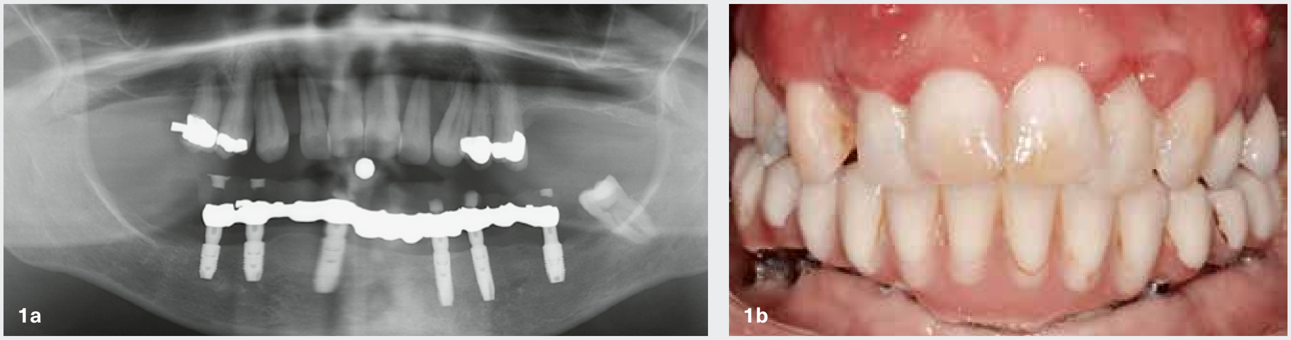
FIG 5 The implant platform is placed in line with the buccal bony level of the extraction site.

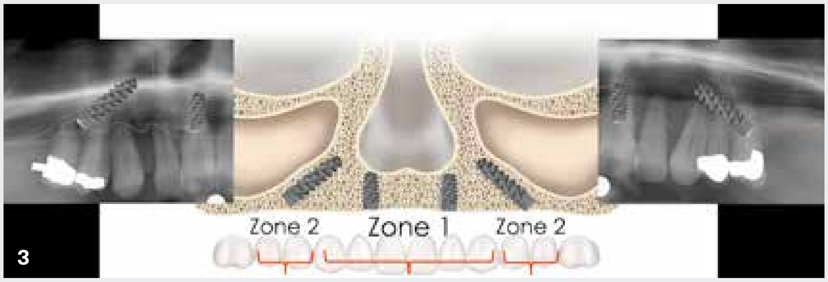
FIG 6 The temporary healing abutment is secured ready for the soft tissue closure.

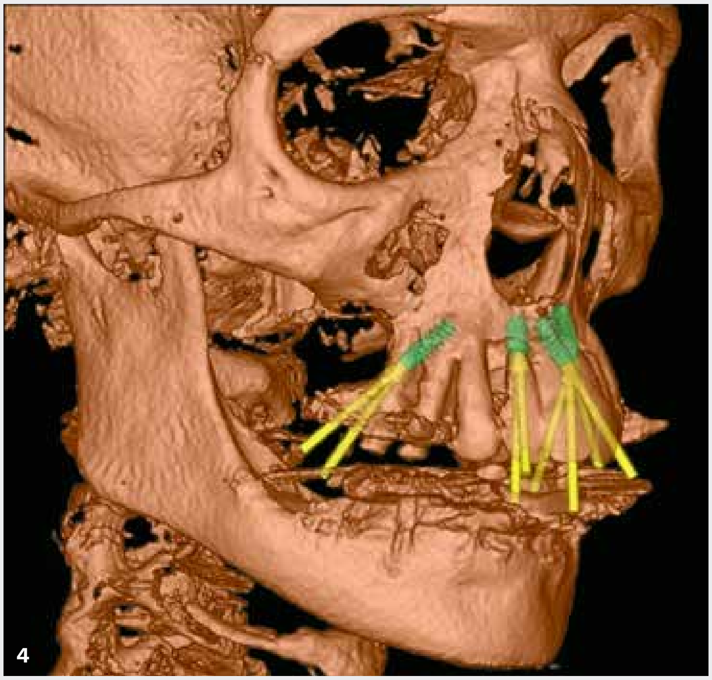
FIG 7 *(a and b)* Immediate postoperative 2D and 3D radiographs confirming the position of the implant.

FIG 8 The lack of air-fluid level illustrates the favorable position of the implant apically without intrusion of the maxillary sinus.

CASE 8 / Tilted concept in the maxilla with analog workflow







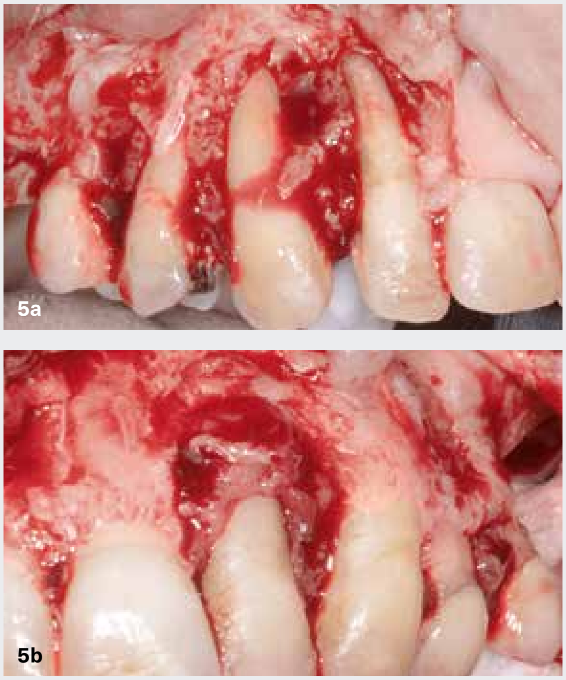


FIG 1 *(a and b)* Radiograph and clinical view prior to implant therapy in the maxilla.

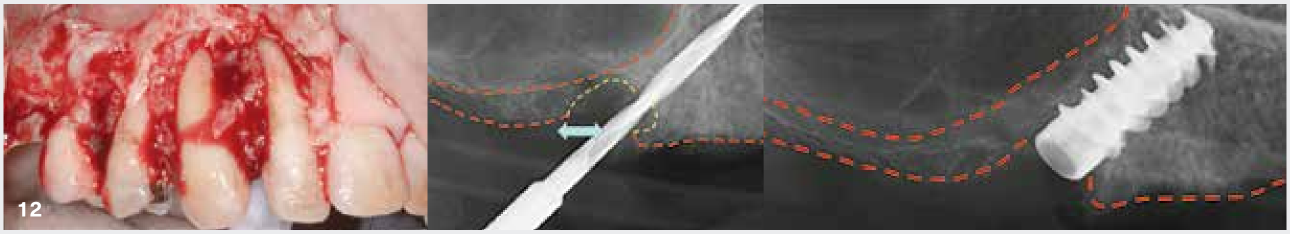
FIG 2 In maximum smile, the patient's transition line would be hidden.

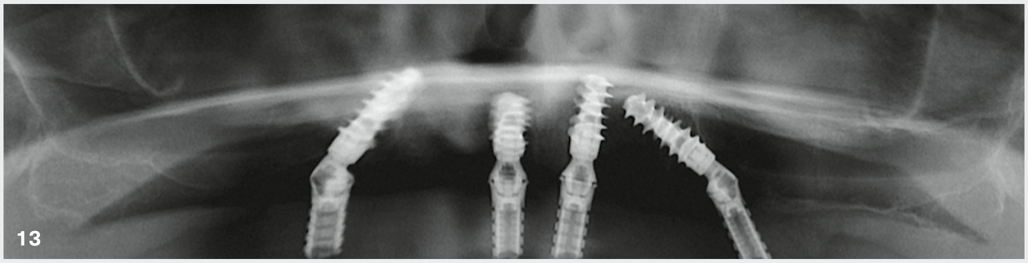
FIG 3 Tilted treatment concept. (Illustration copyright E. M. Titcomb 2022.)

FIG 4 Planning of the implant positions with coDiagnostiX software.

FIG 5 *(a and b)* Nonrestorable maxillary teeth.

CASE 8 / Tilted concept in the maxilla with analog workflow *(continued)*





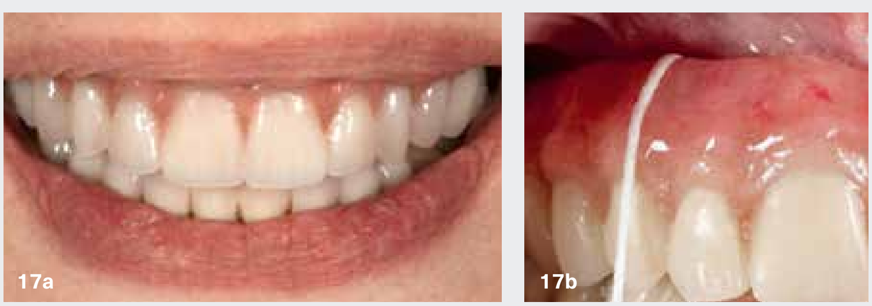


FIG 12 The third implant follows the inclined anterior maxillary sinus wall.

FIG 13 Immediate postoperative panoramic radiograph.

FIG 14 *(a and b)* Smile and clinical view at 1-week postoperative appointment.

FIG 15 *(a and b)* The titanium bar is verified intraorally for passive fit.

FIG 16 *(a and b)* Proper form and function of the final maxillary hybrid prosthesis.

FIG 17 *(a and b)* Final esthetic prosthesis and the proper intaglio form for oral hygiene.

CASE 12 / Zygotmatic implants *(continued)*

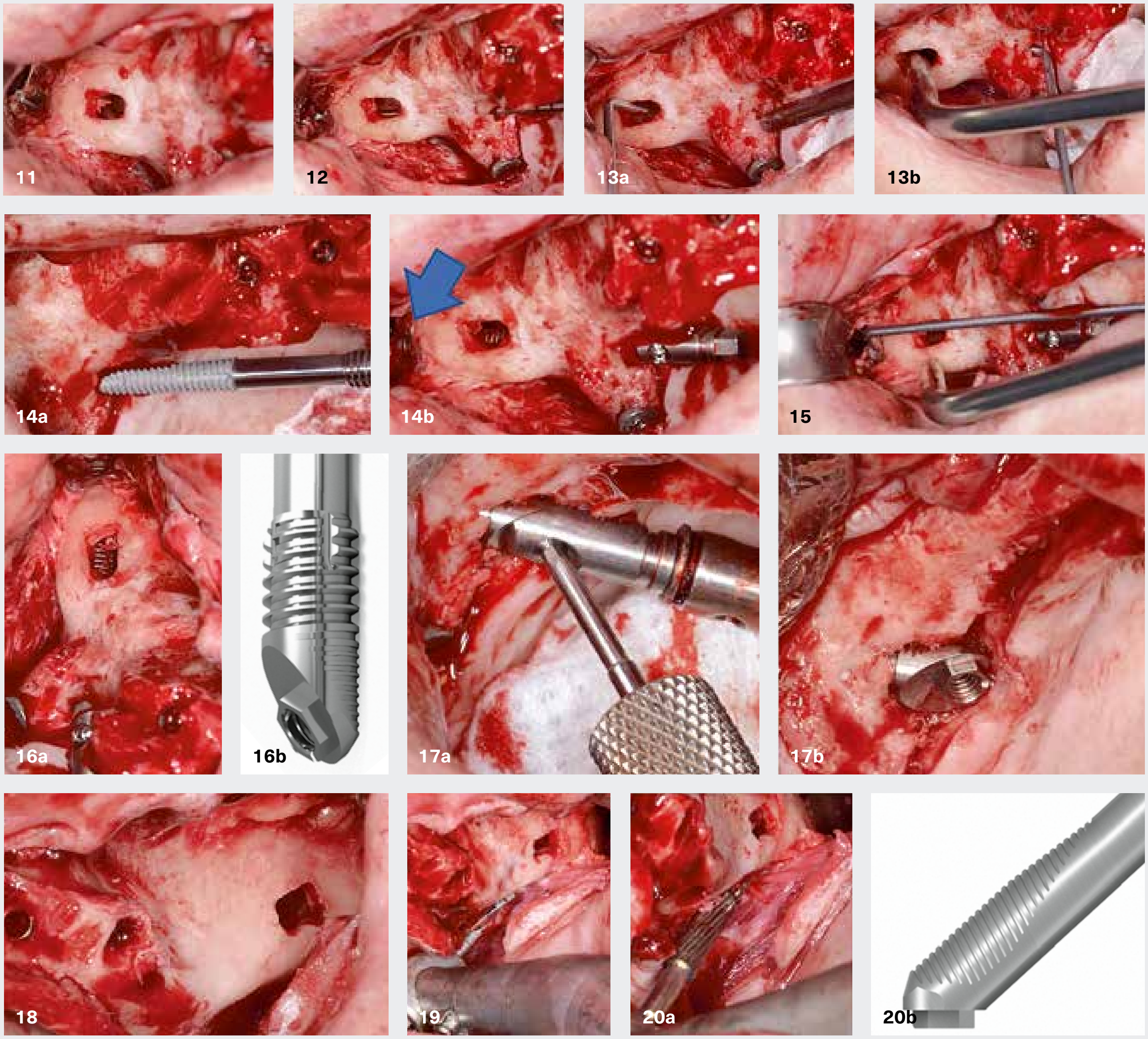


FIG 11 Direct visualization of the 2.9-mm drill confirming the correct trajectory of the osteotomy at the end point.

FIG 12 Direct visualization of the tip of the depth gauge, measuring the length of the needed zygomatic implant.

FIG 13 *(a and b)* Irrigation through the lateral wall opening with suctioning at the starting point as well as the reverse, debriding the sinus.

FIG 14 *(a)* Placement of the round zygoma implant. *(b)* Direct visualization of the implant apex confirms proper trajectory.

FIG 15 Irrigation of the apical portion of the implant, removing any debris prior to removal of the retractor from the frontozygomatic notch.

FIG 16 *(a and b)* The ZAGA 1 topography allows for the round implant design with bicortical stabilization at the maxillary crest.

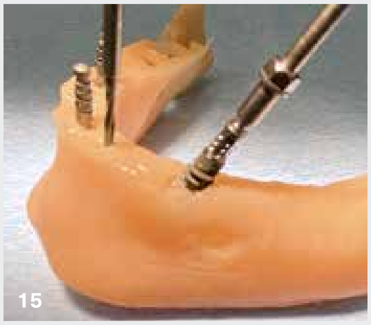
FIG 17 *(a and b)* The shaft of the screwdriver perpendicular to the maxillary crest ensures the proper trajectory of the implant platform into the arch form.

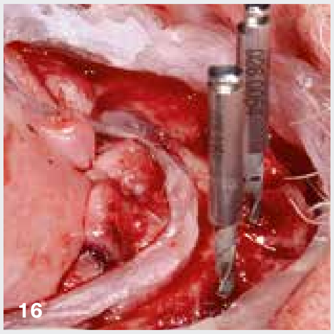
FIG 18 Exposure of the left maxilla with a ZAGA 4 topography. The lateral window allows direct visualization of the base of the zygoma.

FIG 19 The drills parallel the black dotted line in the surgeon's mind's eye to establish the proper trajectory of the osteotomy.

FIG 20 *(a and b)* Planing of the lateral maxillary wall to allow intimate contact of the palatal microgrooves of the flat zygomatic implant.

CASE 13 / "Digilog" approach to treatment planning *(continued)*





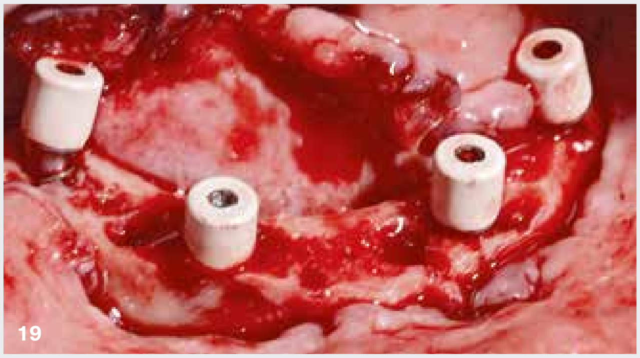


FIG 13 Maxillary model including the zygomatic bone.

FIG 14 Mandibular model with clear identification of the mental foramen.

FIG 15 Placement of the tilted implant with clear appreciation of the relationship of the distal portion of the implant to the anterior aspect of the mental foramen.

FIG 16 Surgical guide used to aid in the identification of the trajectory of the intended implants.

FIG 17 Proper selection of the SRAs.

FIG 18 There are 30-degree SRAs placed on the posterior implants and straight SRAs on the anterior implants.

FIG 19 The SRAs are torqued to 35 Ncm; white protective caps are placed in preparation for soft issue closure.

FIG 20 Placement of the anterior implants within the bone volume of the anterior maxilla.

The identification of the SRAs is also determined using the printed models with the implants in place (Figs 17 and 18). The posterior implants receive 30-degree SRAs, and the anterior implants receive straight SRAs. The combination of the abutments allows the screw access holes to be in the appropriate portion of the intended fixed provisional prosthesis.