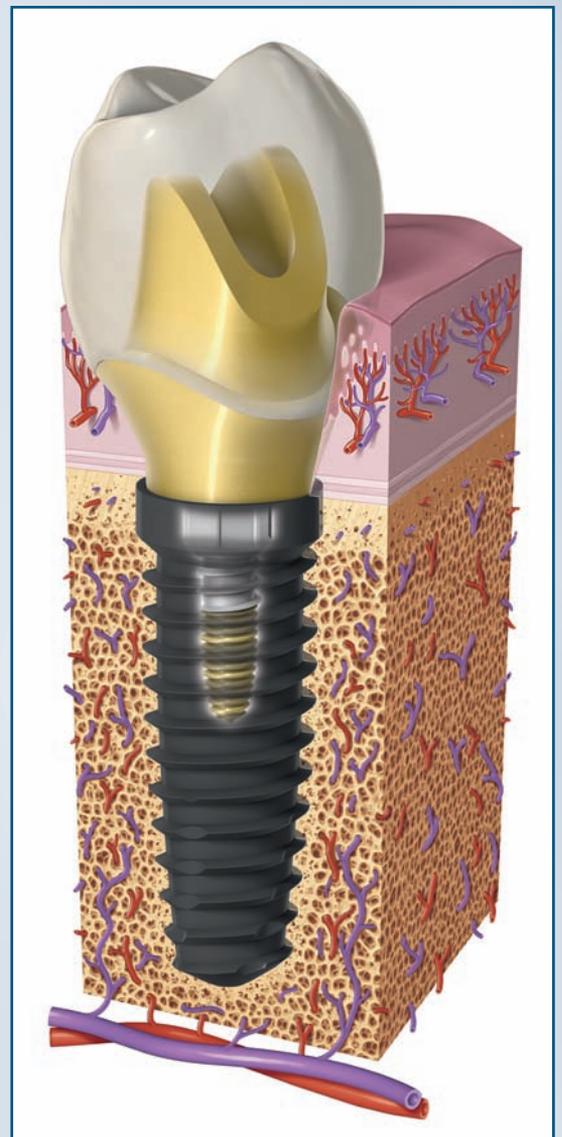




Journal of
**ORAL AND
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**Introduction to Implant Dentistry:
A Student Guide**





Journal of Oral and Maxillofacial Surgery

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**INTRODUCTION TO IMPLANT
DENTISTRY: A STUDENT GUIDE**

Editor: James R. Hupp, DMD, MD, JD



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*Official Journal of the
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Letter of Welcome

The American Association of Oral and Maxillofacial Surgeons (AAOMS) is pleased to provide you with this special publication, "Introduction to Implant Dentistry-A Student Guide." It is intended to expand your knowledge of the rapidly evolving area of implant dentistry and to highlight the important collaborative role played by each member of the dental implant team. The guide addresses all phases of dental implant patient management - from preoperative assessment through final restoration.

Whether you decide to practice general dentistry or pursue a dental specialty after dental school, you will undoubtedly come into occasional contact with a patient who is curious about or undergoing dental implant treatment. We hope the knowledge gleaned from this guide will enable you to better serve and inform your patients.

As you have progressed through dental school, you have become familiar with the nine ADA-recognized dental specialties and the skills and unique training that set them apart from general dentistry and each other. As the surgical specialists of the dental profession, oral and maxillofacial surgeons are the experts in face, mouth and jaw surgery. The AAOMS represents more than 11,000 oral and maxillofacial surgeons, residents and professional allied staff in the United States.

Oral and maxillofacial surgeons enjoy a far-reaching scope of practice that includes - in addition to the surgical placement of dental implants - dentoalveolar surgery; anesthesiology; management of facial injuries and deformities; treatment of oral, head and neck cancer; sleep apnea; and reconstructive and cosmetic surgery. It is an exciting and rewarding specialty. As you consider your future in dentistry, I invite you to learn more about oral and maxillofacial surgery by visiting our website at AAOMS.org.

Sincerely,

A handwritten signature in black ink, appearing to read "Douglas W. Fain". The signature is fluid and cursive, with a large initial "D" and "F".

Douglas W. Fain, DDS, MD, FACS
AAOMS President

Section I Introduction

Dentistry has experienced remarkable advancements in dental restorative materials, techniques, and strategies that are predictably effective for the long-term management of tooth loss. Scientifically proven approaches have evolved that now provide the dental patient with esthetically and functionally excellent options for tooth replacement. The partially edentulous patient can now undergo replacement of a single tooth or several missing teeth with implant retained crowns that provide the same function and esthetics they had with their natural teeth. Through the use of implant stabilized and/or retained removable prostheses the completely edentulous patient no longer has to endure compromised function and the reduced confidence that traditional full denture wearers commonly experienced.

The restoration of dental implants used to be considered a highly advanced procedure for oral health care that was reserved for specialists and required training beyond the regular dental school curriculum. However, most dental schools have come to realize how valuable the service of providing implant-stabilized prostheses is to patients with missing teeth. Thus, education in implant dentistry has become a regular part of the training of a large percentage of dental students, including, in many schools, the planning and placement of restorations on implants in dental student patients. However, although implant dentistry has become a part of the curriculum, it remains a complex topic requiring a sound foundation to gain competence in this field. This was the impetus for this student guide.

The guide begins with discussions of the biologic basis of hard and soft tissue interfaces between the implant and surrounding tissues and their clinical relevance. It then moves to the presentation of an extensive approach to implant treatment planning. The general factors that should be considered are covered, followed by specific diagnostic modalities used when planning the use of dental implants. The treatment planning section also provides the reader with detailed information about the prosthetic and surgical considerations necessary to understand before initiating the surgical phase of implant care. Next, the guide covers the standard set of steps typically followed when placing an implant in a noncomplex situation. For patients whose anatomy requires modification to allow the use of implants, the guide describes the various strategies used by surgeons to make the use of dental implants possible. Finally, a section is provided that covers several of the more complex situations for which advanced forms of surgery are necessary to make the patient eligible for implant-supported dental prosthetics.

The intention in this guide is to present the basic concepts that will provide the dental trainee with a solid foundation for their participation in the care of patients requiring dental implant treatment. It also helps expose the trainee to what is surgically possible for patients who might otherwise not appear to be good candidates for implant care.

This guide is designed to complement a well-structured multidisciplinary didactic and clinical program in implant dentistry taught in an interdisciplinary manner by experienced educators.

The Multidisciplinary Approach to Implant Dentistry

Successful dental implant treatment requires careful treatment planning, meticulous surgical technique, and precise prosthetic restoration. The typical implant team consists of a restorative dentist, a properly trained and experienced surgeon, and a dental laboratory technician, who work together using their individual skill sets to determine proper implant selection, placement, and restoration, and a dental hygienist to help maintain implant health. Skilled dental assisting and business staff members round out the team.

Section II Biologic Considerations

Hard Tissue–Implant Interface

Osseointegration is the key biologic and biophysical process that has made dental implant therapy predictably effective for replacing missing teeth. Histologically defined, osseointegration is the direct structural and functional connection between organized, living bone and the surface of a load-bearing implant without intervening soft tissue between the implant and bone. The discovery of this process occurred by accident when Swedish bone researchers placed chambers into the bone of animals to examine the vasculature of the bone. Hoping to minimize the potentially damaging effects of chamber insertion on the bone they wanted to study, they prepared the site for the chamber using a series of sharp drill bits and drilled at very low speeds, while carefully irrigating the drills to minimize thermal damage. The chambers they used were made of pure titanium, known to be well-tolerated by animal tissues. When they sought to remove the chambers for use in other animals, they discovered that the bone had adhered to the chamber surface so well that they had to fracture the bone to remove the chamber. The investigators realized that such a tight bond of metal implant to bone could be used to anchor implants in jawbones to support prosthetic teeth and to provide anchorage in other parts of the face and body.

The primary goal in implant placement is to achieve and maintain an intimate bone-to-implant connection. This concept is known as *dental osseointegration*. Dental osseointegration is defined clinically as the asymptomatic rigid fixation of an alloplastic material (the implant) in bone with the ability to withstand occlusal forces (Fig II-1).

The factors that the Swedish researchers found key to successful implant osseointegration were as follows:

1. Use of biologically compatible material such as pure titanium
2. Implant surface free of contamination and implantation site free of infectious and other diseases
3. Use of an atraumatic insertion technique that minimizes heat damage to bone adjacent to the implant surface
 - A. Sharp drill bits
 - B. Gradual increase in width of implant site using graduated drills
 - C. Cooling of drill bit during drilling
 - D. Ultra-low speed, high torque drill for implant site tapping and implant insertion
4. Close approximation of the implant surface to the surrounding bone
 - A. Precision in site development and implant insertion
 - B. Tapping of dense cortical bone
5. Delayed implant loading (prosthesis placement), giving time for the biologic process of osseointegration to occur

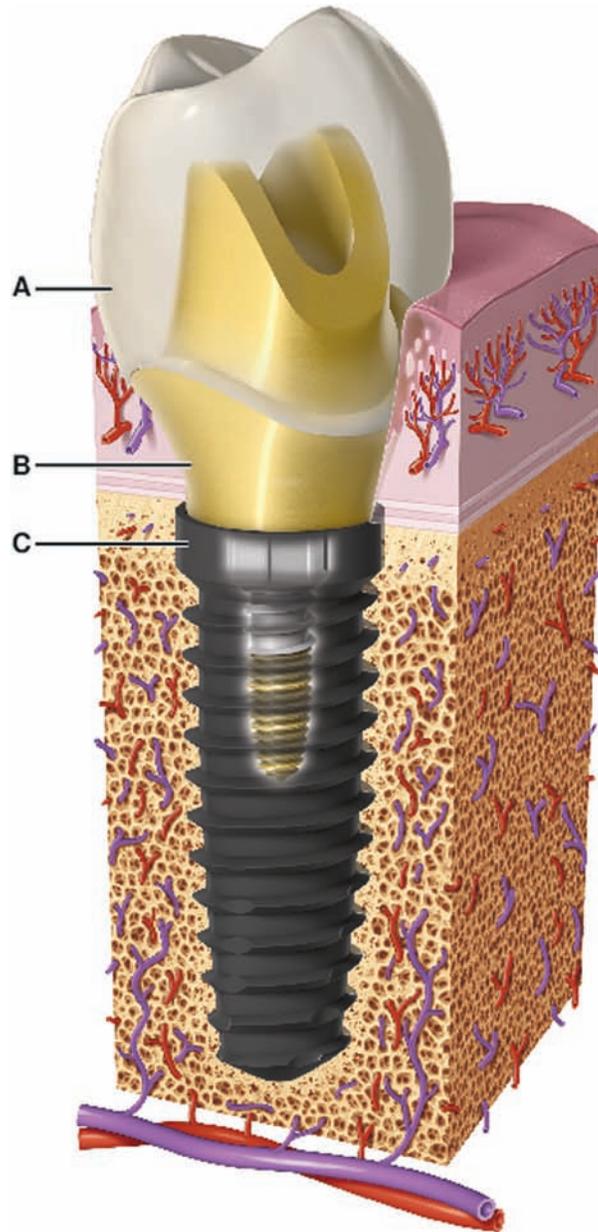


FIGURE II-1. Components of restored implant. *A*, Implant crown. *B*, Abutment. *C*, Implant fixture.

Titanium is an ideal material for dental implants. Titanium is biologically inert; thus, it does not trigger foreign body reactions. For an implant to have intimate contact with bone, the implant site must be prepared with a precise technique. Implant placement kits include designated drills that are used in sequence to remove the bone as atraumatically as possible. Implant insertion is performed in accordance with the normal practices of aseptic surgery. Limiting thermal damage requires using sharp dental implant drills run at very low speeds and providing copious cooling irrigation. The goal is to not allow the temperature of the bone being cut to increase to greater than 47°C (117°F) during implant site preparation.

Ideally, once inserted, the implant should have minimal movement while bone is allowed to biologically adhere to the implant surface. This is achieved by limiting the amount of pressure placed on the implant while osseointegration is occurring. The primary (initial) stability of an implant at the time of placement depends on the nature of the bone (Fig II-2). Cortical bone provides more primary stability than cancellous bone. An implant placed into bone with a high percentage of cortical bone component will have greater primary stability and therefore be less susceptible to movement during osseointegration. Engaging 2 cortical plates is another means of achieving initial stability (Fig II-3). In contrast, an implant site that has a more cancellous nature will provide less primary stability, making the implant-bone interface more susceptible to occlusal and other forces. This difference is managed clinically by having a period after implant placement when the implant is not loaded (no prosthesis is attached to the implant). Such implants can be kept covered by soft tissue during this period and uncovered when sufficient osseointegration is likely to have occurred (Fig II-4). In areas where implant primary stability is good, some clinicians will load the implant immediately after surgery.

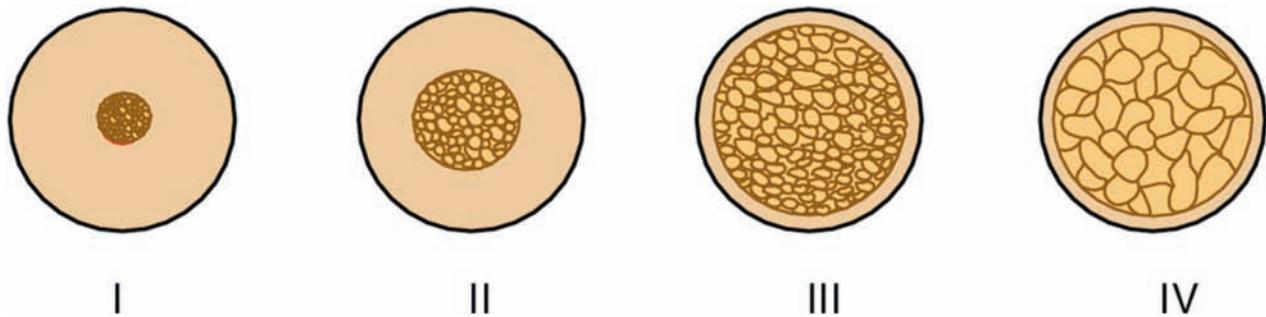


FIGURE II-2. Bone types based on the quantity of cortical bone and density of cancellous marrow. (Reprinted, with permission, from Lekholm U, Zarb GA: Patient selection and preparation, in Branemark P-I, Zarb GA, Albrektsson T (eds): *Tissue Integrated Prosthesis: Osseointegration in Clinical Dentistry*. Chicago, IL, Quintessence Publishing, 1985.)



FIGURE II-3. Whenever possible, it is optimal to engage 2 cortical plates when placing an implant.

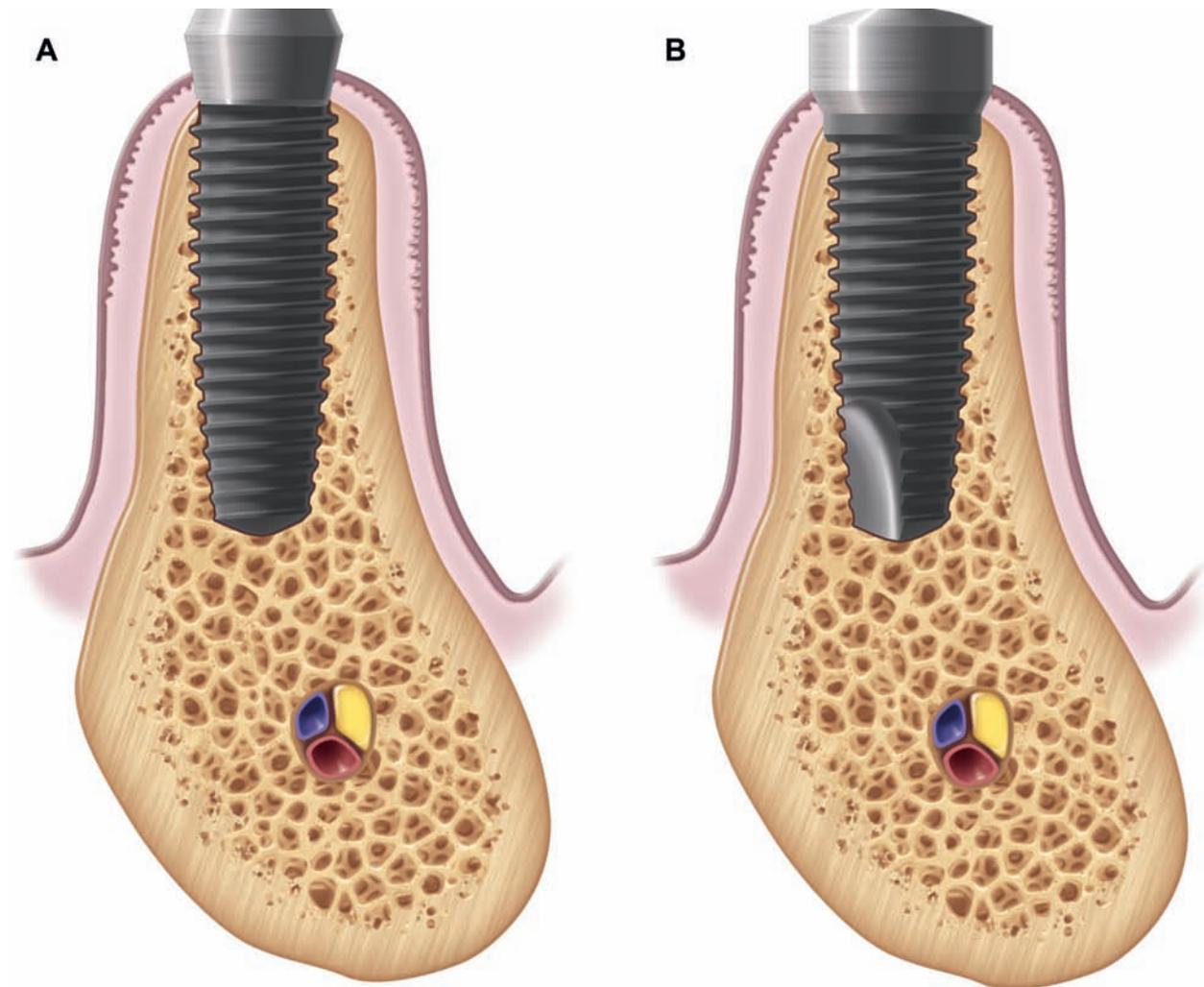


FIGURE II-4. One-stage versus 2-stage implant surgery. *A*, One-stage surgery with implant designed such that the coronal portion extends through the crestal gingiva. *B*, One-stage surgery with implant designed for 2-stage surgery, with the healing abutment in place to keep the gingiva from closing over the implant during healing. (Fig II-4 continued on next page.)

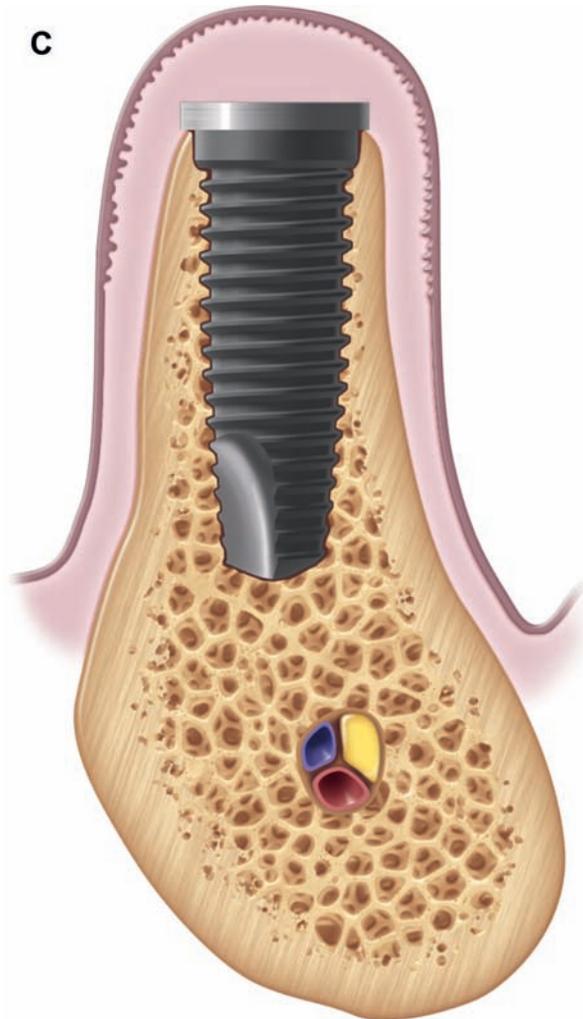


FIGURE II-4 (cont'd). C, First stage of surgery using 2-stage implant with cover screw covering the coronal portion of the implant to keep the soft tissue off the implant platform. The gingiva is allowed to heal over the cover screw during osseointegration.

Soft Tissue-Implant Interface

Early in the modern history of dental implants, most research and clinical focus was devoted to the bone-implant interface (achieving osseointegration). Little attention was given to gingival health and the architecture surrounding implant components. This has changed such that the peri-implant soft tissues are given strong consideration during treatment planning and the placement of dental implants. The desire to optimize esthetics after implant placement is now a key goal of those participating in implant placement and restoration, particularly, for implants in the maxilla whose gingival margins will be visible while smiling.

Understanding the differences between the peri-implant and periodontal soft tissues is important when treatment with implants is being planned (Fig II-5). In the gingiva surrounding an implant, the soft tissue consists of

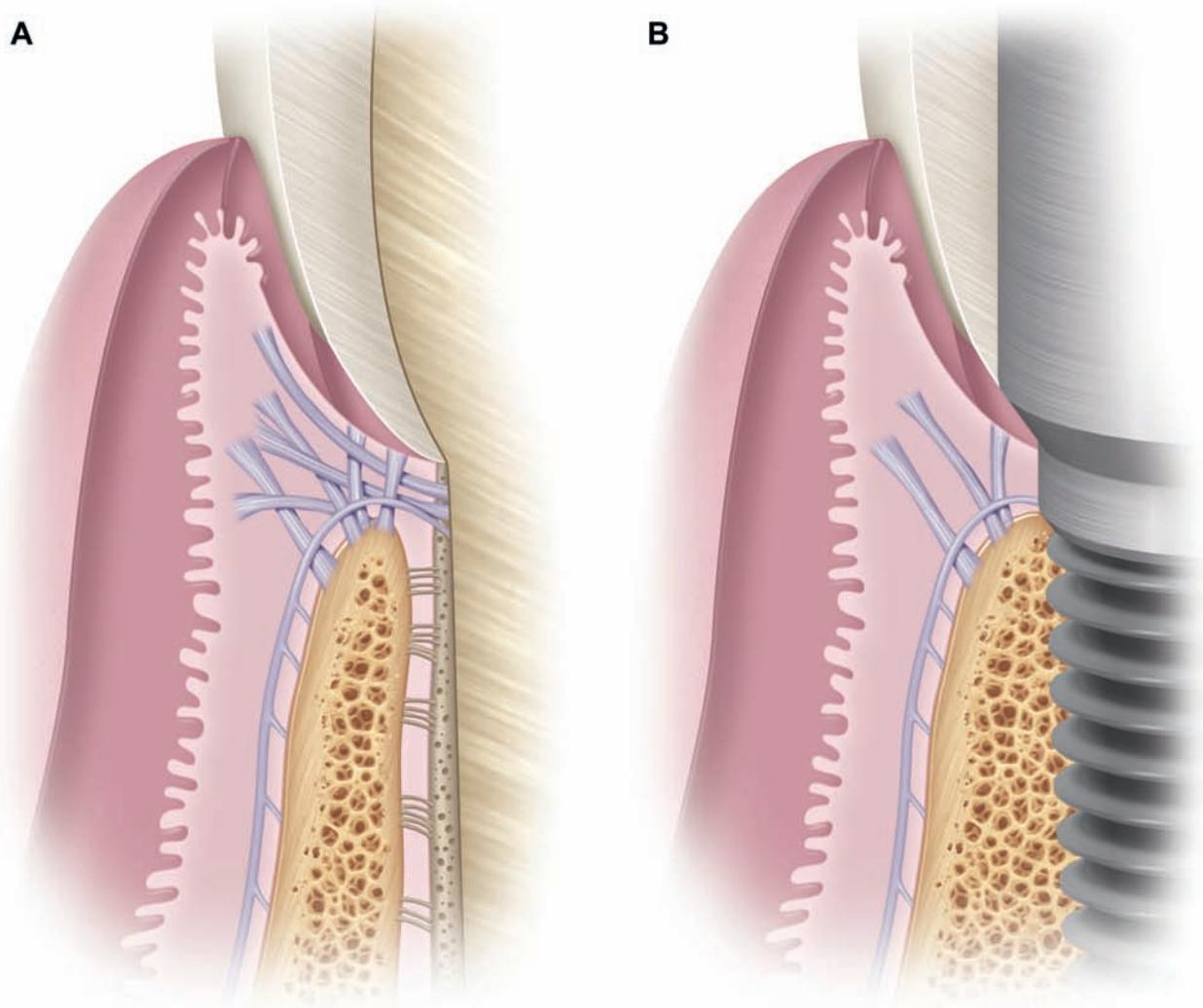


FIGURE II-5. Comparison of tissues around a healthy natural tooth versus a healthy dental implant. *A*, The natural tooth has periodontal ligaments between the tooth root and surrounding bone. A connective tissue zone above the crest of the bone contains connective tissue fibers (Sharpey's) that insert into dentin. The junctional epithelial attachment lined with sulcular epithelium helps form the gingival sulcus. *B*, Dental implant is osseointegrated with the bone; thus, no periodontal ligaments exist. A connective tissue zone exists, but the fibers run parallel to the implant surface and do not insert into it. Junctional and sulcular epithelium line the gingival sulcus.

connective tissue covered by epithelium, which is continuous with an epithelial-lined gingival sulcus. The apical-most portion is lined by junctional epithelium, which forms an attachment. The area of supracrestal connective tissue functions to maintain a stable interface between the soft tissue and the implant, acting as a barrier to the oral environment. The orientation of the connective tissue fibers adjacent to an implant differ from those of a

natural tooth. This area of connective tissue is 1 to 2 mm in height. This becomes important when determining the health of the peri-implant soft tissues. Probing depths in a healthy implant will typically be 1 to 2 mm less than the total measured dimension from the crest of the sulcus to the alveolar bone crest.

Another obvious difference between teeth and implants is that teeth have a periodontal ligament with connective tissue fibers that suspends the tooth in the alveolar bone. A well-integrated implant, however, is in direct contact with the bone, without any intervening soft tissue. This difference has a major impact on the biomechanics, proprioception, and prosthetic considerations for implants versus natural teeth.

Section III Preoperative General Assessment and Treatment Planning

The ultimate goal of dental implant therapy is to satisfy the patient's desire to replace one or more missing teeth in an esthetic and functional manner with long-term success. To achieve this goal, clinicians must first accurately and comprehensively assess the patient's overall physical and mental health. Treatment planning for implant dentistry usually requires a greater degree of attention to detail and precision than other forms of dentistry. This results from the less forgiving clinical situation if an implant's angulation is wrong or the implant-supported restorations are not in proper occlusion compared with when natural teeth are supporting dental prosthetics. In addition, anatomic factors should be considered owing to the nerves, maxillary sinus, nasal floor, and other important anatomic structures commonly present in the area where implants need to be placed. Thus, a close working relationship between the surgeon placing the implant and the clinician restoring the implant is critical from the time treatment planning begins to when the final restoration has been seated.

Initial Observations and Patient History

At the first meeting with the patient, experienced clinicians begin to make general observations about the patient, including items such as their physicality, physique, facial features, speech, attention to their appearance, and personality. These superficial characteristics help guide the clinician during the treatment planning aspects of patient care.

CHIEF COMPLAINT RELATING TO POTENTIAL IMPLANTS

The patient's chief complaint is a statement in their own words that conveys the perceived problem and concerns, and, in some cases, their initial expectations. When the patient's concerns relate to missing dentition, the clinician must assess the patient's current understanding of the restorative options, their knowledge of implant dentistry, and whether the patient's expectations are reasonable.

One question is whether the patient is looking strictly for a functional replacement of missing teeth or has a strong esthetic expectation, or both.

Another question is how the patient's expectations fit with their perceived timeline and financial circumstances.

Ultimately, it becomes the clinician's responsibility to distill all the information conveyed by the patient and determine the available treatment options that would meet or exceed the patient's expectations and then educate the patient about these options. A failure of the doctor and patient to understand each other's expectations is likely to compromise the patient's ultimate satisfaction.

MEDICAL HISTORY AND RISK ASSESSMENT

A thorough medical history is required for every dental patient. Just as with any patient for which a surgical procedure is planned, the patient must be assessed preoperatively to evaluate their ability to safely undergo the proposed procedure and for the surgical wounds to heal. Fortunately, only a few absolute medical contraindications to implant therapy exist. The absolute contraindications to implant placement based on surgical and anesthetic risks are limited primarily to patients who are acutely ill, those with an uncontrollable systemic disease, and patients with certain diseases or damage at the potential implant sites. Contraindications can be limited in duration; once the illness has resolved or the metabolic disease is controlled, the patient could become a good candidate for implant therapy. Relative contraindications relate to medical conditions that affect bone metabolism or the patient's ability to heal. These include conditions such as osteoporosis, immunocompromising disorders, medications (eg, bisphosphonates), and medical treatment such as chemotherapy and head and neck irradiation. Some psychological or mental conditions could be considered absolute or relative contraindications, depending on their severity. Patients with psychiatric syndromes (eg, schizophrenia, paranoia), mental disturbance (eg, neurosis, hysteria), or mental impairment (eg, Alzheimer's dementia), those who are uncooperative, and those who have irrational fears, phobias, or unrealistic expectations might be poor candidates for implant treatment. Certain habits or behavioral considerations, such as tobacco use, substance abuse (eg, drugs and alcohol), and parafunctional habits (eg, bruxing and clenching) must be scrutinized, because they can be potential contraindications as well.

Tobacco smoking, in particular, has been documented as a significant risk factor, resulting in decreased long-term stability and decreased retention of implants.

Dental History

A thorough dental history should be obtained from every dental patient for whom implants are being considered. Factors related to the patient's attention to oral hygiene and regular dental visits are especially important for potential implant patients. For example, if a patient presents with complex dental needs and has a history of seeking dental care in a consistent fashion and a good history of compliance, the clinician could consider the patient to have a below-average risk of failure with implant care. However, if a patient presents with complex dental needs, has shown very little commitment to previous dental treatment, and has demonstrated very little effort to take care of their dentition, the clinician would consider this patient to have a much greater risk of implant failure and might recommend a less complex treatment plan requiring less patient compliance and foregoing implant-supported restorations.

Equally as important, the clinician should explore the patient's emotional connection to their dental history. For instance, has the patient had positive dental experiences in the past or is the patient extremely apprehensive because of previous poor experiences. Surgical or restorative implant dentistry requires significant commitment from both the patient and the clinician. It is imperative that a strong relationship is established between the patient and all the members of the implant team.

Intraoral Examination and Records

The oral examination helps the clinician to assess the current health and condition of the existing teeth and of the oral hard and soft tissues. It is imperative to recognize any pathologic conditions present in any of the hard or soft tissues and the presence of acute or chronic infection or other pathologic features in or near the sites of potential implant placement. The implant-focused intraoral examination should address the restorative and structural integrity of the existing teeth and prosthetics, the vestibular and palatal depths, the periodontal status, occlusion, jaw relationships, interarch space, maximum opening, parafunctional habits, and oral hygiene. Specific attention should be paid to the edentulous ridge anatomy and soft tissue morphology. The height and width of the ridges should be evaluated visually, followed by palpation to help identify any topographic features such as undercuts or bony defects.

The soft tissue surrounding the dental implants contributes to their long-term success. While examining the periodontal health of the patient, the clinician must consider the health of the soft tissue around the existing teeth, the edentulous areas, and any previously placed implants. The soft tissue should be examined for zones of keratinization (eg, quantity and location), clinical biotype (eg, thin, moderate, or thick), redundancy and mobility, and pathologic features. Thick fibrous tissue can often mask a thin underlying bony architecture that will require careful assessment radiographically. In the locations planned for implant placement, a more site-specific evaluation should center on the quality, quantity, and location of the keratinized and nonkeratinized mucosa. If the clinician believes the keratinized tissue is inadequate to maintain the health of the implant or is lacking in esthetic support for the planned implant or restorative complex, soft tissue grafting or augmentation should be considered.

During the examination of the patient, the clinician should also evaluate the surgical ergonomics. These ergonomic factors include how wide the patient can open the mouth, the muscularity of the buccal tissues, the tongue size, the perioral musculature tone, whether an exaggerated gag reflex is present, airway adequacy, and overall patient cooperation and level of anxiety.

All the details of the intraoral examination should be documented. The intraoral examination will help the clinician determine what imaging studies and other diagnostic procedures might be required to further evaluate the patient.

Diagnostic Casts and Photographs

The use of mounted study models and intra- and extraoral photographs complete the usual record collection process. Study models and photographs are often overlooked in preoperative record taking; however, both contribute significantly to the assessment and treatment planning phases of implant dentistry and allow for long-term documentation and outcomes assessments.

Study models mounted on a semiadjustable articulator using a face-bow transfer give the clinician a 3-dimensional working representation of the patient and provide important information required for surgical and prosthetic treatment planning.

The elements that can be evaluated from accurately mounted models include:

1. Occlusal relationships
2. Arch relationships
3. Interarch space
4. Arch form, anatomy, and symmetry
5. Curves of Wilson and Spee
6. Number and position of the existing natural teeth
7. Tooth morphology
8. Wear facets
9. Edentulous ridge relationships to adjacent teeth and opposing arches
10. Measurements for planning future implant locations
11. Visualization of existing and potential force vectors

Mounted study models also have value when communicating with other implant team members during interdisciplinary treatment planning. Study models allow the multiple individuals involved in the treatment of the patient to efficiently evaluate and contribute to the assessment and treatment planning without the patient present. The mounted study models also help document the patient's preoperative condition.

Intraoral photographs allow visual evaluation of the patient's soft tissue (eg, quantity, quality, location, texture, color, symmetry). Extraoral photographs provide views of the patient from many different esthetic perspectives.

The elements that should be assessed included the following:

1. Facial form and symmetry
2. Patient's degree of expression and animation
3. Patient appearance (eg, facial features, facial hair, complexion, eye color)
4. Smile line
5. Incisal edge and tooth display
6. Buccal corridor display
7. Areas of potential esthetic improvements

Implant Planning Imaging

Several radiographic imaging options are useful for dental implant diagnosis and treatment planning. The options range from standard intraoral projections (eg, periapical, occlusal) and extraoral projections (eg, panoramic, cephalometric) to more complex cross-sectional imaging (eg, computed tomography [CT], cone-beam computed tomography [CBCT]).

Multiple factors, however, influence the selection of the radiographic techniques used for any particular case. Such factors as cost, availability, radiation exposure, and the type of case must be weighed against the accuracy of identifying important anatomic structures within a given bone volume and the ability to perform the surgical placement without injury to these structures. The areas of study radiographically include:

1. The location of important structures
 - A. Mandibular canal
 - B. Anterior loop and extension of the mandibular canal
 - C. Mental foramen
 - D. Maxillary sinus (floor, septums, walls, pathologic features)
 - E. Nasal cavity
 - F. Incisive foramen
2. Bone height
3. Root proximity and angulation of existing teeth
4. Evaluation of cortical bone
5. Bone density and trabeculation
6. Pathologic features (eg, abscess, cyst, tumor)
7. Existence of anatomic variants (eg, incomplete healing of extraction site, impacted teeth)
8. Cross-sectional topography and angulation (best determined using CT and CBCT)
9. Sinus health (best evaluated using CT and CBCT)
10. Skeletal occlusal classification (best evaluated using lateral cephalometric images)

Radiographic images allow one to quantify the dimensions and to take measurements. Traditional radiographs must be calibrated for potential magnification. The magnification on a traditional panoramic image can be as much as 25%. One method to determine the amount of magnification is to place metal spheres near the plane of occlusion when taking the radiograph. By comparing the radiographic size with the actual size of the sphere, the degree of magnification can be determined (Fig III-1). Digitally acquired periapical, panoramic, lateral cephalometric images and CT and CBCT scans have bundled software applications that provide very accurate measurements.

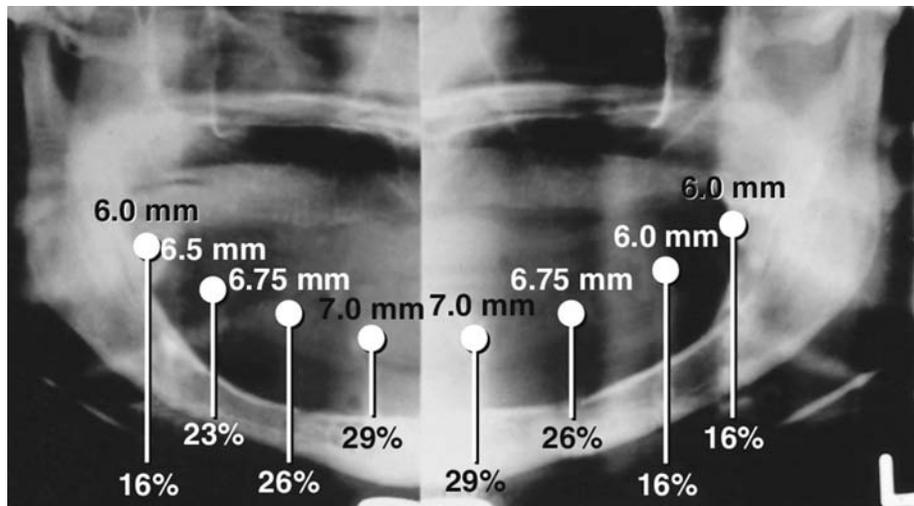


FIGURE III-1. Panoramic radiograph with standard-size steel ball bearings placed along the ridge. The magnification varies from site to site.¹

The critical measurements specific to implant placement include the following:

1. At least 1 mm inferior to the floor of the maxillary and nasal sinuses
2. Incisive canal (maxillary midline implant placement) to be avoided
3. Five millimeters anterior to the mental foramen
4. Two millimeters superior to the mandibular canal
5. Three millimeters from adjacent implants
6. One and one half millimeters from the roots of the adjacent teeth

CT and CBCT image data files can be reformatted and viewed on computers using simulation software. This allows the diagnosis and treatment planning processes to be more accurate with regard to the measurements and dimensions. Critical anatomic structures can be visualized in all 3 coordinate axes, allowing their superior to inferior, anterior to posterior, and buccal to lingual locations to be identified. These measurements are extremely important when planning whether and exactly where implants can be placed (Fig III-2).

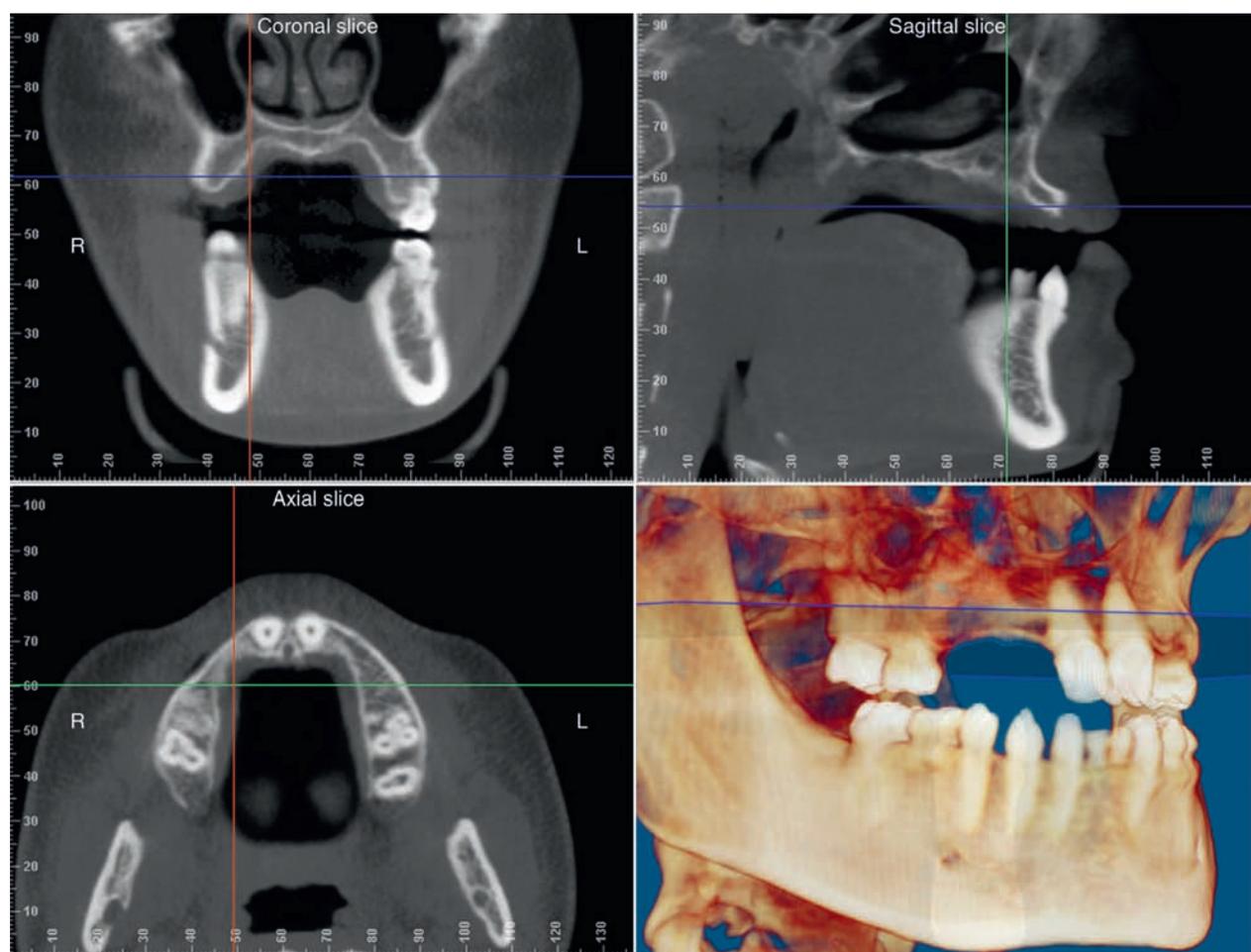


FIGURE III-2. Cone-beam computed tomography scan allowing the visualization of multiple structures in 3 dimensions. *Top left*, The coronal slice through the posterior edentulous area demonstrating the anatomy of the maxillary sinus and alveolar ridge bone. *Top right*, A cross-sectional view of an edentulous anterior maxillary ridge. *Bottom left*, An axial view showing the deficiency of the anterior maxillary ridge. *Bottom right*, 3-dimensional reconstruction.¹

Reference

1. Hupp JR, Ellis E III, Tucker MR: Contemporary Oral And Maxillofacial Surgery (ed 6). St. Louis, MO, Elsevier, 2014

Section IV Prosthetic Considerations During Implant Treatment Planning

Once an implant is well integrated with the surrounding bone, its long-term success is heavily dependent on restorative biomechanical factors. Success depends on how the stresses imposed on a functioning implant or the prosthetic unit or units attached to the implant will be distributed to preserve the osseointegration of the implant. Similar to natural teeth, the load-bearing capacity of an integrated implant must be greater than the anticipated occlusal loading. Loads that are greater than the load-bearing capacity are likely to lead to mechanical and/or biologic failure. Therefore, prosthetic considerations must be accounted for during the treatment planning phase before performing the surgery to place the implants.

Biologic implant failures occur when the functional load exceeds the load-bearing capacity of the implant-bone interface while integration is still occurring or after it has been achieved. This initially presents as bone loss around the coronal portion of the implant. With time, if the load is severe enough, the bone loss can progress around enough of the entire implant to cause it to loosen and become useless. Dentists working with implants must remember that implants lack the “shock absorbing” property provided by the periodontal ligaments of natural teeth. The periodontal ligament allows a slight physiologic movement of teeth; thus, in the absence of microbe-induced inflammation, natural teeth can move and adapt to the forces without pathologic bone loss. This, however, cannot occur with an osseointegrated implant.

Similar in several ways to natural teeth, the load-bearing capacity of implants is qualified by several factors. These factors include the number and size of the implants, the arrangement and angulation of the implants, and the volume and quality of the bone-implant interface. Much of load-bearing capacity relates to the amount of the implant surface area to which high-quality bone has attached. The same factors that maximize unloaded implant stability in hard tissue continue to be important after the attachment of a prosthesis. Thick cortical and dense cancellous bone surrounding a long, wide-diameter implant positioned in line with the functional load offers the greatest load-bearing capacity, providing the best prognosis for long-term success. In contrast, a short, narrow-diameter implant placed in an area of thin cortical bone, with less dense cancellous bone and an off-axis angulation, will have compromised load-bearing capacity and a poorer prognosis. The angulation of the implants as it relates to the occlusal plane and the direction of the occlusal forces is important in optimizing the translation of the forces to the implants and the surrounding bone (Fig IV-1). Loads directed through the long axis of the implants are well-tolerated. Slightly off-axis loads are usually not clinically detrimental; however, loads applied at angles greater than 20° off the long axis result in load magnification and tend to initiate bone loss at the implant-bone interface. Again, if excessive loads persist, the bone loss will continue and likely lead to implant failure.

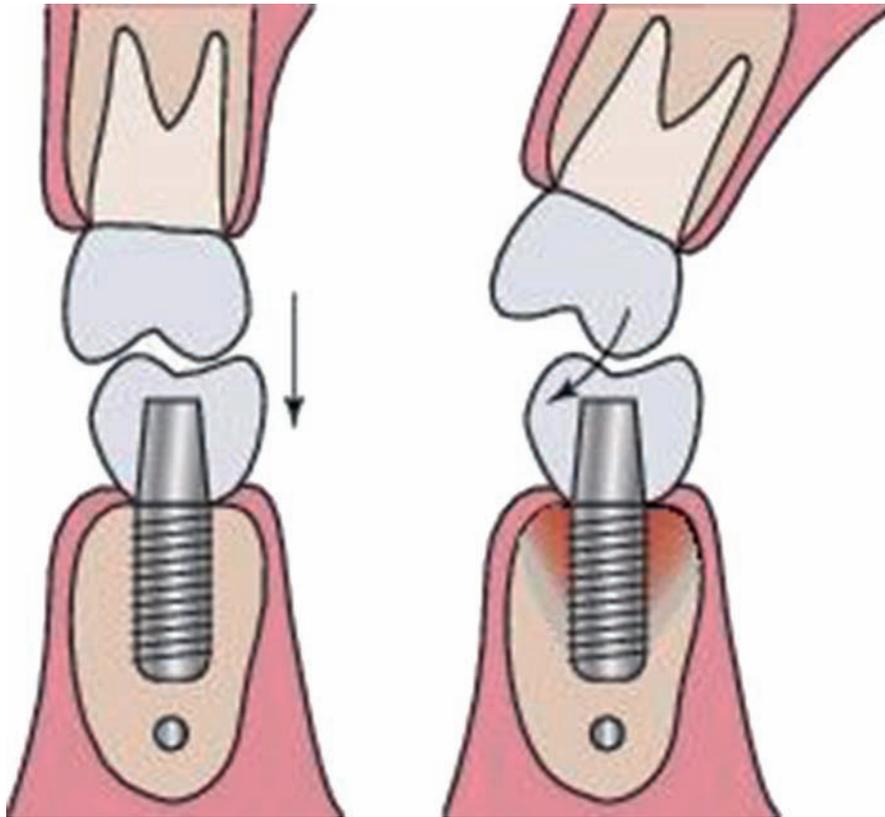


FIGURE IV-1. Off-axis loading can result in unfavorable forces on the implant, jeopardizing the long-term success because of excessive lateral loads.¹

Similar again to natural teeth, the number of implants placed in edentulous spans affects the load-bearing capacity of the implant-borne prosthesis. If a 3-tooth edentulous span is present, the fixed prosthetic options would be to place 3 implants with 3 splinted crowns, 3 implants with 3 single-unit crowns, 2 implants as terminal abutments for a 3-unit fixed partial denture, or 2 adjacent implants with a fixed partial denture with a cantilevered pontic. Of these 3 alternatives, the load-bearing capacity decreases with each successive option.

A straight line or linear arrangement of multiple implants should be avoided because it provides the least biomechanical advantage and is the least resistant to the torquing forces caused by off-center occlusal and lateral loads. Implants are better positioned in a more curvilinear or staggered fashion (Fig IV-2).

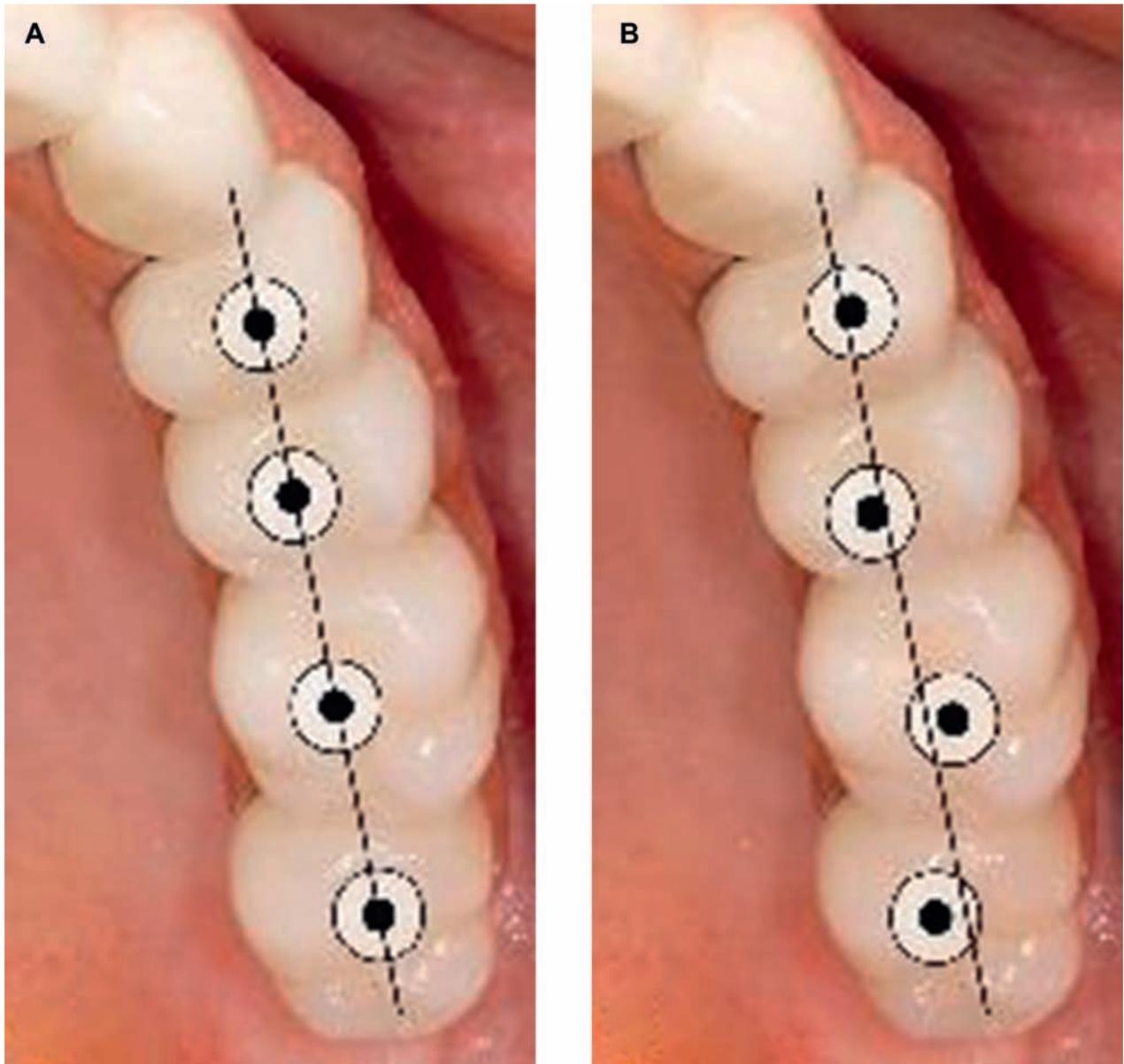


FIGURE IV-2. Placement of implants. *A*, Linear placement of 4 implants. Lateral forces can result in eventual bone loss and implant failure. *B*, A slightly staggered arrangement provides more 3-dimensional stability.¹

Connecting a single integrated implant to 1 natural tooth with a fixed partial denture will effectively create an excessively loaded cantilever situation. Because of the immobility of an implant compared with the mobility of natural teeth, when the loads are applied to the fixed partial denture, the tooth can move owing to its periodontal ligament but the implant will remain immobile. This can create stresses at the implant abutment junction up to 2 times the applied load on the prosthesis (Fig IV-3). Additional problems with a both tooth- and implant-supported fixed partial denture include breakdown of osseointegration, cement failure at the natural abutment, screw or abutment loosening, and possible failure of implant prosthetic components.

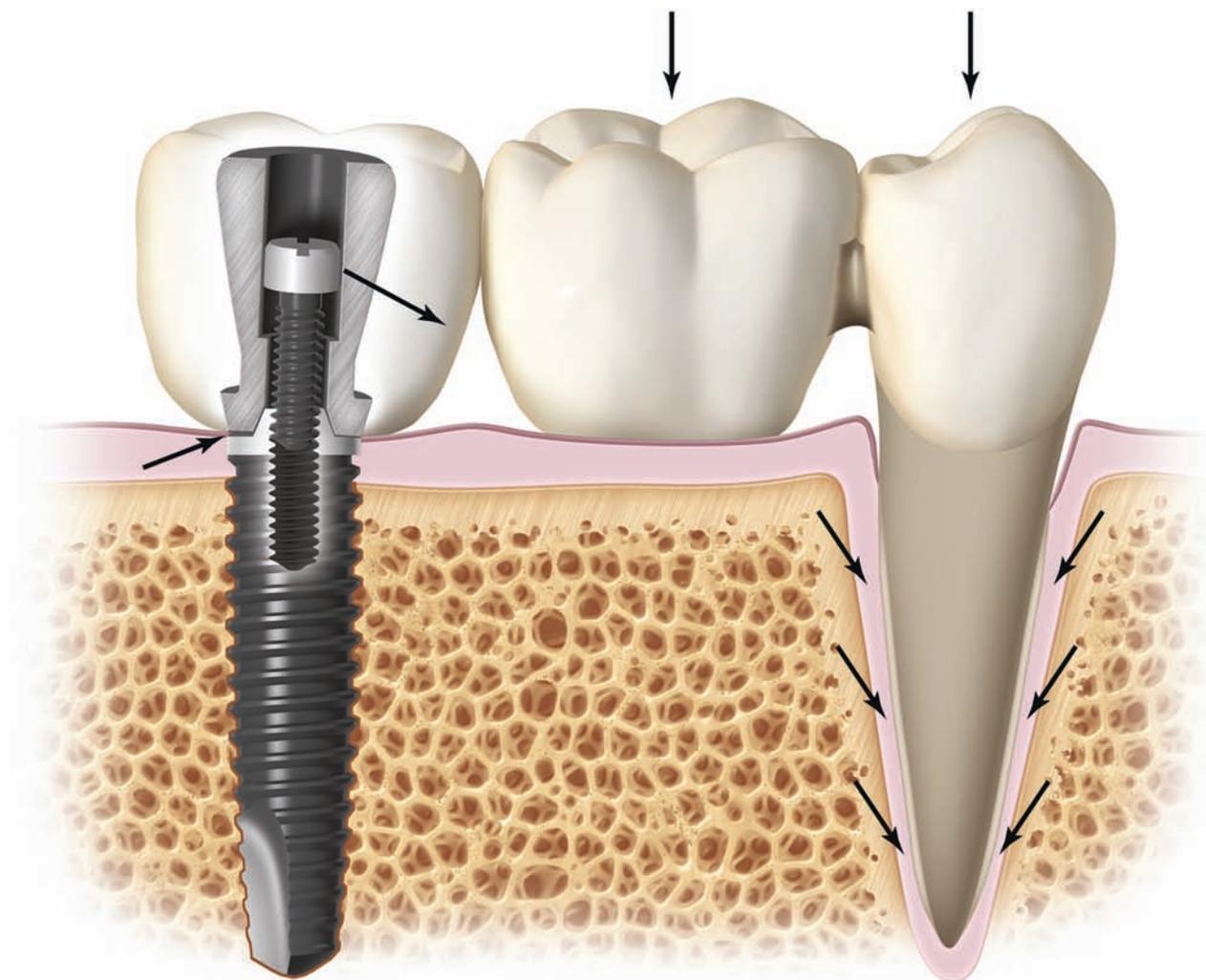


FIGURE IV-3. If an implant-supported crown is used as an abutment for a bridge using a natural tooth as the other abutment, the stress from the occlusal forces will be concentrated at the superior portion of the implant and can lead to fracture of the implant screw or abutment.

Mechanical overload can present as a restoration fracture or as a loosened or fractured attachment screw (the screw that attaches an abutment or prosthetic framework to the implant). Severe overloading can even deliver a force destructive enough to fracture the implant itself.

Detrimental forces can also be applied iatrogenically by placing nonpassive ill-fitting frameworks on implants. When the screws are tightened in an attempt to seat the ill-fitting framework, compressive forces are placed on the implant-bone interface. This excessive force will often lead to bone loss and implant failure.

The prosthetic assessment takes the gathered diagnostic data and integrates it with the clinical judgment of the clinician performing the restoration, the patient's expectations, and an understanding among the team members of what is surgically safe and reasonable, and is used to form the treatment plan. The assessment for prosthetic treatment is multifactorial, is unique to each patient, and can range from straightforward to highly complex.

The typical starting point is the determination of:

1. What needs to be replaced (single tooth, multiple teeth, or all the patient's teeth)
2. Whether the replacement will be more functional (eg, a mandibular first molar) or will have a strong esthetic consideration (eg, maxillary central incisor)
3. Whether the patient is expecting a fixed prosthetic option or one that is removable
4. Whether the prosthetic solution includes replacing just the tooth, the tooth and gingival tissue, or the tooth, bone, and gingival tissue (Fig IV-4)



FIGURE IV-4. Implant treatment options. *A, B*, Single tooth replacement. Replacement of a single missing mandibular first molar. *C, D*, Restoration of missing upper right lateral incisor to upper left lateral incisor. The prosthesis replaces the teeth and gingival tissue. *E, F*, Restoration of missing upper right central incisor to upper left canine. The prosthesis replaces the teeth, gingival tissue, and bone.¹

In the partially edentulous patient, an evaluation of the existing natural teeth and their periodontal support is imperative. The prognosis for the remaining teeth and their value in the overall dental health of the patient must be determined. If the patient is only missing a single tooth and all the remaining teeth are healthy, the prognosis for the patient's overall dental health is clear. However, if the patient has only a few teeth scattered throughout the maxillary and mandibular arches, and the remaining teeth have been heavily restored, are periodontally compromised, and their prognosis is questionable, a decision must be made regarding whether the remaining teeth hold any prosthetic value or could potentially compromise the esthetic result. In some cases, removal of the remaining teeth might be the best option.

The patient's occlusion should also be examined to determine whether the components of occlusion are favorable or will need to be reestablished. The clinician must also evaluate the occlusal scheme (eg, canine protected, group function, or some variation). The occlusion can be classified (eg, Class I, Class II, Class III) and compared with the patient's skeletal classification (eg, angle Class I, Class II, Class III). Open bites, deep bites, cross-bites, and the curves of Wilson and Spee must be recognized and assessed for how they might affect the planned prosthetics. Dental compensations for dental or skeletal abnormalities should also be considered (eg, wear facets, abfraction lesions, gingival recession, mobility, tooth migration, anterior splaying, mesially inclined molars, lingually inclined incisors). All these conditions can have a direct impact on the biomechanics of any proposed treatment.

An evaluation of the interarch space is critical in both the partially edentulous patient and the totally edentulous patient. The interarch space determines the spatial limitations and the opportunity for specific prosthetic options. For example, a cement-retained, abutment-supported crown on an implant replacing the mandibular right first molar requires a minimum of 8 mm of interarch space from the osseous crest of the edentulous space to the occlusal surface of the opposing tooth. If 8 mm of interarch space is not available, a screw-retained implant crown is necessary. For the edentulous patient, approximately 15 to 17 mm of interarch space is required for a bar-retained overdenture. If less interarch space is available, an abutment-retained (eg, locator attachment, O-ring) overdenture is necessary or surgery can be done if there is the need to remove excess soft and/or hard tissue.

The crown-to-implant ratio must be carefully considered in implant treatment planning. The clinician must measure the interarch space in the area planned for the crown and implant and reference that measurement against the intended implant length. For example, if the interarch space between the osseous crest of the edentulous site of the lower right first molar and the opposing occlusal surface is 10 mm and the longest implant that can be placed is 10 mm, the crown-to-implant ratio is 1:1. Any ratio less than 1:1 provides increased confidence for favorable biomechanics (eg, a crown height of 8 mm supported by an implant that is 13 mm long). When the ratio is greater than 1:1, the clinician must understand the potential biomechanical liability of incrementally exceeding that ratio (eg, a crown height of 15 mm supported by an implant 8 mm long).

Implant spacing must be understood as a dimensional requirement. Implants require 1.5 mm of space from the outer surface of the implant to the adjacent root surface and 3 mm of space between adjacent implants. For example, if a 4-mm-diameter implant were planned to replace a missing tooth, the minimum edentulous space required would be 7 mm (1.5 mm plus 4 mm plus 1.5 mm = 7 mm). If 2 adjacent 4-mm implants were planned between natural teeth, the edentulous span would have to be at least 14 mm (1.5 mm plus 4 mm plus 3 mm plus 4 mm plus 1.5 mm = 14 mm; Fig IV-5).



FIGURE IV-5. The minimum mesial to distal distance between 2 existing teeth to allow 2 standard diameter implants is 14 mm.

The edentulous maxilla requires scrutiny before selecting the prosthetic options. Because of the pattern of resorption (apically and palatally), consideration must be given to the intended location of the implant platform and the final position of teeth. In the case of a missing single tooth or a few anterior teeth, the ridge resorption might require grafting before implant placement (Fig IV-6). In a more severely resorbed atrophic maxilla opposing a dentate mandible, the anterior-posterior difference could be too great for a conventional, abutment-supported, fixed partial denture prosthetic option. In such cases, a framework-supported, fixed hybrid prosthesis or a removable overdenture option would need to be used. Close attention must be paid to the upper lip esthetics as well. Many patients need the support provided by the labial flange of the maxillary denture to support their upper lip, although others can have an acceptable result without the flange. One of the major motivators for patients seeking implants to retain a maxillary denture is the possibility of having a prosthesis without any coverage of the hard palate. In most cases, with appropriate implant support, this is, indeed, possible. However, in cases in which an extremely shallow buccal vestibule and palatal vault are present, the prosthesis might require palatal coverage for stability and enhanced biomechanics.

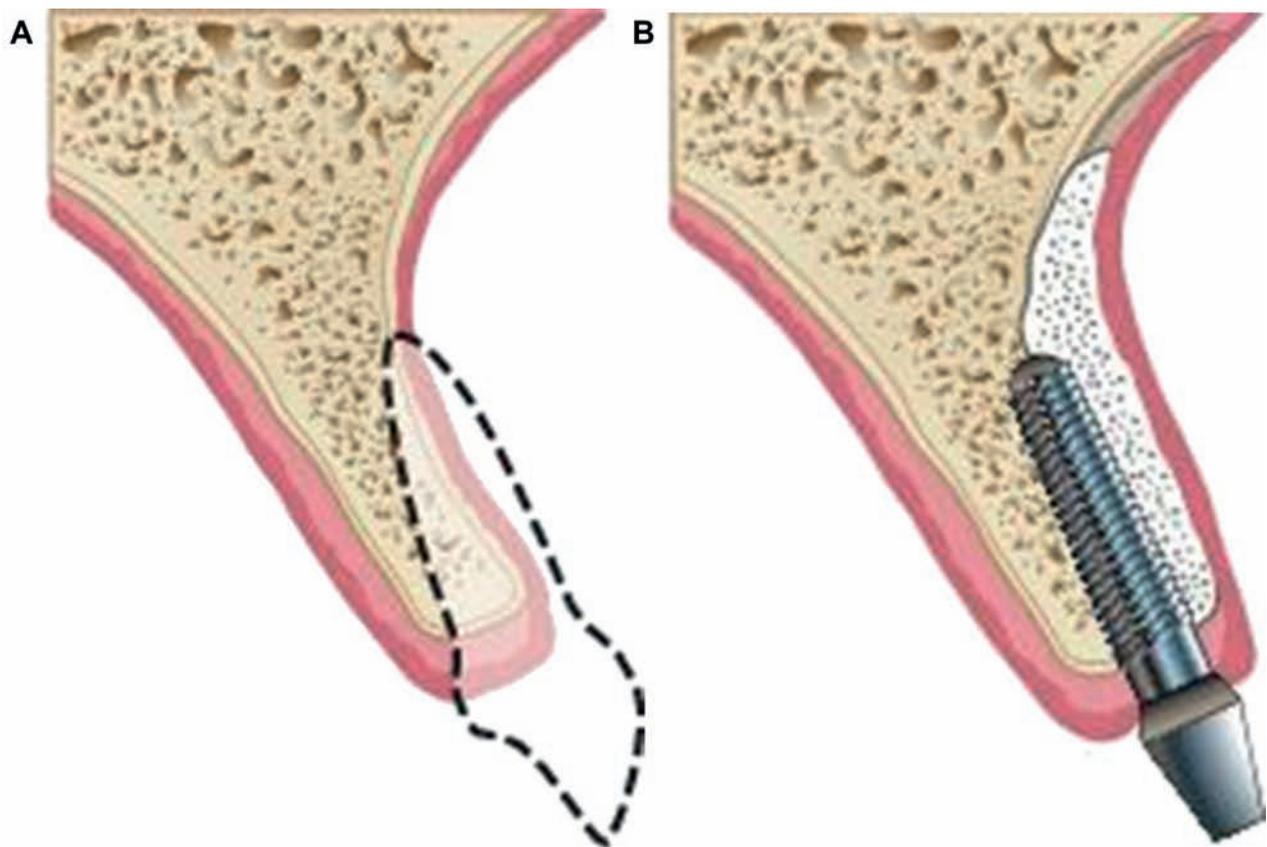


FIGURE IV-6. Deficient anterior maxillary ridge. *A*, After tooth loss, significant vertical and buccolingual loss of alveolar bone often occurs (original position of tooth shown). *B*, To facilitate implant placement, this type of bone defect will require a bone graft before implant placement.¹

A major determinate in overdenture support, as well as in fixed prosthetic options in the edentulous arch, is the concept of the anteroposterior (AP) spread of the implants. The AP spread is defined by the distance measured between a line drawn horizontally through the middle of the most anterior implant and a line drawn horizontally through the distal aspect of the most posterior implant on each side of the arch. The greater the AP spread, the more stable the prosthesis. If a retentive bar or fixed framework needs to be cantilevered to increase its length and, thus, its support, the AP distance measured can be multiplied by a factor of 1.5 to determine the additional

length that can be added to the bar or frame. Therefore, if the distance measured from the center of the most-anterior implant to the distal of the most-posterior implant is 10 mm, a retentive bar or fixed framework could be extended 15 mm further posteriorly to the most-posterior implant on that side (Fig IV-7). If the cantilevered distance is excessive, this can lead to failure of the prosthetic structure or can place undue stress on the implants, compromising implant integrity and potentially causing implant failure.

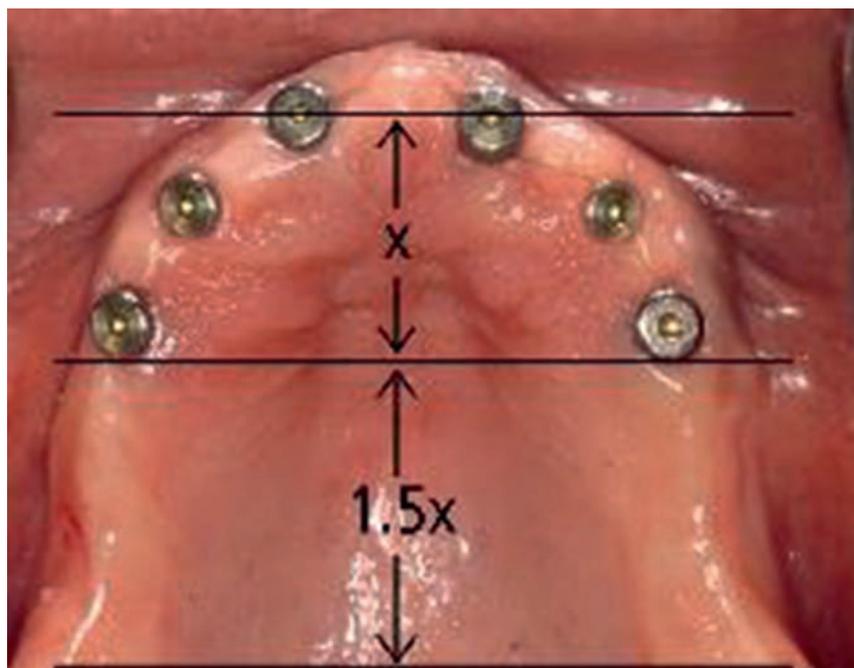


FIGURE IV-7. Anteroposterior spread lines for cantilever stability. Edentulous maxilla with 6 implants placed and depiction of the quantitative determination for the ability to extend a prosthesis or framework.¹

Many prosthetic options are available for implant reconstruction, each with a specific list of attributes and liabilities. The clinician must be aware of the pros and cons of each. The factors to take into consideration include the cost, durability, retrievability (ie, cement- or screw-retained), reparability (ie, degree of difficulty, time, cost), material choices (ie, acrylic, resin, porcelain), fixed or removable, clinical demand, patient expectations, and patient dexterity. For example, a patient with a completely edentulous maxilla might be a candidate for a removable, attachment-retained overdenture or a fixed, all-ceramic, hybrid prosthesis. The cost and durability of the all-ceramic hybrid is considerably greater than that of the overdenture; however, the retrievability and reparability of an overdenture is far easier and less expensive. The patient might have the financial means to afford the far more expensive all-ceramic hybrid prosthesis but might not have the physicality required for the increased clinical demand or the dexterity to care for the fixed option.

Reference

1. Hupp JR, Ellis E III, Tucker MR: Contemporary Oral And Maxillofacial Surgery (ed 6). St. Louis, MO, Elsevier, 2014

Section V Surgical Treatment Planning Considerations

Surgical treatment planning takes the diagnostic data that have been gathered and combines them with the restorative dentist's and surgeon's clinical judgment to determine the potential surgical options. The surgeon must be mindful of the proposed prosthetic goals, which are typically driven by the number of implants required in the suggested locations for a specific prosthetic design. Because implant dentistry is a team endeavor, it is advantageous for the surgeon to have a reasonable understanding of the prosthetics and for the restoring dentist to have an understanding of the surgical aspects of implant placement.

After evaluating all the diagnostic records, the surgeon must determine the prognosis of implant placement according to the specific limitations present as a result of anatomic variations, bone quality, and bone quantity in the different areas of the jaw. The anterior mandible is usually tall enough and wide enough to accommodate implant placement. The bone quality is usually excellent and is typically the densest of any area in the 2 arches. The primary surgical concerns in this area include proper angulation of the implants and avoiding the mental foramen and mandibular canal. Implants should be placed at least 5 mm anterior to the most anterior portion of the mental foramen, thereby avoiding the anterior loop of the mandibular canal (Fig V-1).

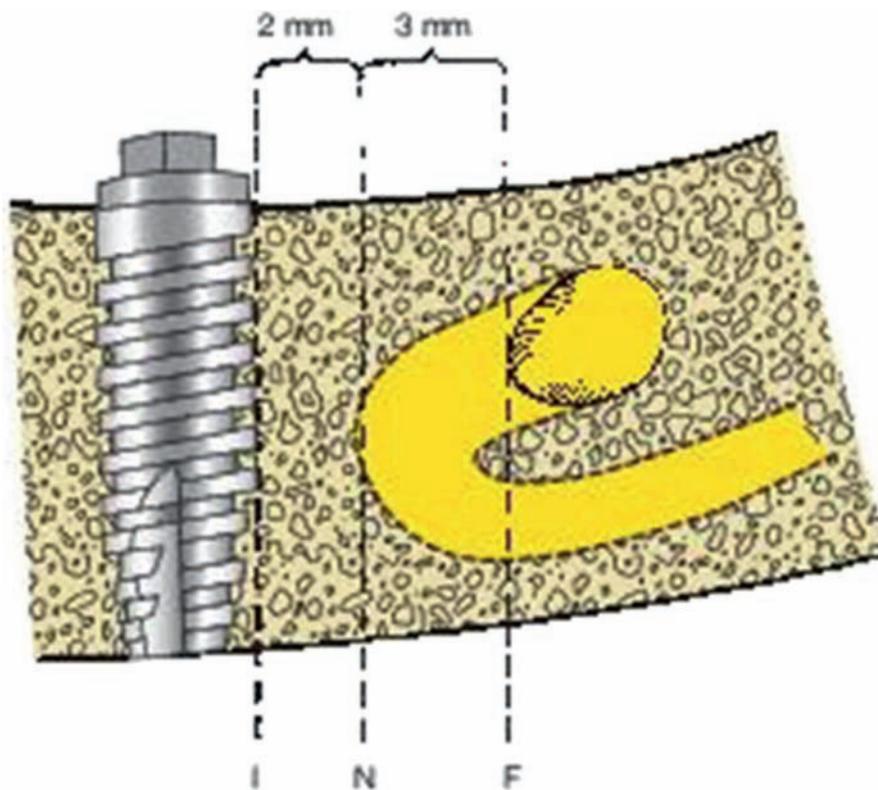


FIGURE V-1. The most-anterior extent of the bony mental foramen (F) is frequently located posterior to the most-anterior extent of the mental nerve before it exits from the bone (N). The most posterior aspect of the implant (I) should be placed a minimum of 2 mm from the nerve. Thus, the implant must be placed 5 mm anterior to the most-anterior aspect of the bony mental foramen. Radiographic images are used to show mental nerve path and foramen.¹

The posterior mandible limits the length of the implants because of the position of the mandibular canal that traverses the body of the mandible in this region (Fig V-2). Ideally, the apical tip of the implant should be at least

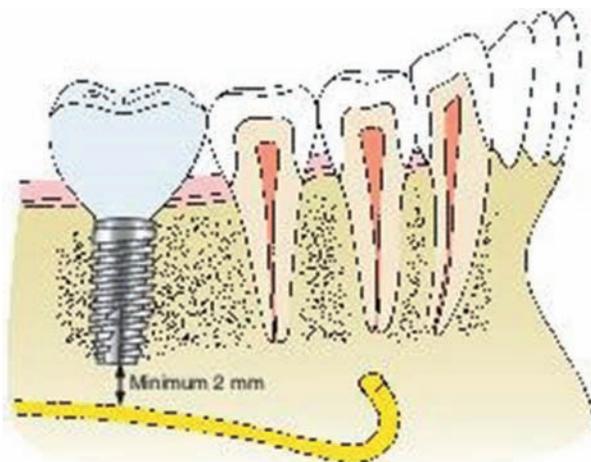


FIGURE V-2. The apical end of posterior mandibular implants should be a minimum of 2 mm from the superior aspect of the inferior alveolar canal.¹

2 mm from the inferior alveolar nerve (IAN). It is important to consider the buccolingual position of the nerve as well. The width of the posterior mandible must also be considered. If the nerve is located very near the buccal cortex, a longer implant can be placed, with the implant extending lingually to the IAN, although the implant will extend vertically past the nerve in reality and on imaging. Computed tomography (CT) or cone-beam CT (CBCT) can be helpful in making this determination. The mandibular canal also precludes any posterior implants from engaging the inferior cortical plate, which tends to lessen the initial primary stability of the implant. The attachment of the mylohyoid muscle helps to maintain the bony width along the superior aspect of the ridge, although this can often be deceiving, because a deep lingual depression, “the lingual undercut,” is usually present immediately below this attachment. This is a critical area that must be assessed and palpated during the clinical examination (Fig V-3).

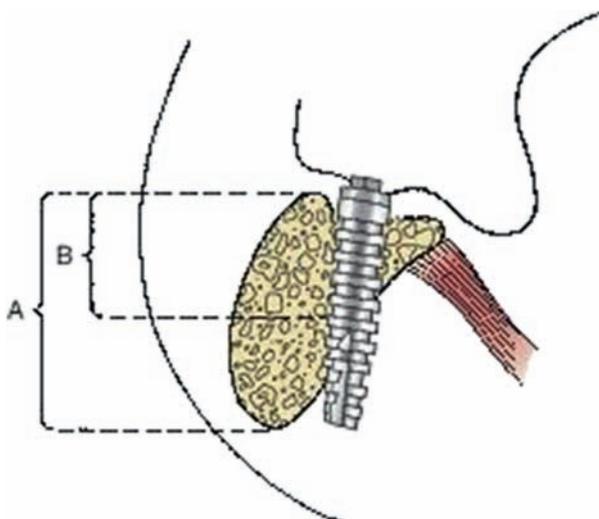


FIGURE V-3. The mylohyoid muscle tends to maintain the bone along its attachment to the mandible. Frequently, a significant narrowing of the mandible (undercut) is found below the mylohyoid ridge. If the implant length, position, and angulation do not compensate for this anatomic feature, the implant will perforate the lingual cortical plate. *A*, Bone height when viewed on a lateral radiograph. *B*, Actual height of available bone in the area desired for implant placement.¹

When planning implant placement, if primary stability is questionable, increased time for osseointegration to occur can be considered. The clinician might also want to consider “overengineering” the case by using more implants (eg, 3 implants replacing 3 teeth instead of 2 implants replacing 3 teeth).

An example of a very favorable situation would be a long implant that engages a thick cortical plate, proceeds through relatively dense cancellous bone, and then engages a thick cortical plate (see Fig II-3). In contrast, a less optimal situation would be a short implant placed in an area that has a thin cortical plate, proceeds through cancellous bone with a high fat content, and does not engage another cortical plate. The latter situation would provide poor primary stability.

The posterior maxilla poses 2 specific concerns related to implant placement. The first is the quality of bone in this area. As previously discussed, the bone quality in the posterior maxilla is typically the poorest of any area. It is limited by thin cortical bone at the ridge crest and the least dense cancellous bone, which can have a high fatty tissue component. This often results in less implant stability at the time of placement. Therefore, more time, such as 6 months or longer, can be required for satisfactory osseointegration to occur in this region. The second concern is the proximity of the maxillary sinus to the edentulous ridge. Often, as a result of bone resorption and increased pneumatization of the sinus, a limited height of bone remains for implant placement. If an adequate bone height is present, the implant should be placed, leaving 1 mm of bone between the sinus and the implant. If the bone height is inadequate, either a “sinus bump” or “sinus lift” procedure will be necessary to augment the height of bone. Both procedures are discussed in Section VIII of this guide.

The anterior maxilla, although the most surgically assessable area, might be one of the most difficult regions for implant placement. This area, even when healthy teeth are present, usually has a thin labial plate. After tooth loss, the resorption of the ridge follows a pattern of moving apically and palatally, only exacerbating already tenuous anatomy (see Fig IV-6A). The residual ridge anatomy results in a ridge that is narrow and angulated such that ideal implant positioning might be impossible and the esthetic outcome compromised. The nasal cavity and the incisive canal are vital structures that also define the anatomic limitations of anterior implant placement. Implants should be placed 1 mm short of the nasal floor and should not be placed in the maxillary midline. A number of advanced procedures can help with ideally placing maxillary anterior implants and are discussed in Section VIII of this guide.

The final stage of surgical treatment planning involves integrating the clinical and radiographic information with the surgical options and limitations to produce the best final result for prosthetic treatment. The positioning and angulation of implant placement are critical to the biomechanical stability and esthetics required for long-term success. To facilitate ideal implant placement, surgical guides prepared by the restorative dentist member of the implant team are frequently used. The surgical guide template is a critical factor for implants placed in an esthetically important area, because even slight variations of angulation can have large effects on the appearance of the final restoration. The construction of the surgical guide template is nearly indispensable for patients for whom it is necessary to optimize implant placement to ensure correct emergence profiles in the anterior esthetic zone.

The 4 objectives of using a surgical guide template for the partially edentulous patient are as follows: 1) delineating the embrasure, 2) locating the implant within the tooth contour, 3) aligning the implants with the long axis of the eventual completed restoration, and 4) identifying the level of the cemento-enamel junction or tooth emergence from soft tissue.

This template can be constructed using a diagnostic wax-up over the preoperative cast to construct a clear resin template with a guide hole. This provides the surgeon with ease of access to the bone and uninterrupted visual confirmation of the frontal and sagittal positions and angulation. Although the underlying bone can dictate some minor variations, the surgeon must attempt to stay as close as possible to the template during implant placement. With the aid of computer technology, accurate “virtual” treatment planning can be accomplished. CBCT data are used to produce a 3-dimensional reconstruction, which offers the ability to view anatomic structures in cross-section views. The ideal prosthetic position can be simulated and the position and angulation of the implant determined (Fig V-4). A computer-generated surgical guide can then be constructed with guide sleeves matched to the

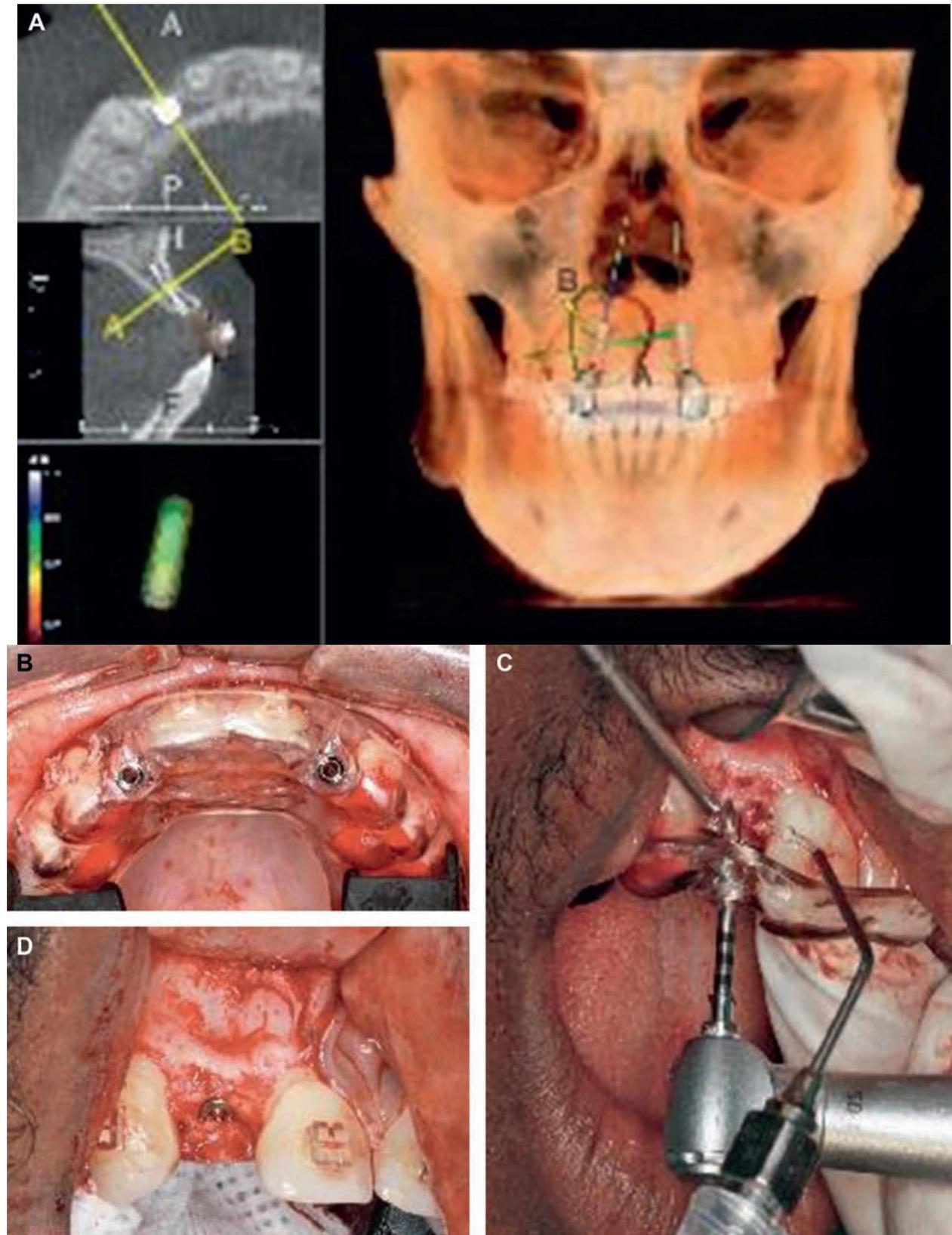


FIGURE V-4. Anterior surgical guide. *A*, Computer image showing 3-dimensional reconstruction of the anterior maxilla and cross-sectional view with proposed implant placement. *B*, Computer-generated surgical guide in place. *C*, Drill position and angulation determined by the surgical guide. *D*, Implant in place.¹

implant drill sizes. This allows for precision placement of the implant during surgery. The ultimate result should allow the surgeon to place the implant optimally in the bone while maintaining the angulation that will provide the best foundation for the final restoration.

The surgical guide template for the completely edentulous mandible should allow the surgeon maximal flexibility to select the implant position in the resorbed bone and yet provide guidance for the angulation requirements of the restorative dentist. A template with a labial flange that simulates the labial surface of the anticipated position of the denture teeth but that is cut out on the lingual aspect satisfies these 2 requirements. The surgeon places the implants within the arch form, as close to the surgical template as possible, to prevent the placement of the implants too far lingually or labially.

Reference

1. Hupp JR, Ellis E III, Tucker MR: Contemporary Oral And Maxillofacial Surgery (ed 6). St. Louis, MO, Elsevier, 2014

Section VI Basic Surgical Techniques

Surgical Preparation and Site Development

Surgical procedures always start with detailed surgical preparation. Preparation for implant surgery requires a thorough review of the patient's medical records, including medical and dental histories, radiographs, and restorative dentist-fabricated surgical guides. The surgeon should have a plan for surgical sequencing and strategy, anesthesia, operating time, instrumentation, and postoperative management. The surgeon should also have a clear understanding of the restorative plans. An inventory of the anticipated implant sizes and closely sized alternatives should be available, as well as a fully stocked implant placement kit with the needed drills, taps and insertion instruments. The implant handpieces, motor, and irrigation equipment should be tested preoperatively to ensure proper function. Preoperative prophylactic antibiotic administration is sometimes recommended. No postoperative antibiotic administration is usually considered necessary.

Once the patient has been draped, and the surgical team has been gloved and gowned, the patient is anesthetized. In many cases, the implants can be placed using local anesthetic blocking or infiltration techniques. Additional long-acting anesthetics for postoperative pain control might be warranted. For more complex and lengthy procedures or when requested by the patient, some type of sedation or general anesthesia might be preferred.

IMPLANT SITE EXPOSURE

Exposure of the implant site can be accomplished by several methods, including flapless surgery or tissue elevation, and can include sulcular, mid-crestal, and vertical-releasing incisions. Flapless surgery could be indicated when adequate keratinized tissue is available over an ideal ridge form (Fig VI-1). This will result in the least soft tissue trauma. In patients with excellent preoperative anatomy and papilla shape, flapless surgery might provide the best postoperative esthetics. In flapless surgery, the implant and the healing or provisional restoration are placed in a single stage.

When a flap is required, the incision should be designed to allow for convenient retraction of the soft tissue for unimpeded access for implant placement (Fig VI-2). Such an incision design is usually necessary when better access and visualization of the underlying bone is necessary and when additional procedures such as bone or soft tissue grafting will be performed at the time of implant placement.

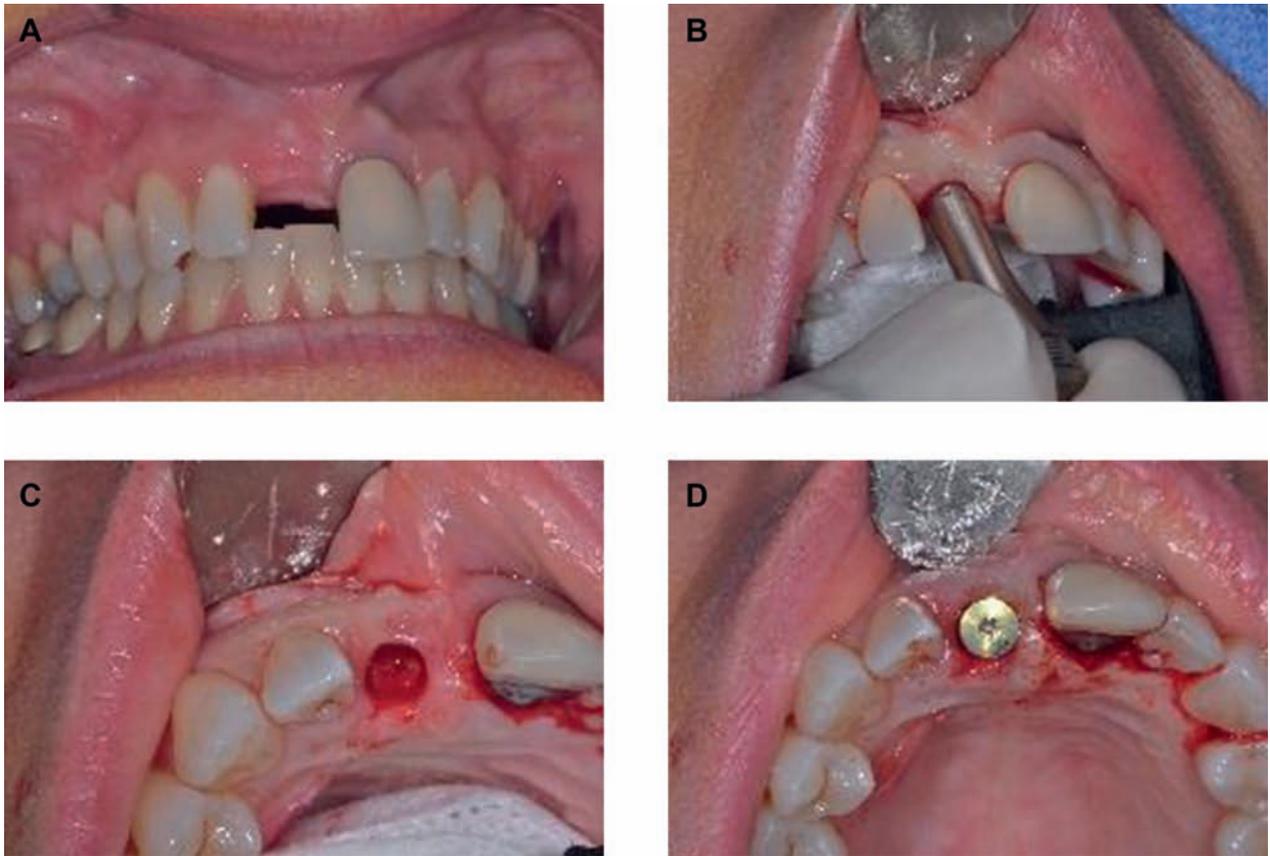


FIGURE VI-1. Flapless surgery. *A*, Preoperative view. *B*, Tissue excised in the exact diameter of the implant to be placed using a tissue punch. *C*, Tissue removed. *D*, Implant placement.¹

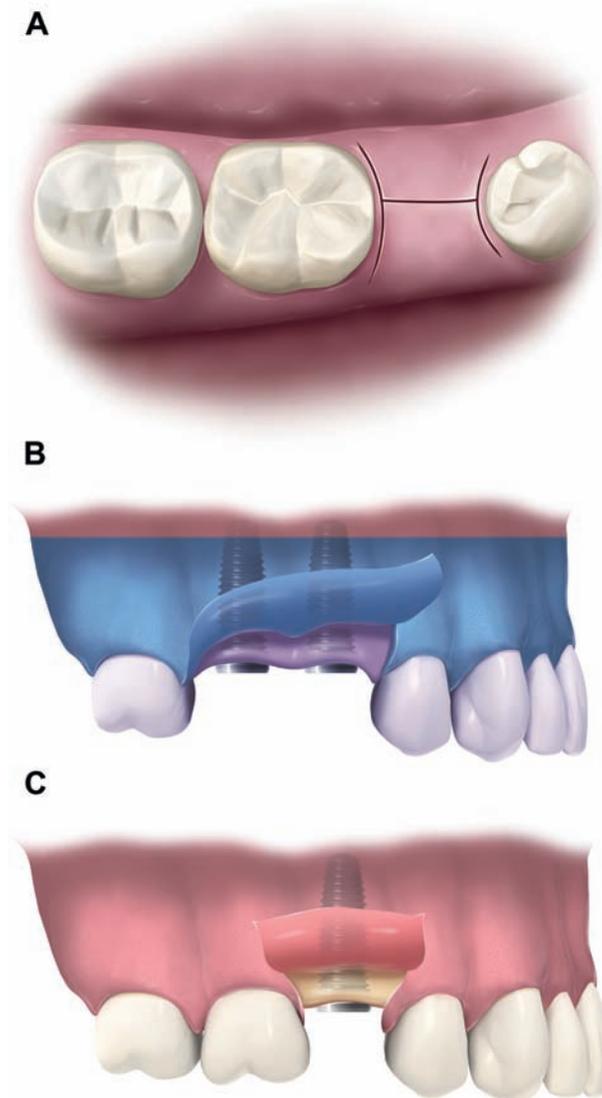


FIGURE VI-2. Various incision designs for placing implants. *A*, Papilla-sparing, mid-crestal incision with conservative release. *B*, Incision, with an anterior-releasing incision providing greater exposure. *C*, Papilla-sparing incision, with mesial- and distal-releasing incisions allowing more exposure.

- *Mid-crestal incision*: The mid-crestal incision should be made through the keratinized tissue, ensuring the blade is up against the mesial-distal surfaces of the teeth adjacent to the edentulous space. In areas with a narrow zone of keratinized tissue, the incision can be made slightly to the palatal or buccal aspect to allow for keratinized tissue transfer to the buccal or facial aspect and better soft tissue closure. If sulcular incisions are necessary, great care should be taken to follow the contour of the sulcus so as to not damage the soft tissue architecture.
- *Vertical-releasing incision (when indicated)*: Using a sharp no. 15 blade, a papilla-sparing incision should be made to reduce or eliminate incision scarring. One must ensure that the vertical-releasing incision is extended apically enough to allow for complete release of the flap.

Implant Placement

FLAP REFLECTION

- Reflection at the papilla is initiated with a periosteal elevator, using gentle, well-directed, and controlled pressure. The periosteal elevator's edge can be used in a "light painting stroke" to cleanly release the subperiosteal fibers. At this point, the flap is developed from the papilla up along the vertical release, if present.

- The dissection is then directed along the sulcular tissue to the point at which it meets the crestal portion of the incision. Using the index finger of the opposing hand supporting the facial aspect of the ridge will allow greater control and protection of the flap during reflection.
- The reflection is continued by the elevation sulcularly to the distal extent of the incision.
- Once the buccal flap has been reflected, the palatal or lingual flap can be reflected enough to visualize the width of the ridge. Any soft tissue tags should be carefully removed.
- When the buccal flap has been reflected completely, a retractor can be positioned against the bone inside the flap. This allows for good visualization of the operative site while protecting the integrity of the flap (Fig VI-3). It is extremely important to avoid inadvertent trauma to the flap with the tip of the retractors.

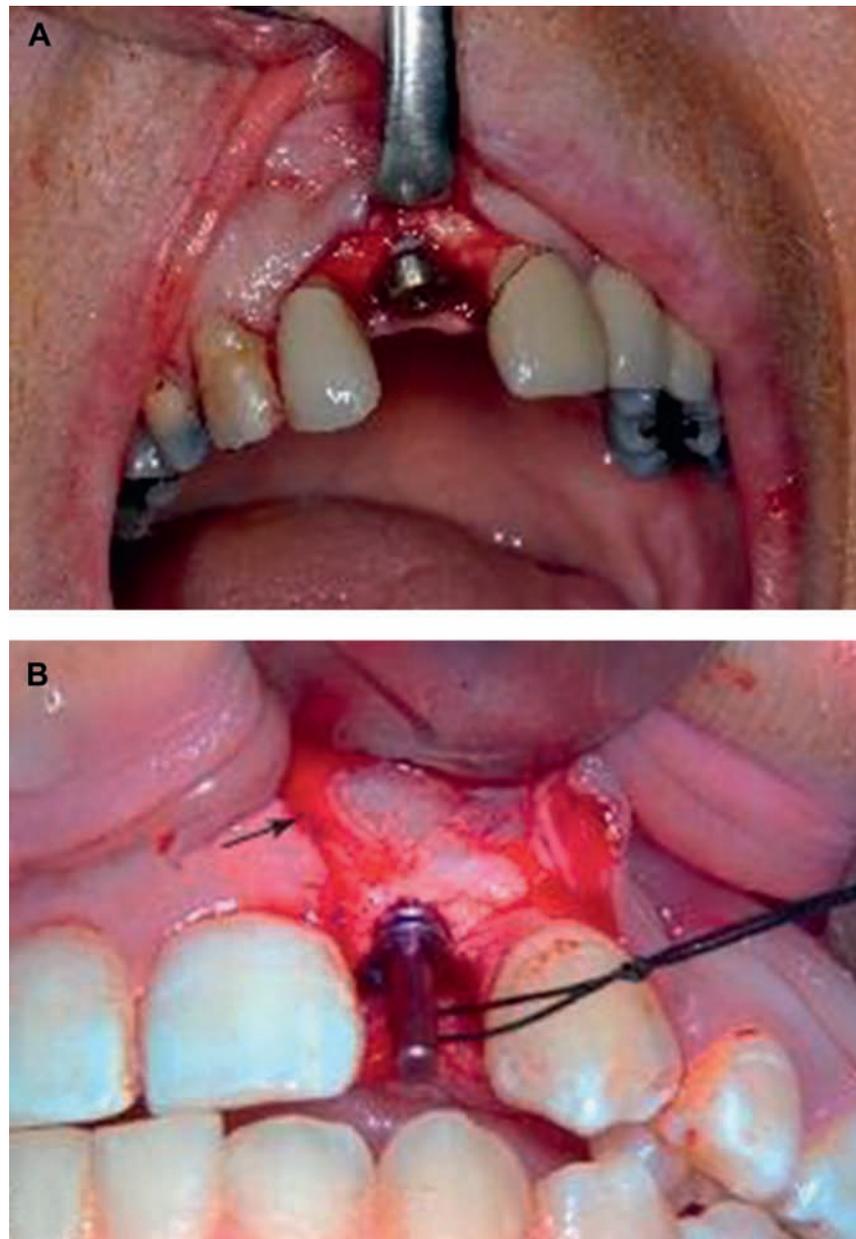


FIGURE VI-3. Typical examples of flap reflection for exposure to implant site. *A*, Without releasing incisions. *B*, With releasing incisions.¹

PREPARING THE OSTEOTOMY*

- The surgeon must confirm that the handpiece and motor are functioning properly. The speed setting on the motor should be checked. Also, it must be confirmed that the drill is spinning in the forward mode. The speed should be set at 1,000 to 1,500 revolutions per minute (rpm) for the initial set of drilling steps.
- All drills, including the osteotomy drills, should be copiously irrigated, internally or externally, or both, when preparing the bone.
- The depth indicator markings on the drills should always be reviewed by the surgeon to ensure the surgeon is certain of the depths they indicate.
- A small round burr should be used to mark the site of the implant through the cortical bone to help prevent the initial twist drill from displacement (Figs VI-4A and B).

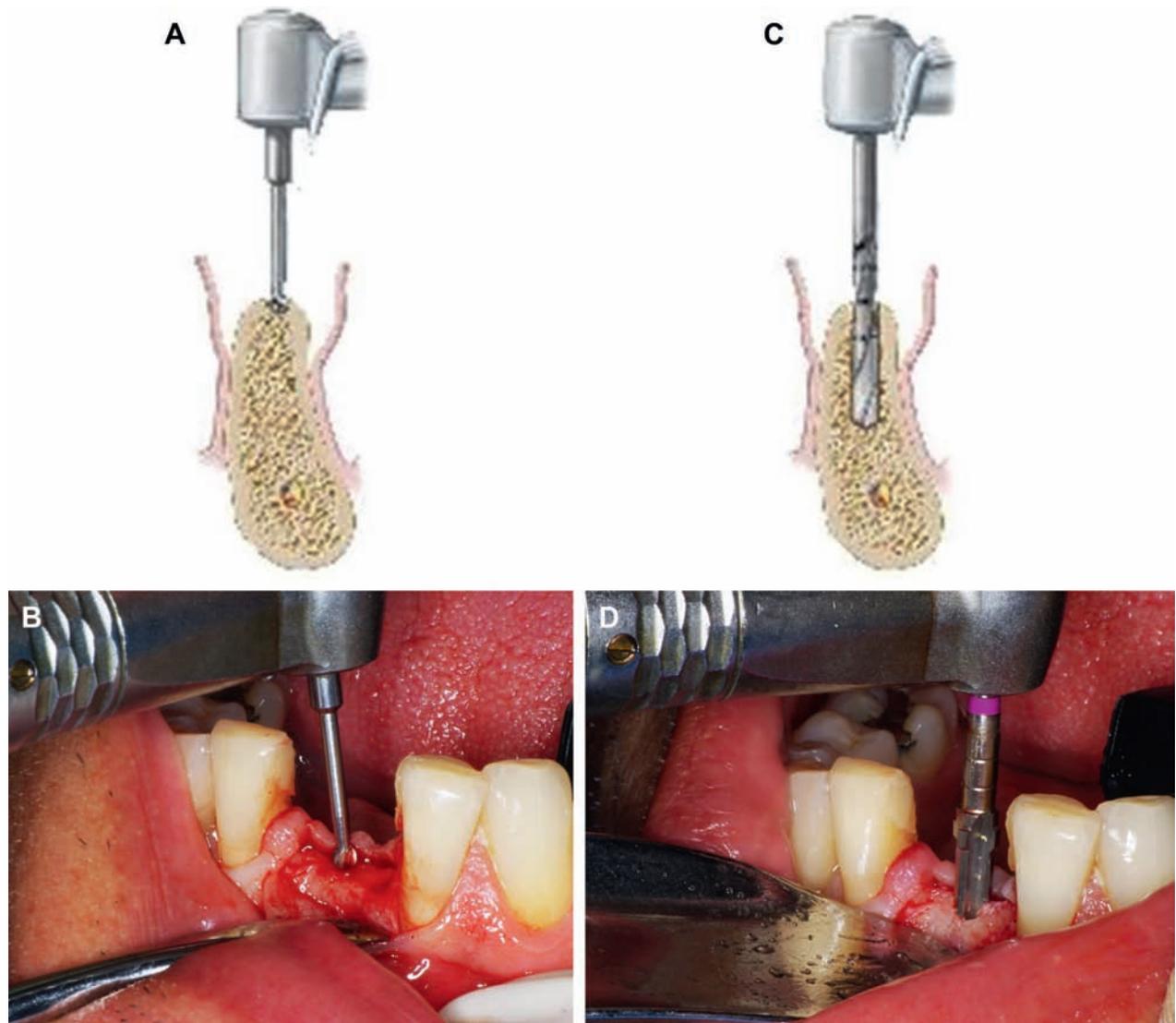


FIGURE VI-4. Typical implant site preparation and placement. *A, B*, Initial marking or preparation of the implant site with a round burr. *C, D*, Use of a 2-mm twist drill to establish the depth and align the implant. **(Fig 4 continued on next page.)**

*Implant manufacturers produce implant kits that contain the various drilling and implant placement components required to prepare the implant site for their particular brand and type of implant. The kits vary with respect to the size and length of the drills and the recommended speeds and sequences of drill use. The description of implant placement in this guide is only 1 example of how implant sites can be prepared but generally resembles the procedures followed by many dental implant systems.

- The initial drilling should be done with the 2-mm twist-drill at full speed (range 1,000 to 1,500 rpm) to the depth of the intended implant. The proper angulation should be verified from different vantage points. Gentle pressure should be used with a pumping action to clean out bone within the flutes of the drill, especially when drilling in dense bone (Figs VI-4C and D).
- A surgical guide pin is usually used to check the orientation. If adjustments in angulation or position are needed, the round burr is used to remove additional cortical bone at the osteotomy site (Figs VI-4 E and F).
- The pilot drill (if available in the system being used) is now used to help widen the coronal portion of the osteotomy site to help maintain the intended orientation of the site when the next larger twist drill is used. The area is irrigated, and the pilot drill is positioned in the exact same location, after verifying the correct angulation. The drill is again run at full speed and taken to the final depth of the intended implant (Figs VI-4G and H).
- The area is rinsed, and the guide pin is placed. The use of the guide pin allows the surgeon to evaluate the position, spacing, and angulation of the developing osteotomy. It also helps evaluate where the pin lines up against the opposing dentition and in relation to any other implant site being prepared at the same procedure.

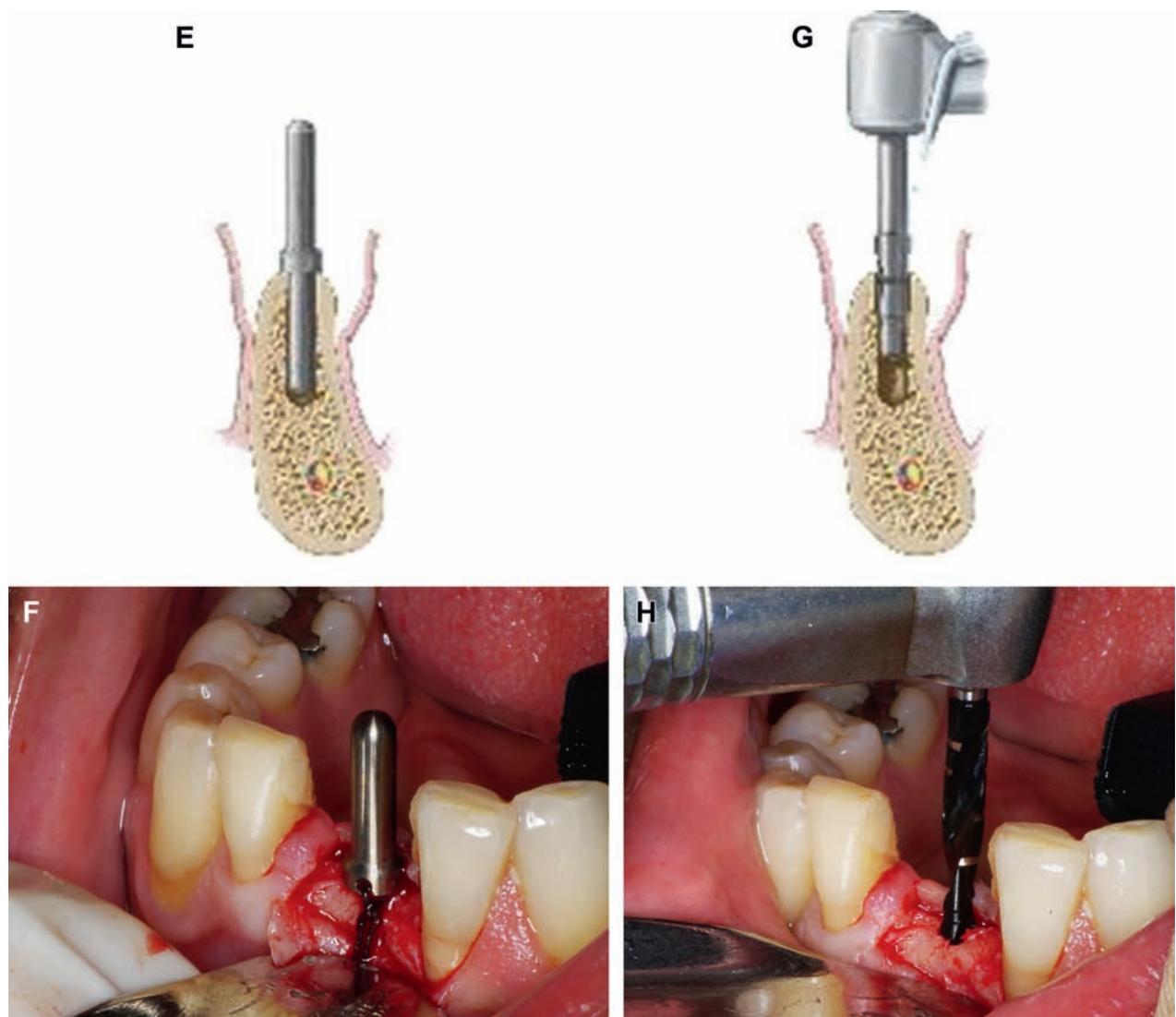


FIGURE VI-4 (cont'd). E, F, Guide pin placed in the osteotomy site to confirm position and angulation. G, H, Pilot drill used to increase the diameter of the coronal aspect of the osteotomy site. (Fig 4 continued on next page.)

- The surgeon then determines the location on the next larger twist drill that corresponds to the intended implant platform position of the implant to the ridge. Typically, the top of the implant platform would be even with the mesial and distal bone height. Great care should be taken to achieve the desired position and angulation, because this is the drill that finalizes the osteotomy (Figs VI-4I and J).
- The osteotomy is rinsed, and the appropriate guide pin is placed to re-evaluate the position and alignment.
- For larger diameter implants, a final, larger diameter twist drill is placed into the opening of the osteotomy, and its position and angulation are verified.

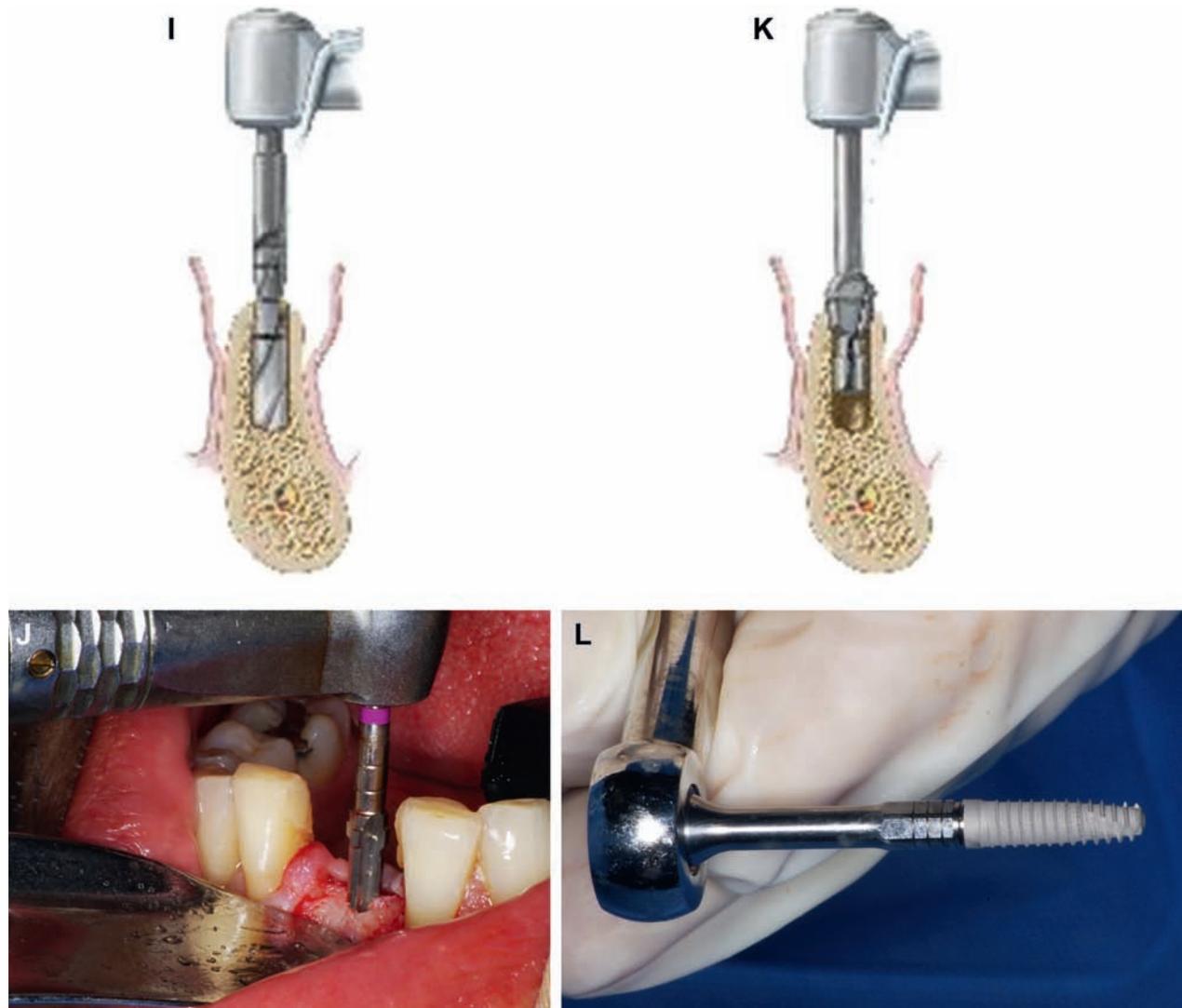


FIGURE VI-4 (cont'd). I and J, Final drill used is a 3-mm twist drill to finish preparation of the osteotomy site. K, Countersink drill is used to widen the entrance of the recipient site and allow for the subcrestal placement of the implant collar and cover screw. Note: An optional tap (not shown) can be used after this step to create screw threads in areas of dense bone L, Implant placed on manual driver ready for insertion. **(Fig 4 continued on next page.)**

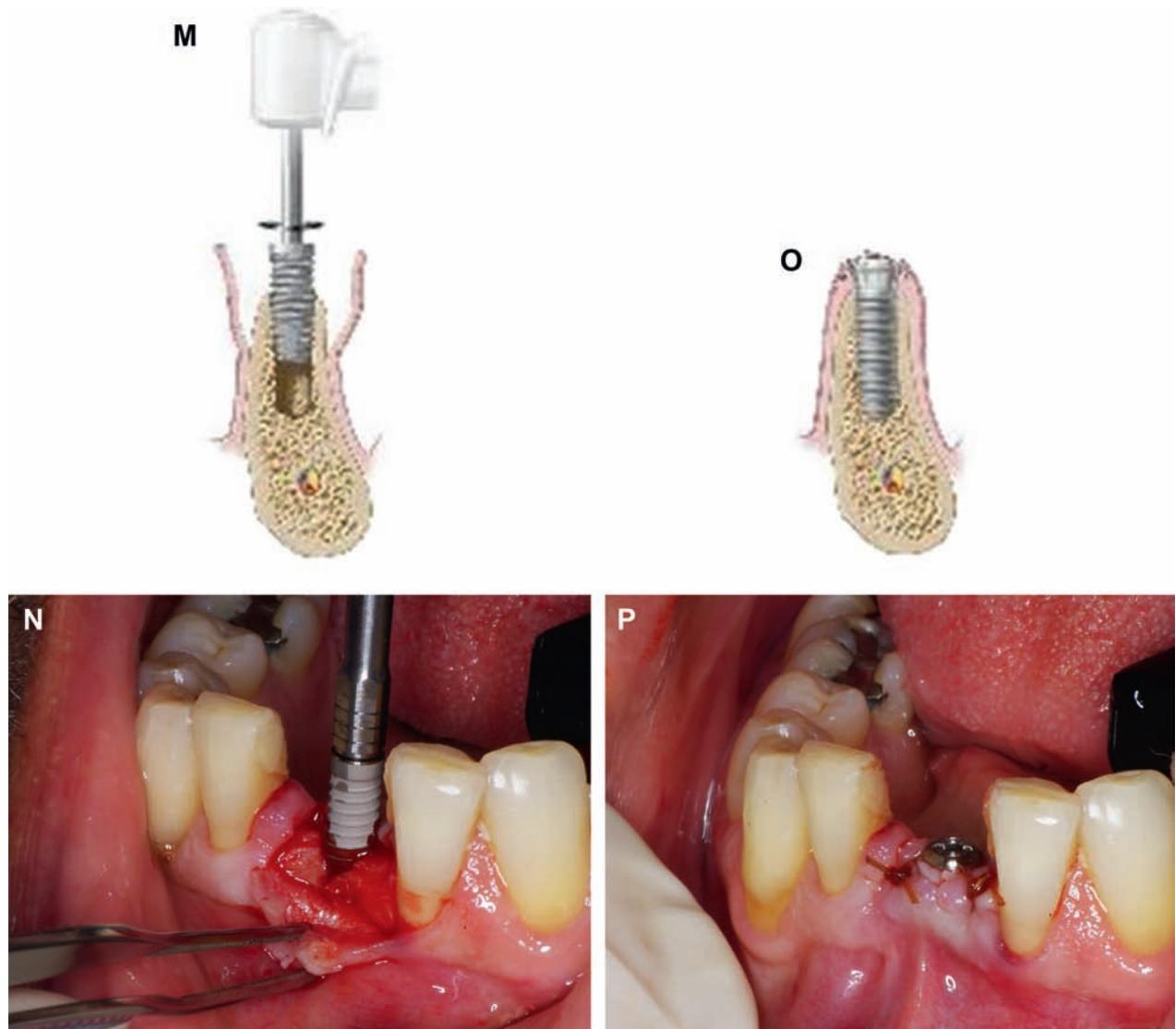


FIGURE VI-4 (cont'd). *M* and *N*, Implant is inserted into the prepared osteotomy site with a handheld (manual) driver. The implant can also be inserted using a handpiece at ultraslow speed. *O* and *P*, Cover screw is placed and soft tissues readapted and sutured. (Drawings from Narcisi EM, Tucker MR. Implant treatment: basic concept and techniques. Chap. 14 in Hupp JR, Ellis III E, Tucker MR, Contemporary Oral and Maxillofacial Surgery, ed. 6, St. Louis, 2014, Elsevier; clinical photographs courtesy of Dr. Stuart Lieblich, Avon, Connecticut.)¹

- Once the drill has been properly positioned, it is run at full speed with a gentle pumping motion to the final depth of the intended implant. The osteotomy is then inspected using a thin instrument for possible bone perforation (eg, sinus communication or buccal wall perforation).
- After completing the osteotomy, the speed of the motor is changed to the implant insertion setting on the drilling unit for placement of the implant (commonly 15 rpm). If the speed is not changed, and the implant is placed using the original setting of 1,000 to 1,500 rpm, the osteotomy could easily be damaged. The osteotomy site should be irrigated before placing the implant so that any loose bone particles do not impede the final seating of the implant.
- In situations in which dense cortical bone exists, a drill that taps the bone can be used before implant placement. This drill can be used with a drill speed of about 15 rpm with copious irrigation or can be used with the hand ratchet driver. If it is desired to have the implant platform rest just below the height of the cortical bone a countersink drill can be used. (Figure VI-4K).

INSERTING THE IMPLANT

- The implant is opened and placed on the appropriate driver, which has been inserted into the handpiece. If entirely manual implant insertion is planned the implant is mounted on the hand torque wrench (Figure VI-4L).
- The tip of the implant is inserted into the osteotomy, and the position and angulation are verified again. The implant is driven into position by keeping light pressure in an apical direction until the implant is almost completely seated or until the motor torques out (approximately 1 to 2 mm short of complete seating).
- Using the hand torque wrench, the surgeon continues to seat the implant, using the torque lever of the wrench to quantify the amount of torque present. If the torque exceeds the lever, the implant should be manually torqued to its final position using the handle of the torque wrench. Caution is necessary, especially with narrower implant diameters (eg, <3.5 mm), because excessive torque can cause “flowering” of the head of the implant. If excessive torque is noted on insertion, the fixture should be reversed out of the osteotomy. In such cases, either a dense bone drill can be used to widen the osteotomy or the site can be tapped (Figure VI-4N).
- The seating of the implant is finalized by verifying that the platform is even with the mesial and distal heights of bone and that the orientation of any marker that is critical for the prosthetic attachment is in the correct position.
- The area should then be thoroughly irrigated.
- It should be determined whether the healing period will be single stage or 2 stage. This is determined by the torque value measured on the surgical motor or the hand torque wrench. An implant with a torque value of 35 Ncm or greater can be considered to have good primary stability and single-stage healing is possible. If so, an appropriate-size transmucosal healing abutment is placed. If a 2-stage process is required, an appropriate-size cover screw should be placed. It is important that the surgeon ensure that the cover screw is fully and securely seated on the implant platform before suturing the flap to prevent bone or soft tissue from growing between the screw and the implant (Figures VI-4O and P).
- A transmucosal healing abutment should protrude 1 to 2 mm through the tissue.
- The healing abutment is placed onto the insertion wrench by holding the screw pointing up. The abutment is screwed into the implant and tightened with finger pressure, ensuring that no tissue is caught under the abutment.

When bringing small components such as healing abutments and cover screws into the surgical field, a gauze throat shield should be placed to avoid patient aspiration of the components. Most company’s manual drivers have a hole for a protection thread long enough to remain outside the oral cavity that can be placed in case the tool is dropped within the oral cavity.

HEALING OR INTERIM ABUTMENT

Healing abutments are dome-shaped intrainplant screws that provide permucosal access to the implant platform. Healing abutments are placed at the completion of the implant placement surgery in a 1-stage surgical approach or after uncovering in a 2-stage surgical approach. Healing abutments are composed of titanium or titanium alloy. The abutments can be parallel walled or tapered and range in height from 2 to 10 mm. The height of the abutment used should be determined by the thickness of tissue present. The healing abutment should project 1 to 2 mm superior to the height of the gingival tissue (Fig VI-5). A tapered healing abutment is used to help shape the

soft tissue to a more appropriate emergence for the planned restoration (eg, a crown). A parallel-walled abutment would be used if tapered emergence is not necessary (eg, a retentive bar for an overdenture). It is important to allow for sufficient healing of soft tissue after placing the healing abutment before taking any impressions for the final prosthetics.

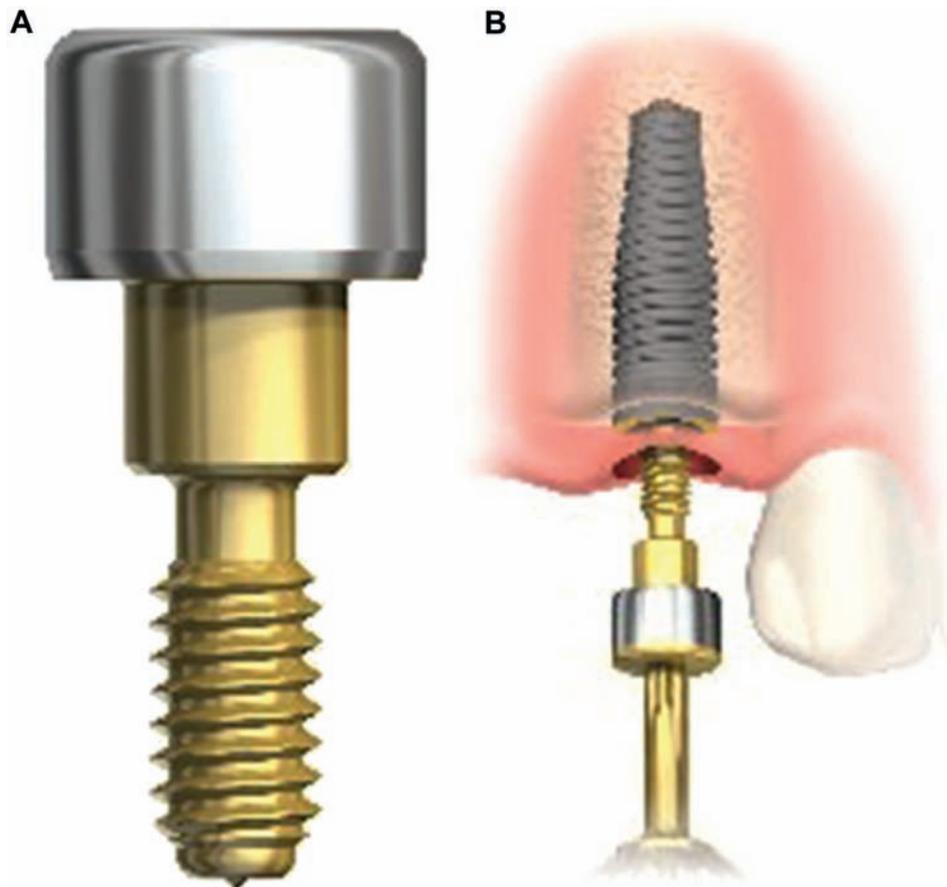


FIGURE VI-5. Healing abutment. *A*, Nobel Biocare healing abutment. *B*, A healing abutment being placed into the implant. (Fig 5 continued on next page.)

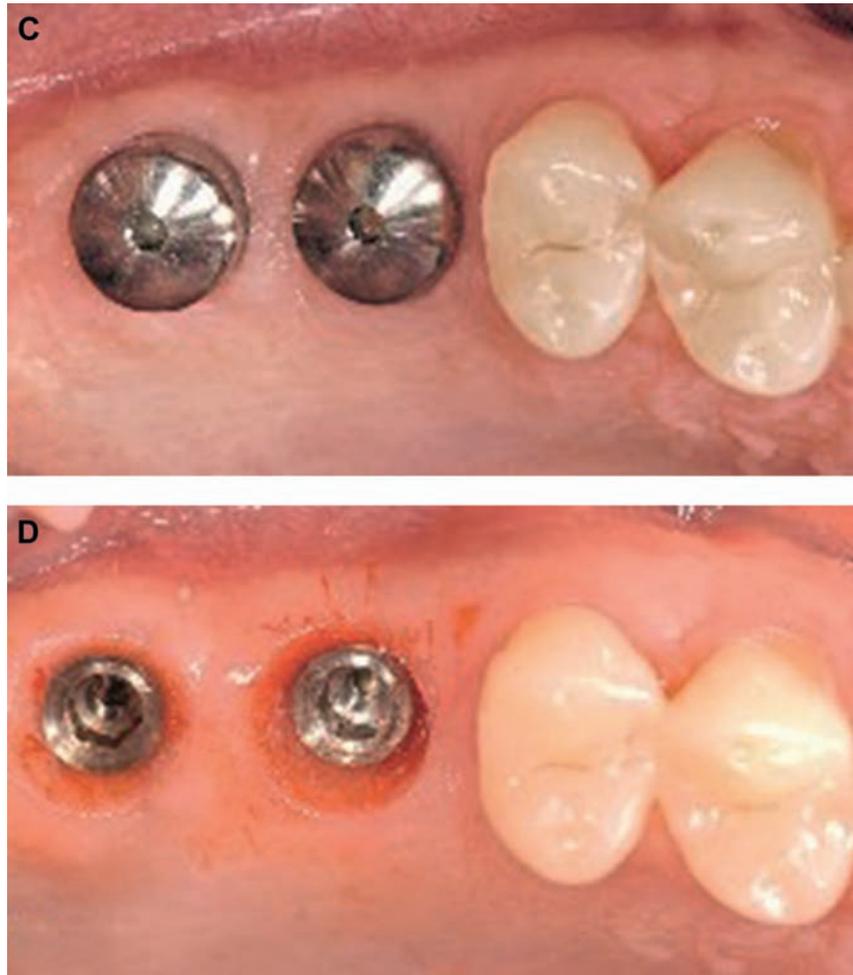


FIGURE VI-5 (cont'd). C, Two healing abutments in place. D, Clinical view after removal of the healing abutment. Note the way the tissue has been shaped by the contour of the healing abutment. (A and B, Courtesy of Nobel Biocare USA, LLC, Yorba Linda, CA.)¹

SUTURING THE FLAP

- The flap is sutured back into place using some type of resorbable suture (chromic gut or polyglactin 910) or nonresorbable sutures such as black silk.
- The anterior papilla should be secured first. The buccal aspect of the papilla is entered with the suture needle, which is passed through the embrasure to engage the palatal tissue. The needle is then positioned lower on the palatal tissue. It penetrates and is brought through the embrasure to the buccal and the papilla engaged apical to the first entry point.
- The vertical release is then sutured, followed by the mesial and distal sides of the abutment. These are routine interrupted sutures tied in the same fashion as the first suture described.

Postoperative Management

A radiograph should be taken postoperatively to evaluate the position of each implant placed in relation to the adjacent structures such as the sinus or inferior alveolar canal and relative to the teeth and other implants. The radiograph should also be viewed to help ensure that the cover screw or healing abutment is fully seated.

The patients should be given analgesics for pain control postoperatively. Mild to moderate strength analgesics are usually sufficient. Antibiotics are often given prophylactically before surgery but are usually not required in the postoperative period. The patient should be evaluated weekly until soft tissue wound healing is complete (approximately 2 weeks). If the patient wears a tissue-borne denture over the area of implant placement, the denture can be

relined with a soft liner after 1 week. Interim partial dentures or orthodontic retainers with an attached pontic can be worn immediately but must be relieved to avoid soft tissue loading over any implant site.

UNCOVERING

The healing time or the time necessary to achieve osseointegration varies from site to site and from patient to patient. The insertion torque values, quality of bone, bone grafts, patient health, location of implants, and soft tissue health will all have an effect on the time needed to achieve osseointegration. The typical healing times for adequate osseointegration are 3 to 6 months.

In single-stage surgery, no surgical uncovering is necessary. The implant will stay exposed by way of the healing abutment after surgery and throughout the healing phase. After an appropriate integration time, restoration of the implant can proceed. After placement of the implant fixture in a 2-stage surgical approach and before suturing, the implant fixture is sealed at its platform with a low-profile, intrainplant cover (healing) screw. It is important that the surgeon ensure that the cover screw is fully and securely seated on the implant platform before suturing the flap to prevent bone or soft tissue from growing between the screw and the implant. In the second-stage uncovering procedure, the cover screw is removed and replaced with a healing abutment.

In a 2-stage system, the implant must be surgically uncovered and a healing abutment placed. The goals of surgical uncovering are to attach the healing abutment to the implant, preserve the keratinized tissue, and modify the form or thickness of the tissue. A soft tissue healing period after uncovering must be allowed before restoration of the implant can take place and typically requires 2 to 4 weeks.

One method of surgical uncovering is the use of a “tissue punch” (Fig VI-6). This method of uncovering using a soft tissue punch equal to or slightly larger than the diameter of the implant placed. The implant is palpated through the tissue to determine its location. The tissue punch is placed directly over the implant circumference and twisted through the soft tissue thickness, taking care not to damage the bone at the level of the implant platform. The punch is then removed, along with the precisely determined piece of tissue that was lying directly above the implant, exposing the implant cover screw. The cover screw is then removed, and an appropriate-size and -shape healing abutment is placed. The advantage to this technique is that it is less traumatic, no periosteum needs to be

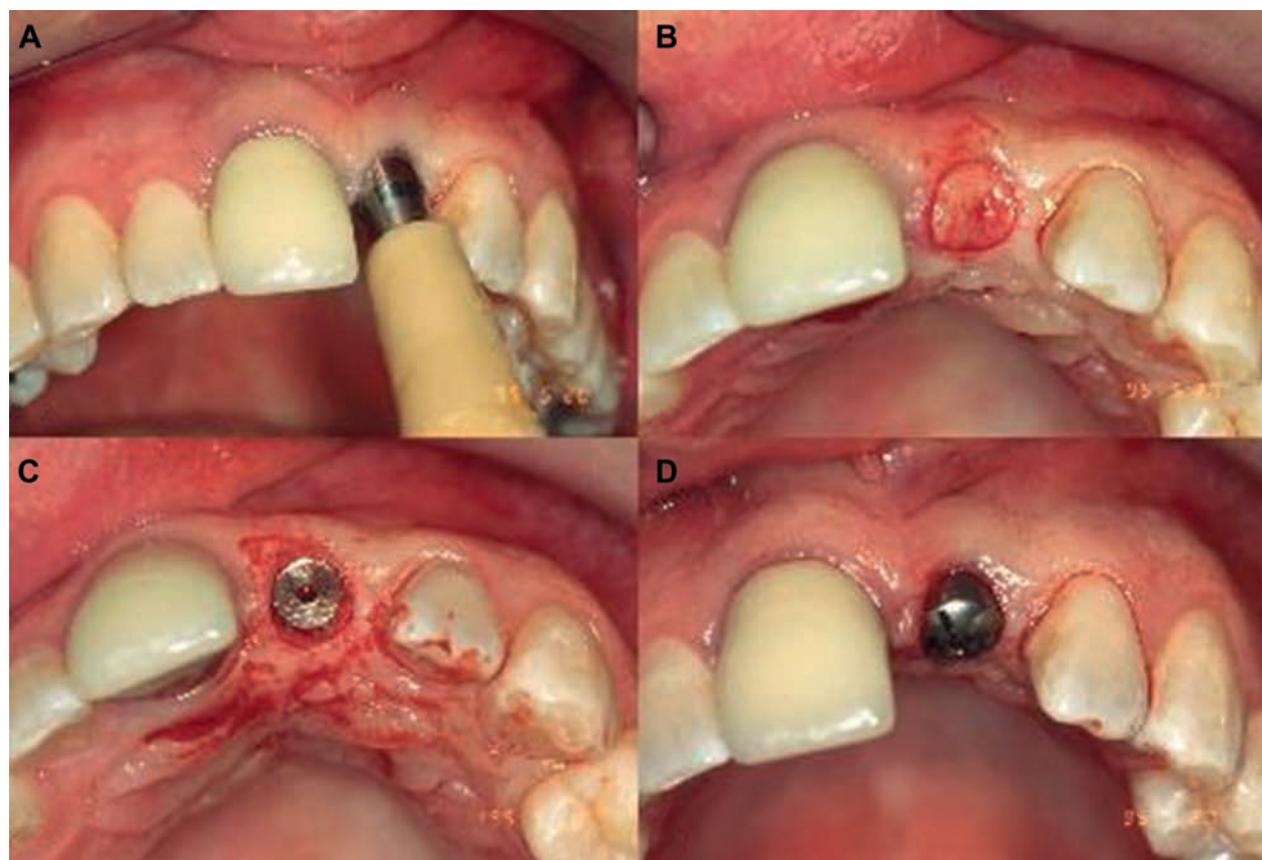


FIGURE VI-6. A-D, The most straightforward method to uncover an implant is to use a tissue punch. This method only minimally disrupts the tissue surrounding the implant platform and produces little patient discomfort. To use this technique, the implant must be located such that the surgeon is certain the punch will remove the correct soft tissue.¹

reflected, and only a short soft tissue healing time is required. This technique does, however, require an adequate zone of keratinized tissue so that the implant can be accurately located. The disadvantages to this technique include sacrifice of a portion of the keratinized tissue, an inability to visualize the bone surrounding the implant, and the inability to directly visualize the precise abutment-implant interface.

If the implant cannot be accurately located, if the clinician needs to visualize the underlying bone, or if a slight transposition of keratinized tissue is indicated, a crestal incision with the creation of a slight soft tissue flap will be required to uncover the implant. If an adequate zone of keratinized tissue is present, the soft tissue flap can be contoured with a scalpel, scissors, or a punch to conform to the shape of the healing abutment (Fig VI-7). This will create a nicely shaped and contoured soft tissue cuff around the healing abutment and, eventually, the final implant restoration. The obvious advantages to this technique include the ease of access, minimal invasiveness, and ability

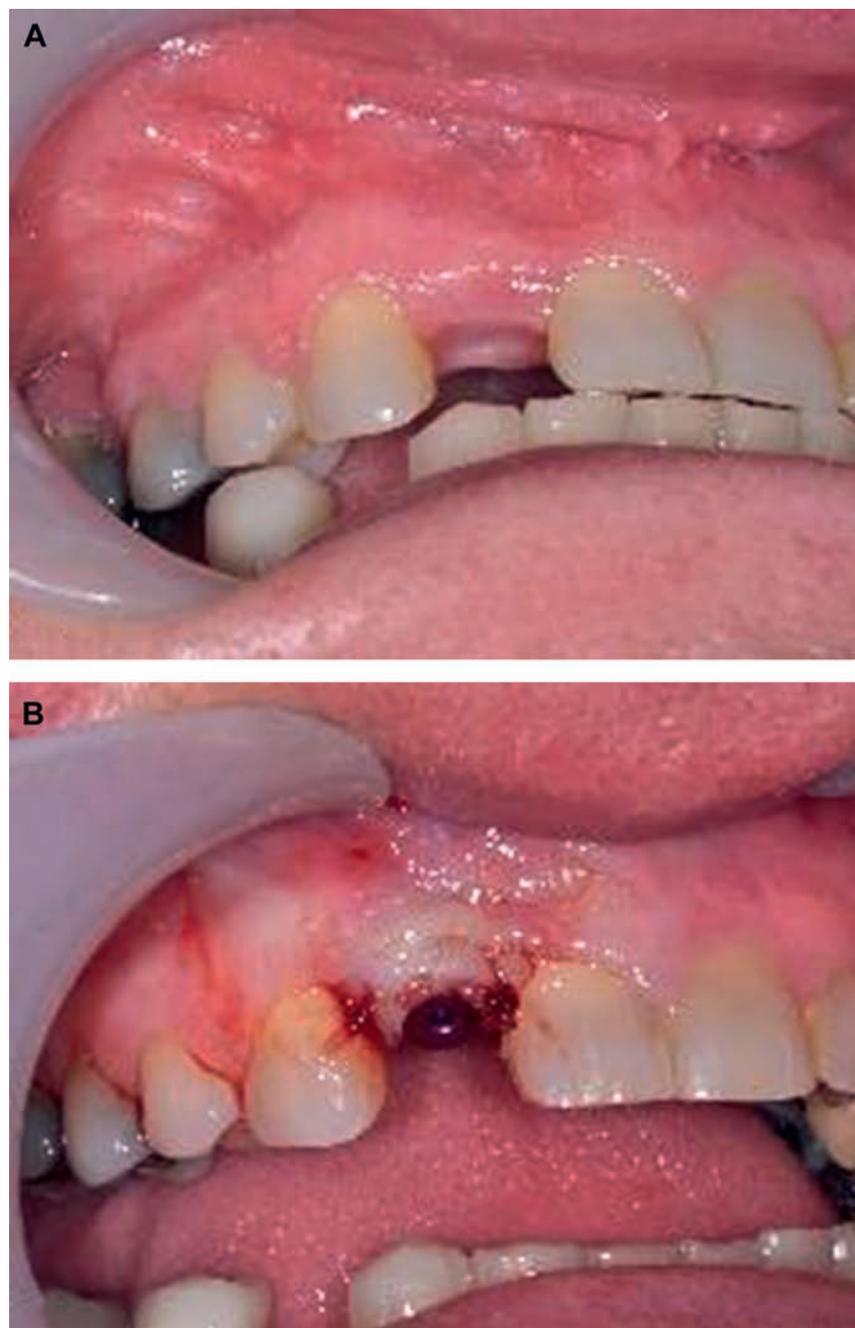


FIGURE VI-7. Second-stage exposure of an implant using small flaps. *A*, Before starting the uncovering. *B*, After small flap elevation using the incision shown in Fig VI-2A once the implant-exposed tissue has been contoured and sutured to maintain keratinized gingiva around the implant.¹

to directly visualize the bone surrounding the implant and to precisely fit the healing abutment to the implant platform. The disadvantage to reflecting a flap during uncovering is the possibility of bone loss due to periosteal stripping from the bone during uncovering. Advanced techniques for cases with an inadequate zone of attached tissue include tissue transfer procedures, tissue grafting, and split-thickness apically repositioned flaps.

IMPLANT STABILITY

Initial implant stability is one of the most important predictors of long-term implant success. The stability will depend on the depth and density of the bone, implant size, and precision of the surgical technique. A good sense of implant stability can be obtained during the seating process and by verifying adequate torque resistance capability of the seated implant.

Recently, radiofrequency analysis has been used to measure and verify implant stability. This technology involves attaching a transducer to an implant and applying a steady-state resonance frequency to the implant. The advantage of this technology is that it is not dependent on measuring implant movement in just 1 direction but instead allows the evaluation of the complete bone-implant interface.

Complications

Implant placement surgery can be performed with great accuracy and with a low likelihood of complications if the case has been diagnosed, planned, and surgically performed well. However, just as with any surgical or clinical procedures, complications are possible and include:

- Those that can occur with any surgical procedure, including greater than expected pain, bleeding, swelling, or an infection.
- A positioning error resulting in implants placed at a compromised angulation or position. The implant could have been placed too close to an adjacent tooth root or existing implant. It might be too far from the mesial, distal, or buccal aspect, compromising bony support. The implant could have been placed too far into the bone, making prosthetic access difficult. If the implant has not been placed deep enough into the bone, leaving threads of the implant body above the osseous crest, the bony support, soft tissue health, hygiene, and esthetics will be compromised.
- Surgical technique problems, such as a tear of the soft tissue flap, poor closure of the incision, or excessive soft tissue trauma from retraction, can result in tissue dehiscence and eventual loss of the implant. Poor attention to detail in preparation of the osteotomy site such as overdrilling the diameter of the osteotomy could result in a poor prognosis for integration.
- The invasion of important anatomic structures can create more serious complications. An implant that enters or impinges on the canal of the inferior alveolar nerve can result in paresthesia (altered sensation that the patient does not find painful; eg, numbness, tingling), or dysesthesia (altered sensation that the patient finds uncomfortable). An implant that enters the maxillary sinus or the nasal cavity can result in an infection. Bone structure compromise can present as overthinning of the buccal or facial plate or dehiscence or fenestration of the overlying tissue. Bone perforation can occur at the inferior border of the mandible owing to an inaccurate drilling depth or at the lingual aspect of the posterior mandible because of the lingual undercut from poor positioning or angulation of the implant drills.
- Mechanical complications can present as an implant platform fracture because of excessive insertion torque. If the osteotomy has been improperly prepared in dense bone, it is possible for the implant to become “stuck” in the bone, short of complete seating, making it extremely difficult to fully insert or retrieve the implant.
- An incision line opening can occur from inadequate suturing or not achieving tension-free closure.
- Esthetic complications can occur from poor implant positioning or angulation, making esthetic prosthetic restoration unrealistic.

Reference

1. Hupp JR, Ellis E III, Tucker MR: Contemporary Oral And Maxillofacial Surgery (ed 6). St. Louis, MO, Elsevier, 2014

Section VII Restoring Dental Implants

Implant Components

Successful surgical placement and proper healing typically result in an osseointegrated implant ready for prosthetic restoration. Contemporary dental implants have an internally threaded portion that can accept second-stage prosthetic components, allowing the restoring clinician to assemble a restorative platform. Implant restorations require the use of several component parts. For the inexperienced implant clinician, the sheer number of parts and the infinitely unique restorative needs presented by patients can be overwhelming. This section describes, in generic terms, the component parts typically used in the restoration of dental implants. It should be noted that the component nomenclature can differ from 1 manufacturer's implant system to that of another; however, conceptually, the components have similar purposes.

IMPLANT BODY OR FIXTURE

The implant body, or fixture, is the implant component placed within the bone during the first stage of surgery. Most contemporary implant fixtures are referred to as *root form implants*, taking the form of a cylinder or a tapered cylinder, and are made of titanium or titanium alloy (Fig VII-1). Most current implant fixtures have an external threaded design, although historically smooth-surfaced implants have been used that were pressed into position. A wide variety of external thread designs and different surface textures and coatings that attempt to maximize implant stability and the process of osseointegration have been offered by manufacturers. Most implant fixtures incorporate an antirotational design feature at the interface of the adjoining prosthetic components. This antirotational feature can be located internally or externally to the implant platform (Fig VII-2).



FIGURE VII-1. Typical root form implant. (Courtesy of Zimmer Dental Inc., Carlsbad, CA.)¹

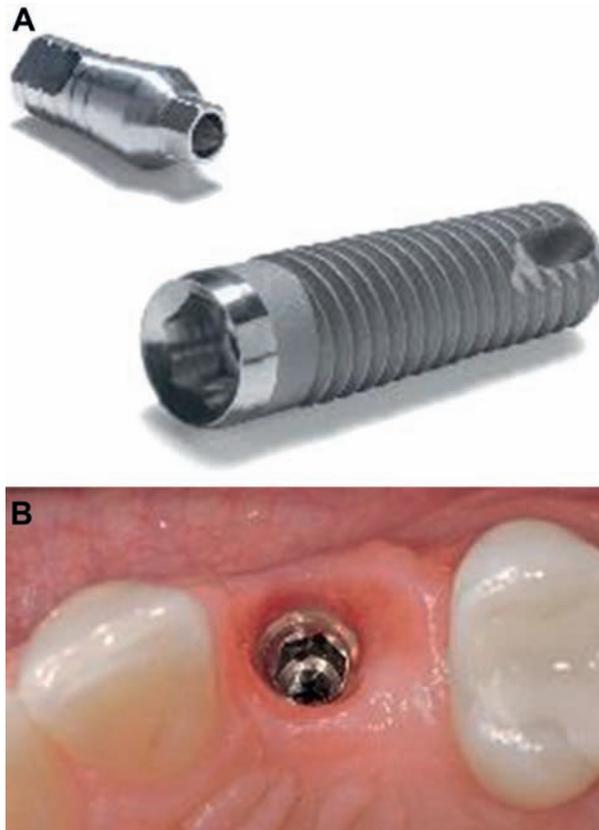


FIGURE VII-2. Internal antirotation hex. *A*, Internally hexed Zimmer brand implant and associated abutment with hex base designed to seat into an implant. *B*, Intraoral view of internally hex implant without abutment in place.¹

The overwhelming majority of implants are referred to as *2-stage implants* (ie, the surgically placed fixture is the first stage and the screw-in prosthetic components are the second stage). The second-stage components attach to the implant body using an internally threaded feature within the implant body. One-piece implants (1-stage implants) exist that have the threaded portion housed in the bone and the prosthetic abutment together as 1 unit; however, these are uncommon. It is important to recognize the difference between a 2-stage implant and a 2-stage surgical approach. A 2-stage implant with a healing abutment can be placed using a 1-stage surgical approach or with a cover screw in a traditional 2-stage surgical approach. All 1-piece (1-stage) implants are placed using a 1-stage surgical approach (Fig VII-3).



FIGURE VII-3. Single-stage and 2-stage implants. A, Two-piece implant and abutment (*top*) and one-piece implant (*bottom*; Zimmer). B, One-piece implant (Nobel Biocare). C, One-piece implant replacing the lower left central incisor. D, The final restoration of the implant replacing the lower left central incisor. (A, Courtesy of Zimmer Dental Inc., Carlsbad, CA; B, courtesy of Nobel Biocare USA, LLC, Yorba Linda, CA.)¹

IMPRESSION COPING

Impression copings facilitate transfer of the intraoral location of the implant to the same position on the laboratory cast. Impression copings can be either screwed into the implant body or screwed or snapped onto an implant abutment. Some impression copings have a flat side that acts to orient the threads or the antirotational design of the implant (eg, hexagon or trilobe). This is important when using stock-type abutments or components (Fig VII-4). Typically, the impression transfer can be either a closed-tray transfer or an open-tray transfer. The closed-tray technique captures the index of the impression coping, and, after the impression has been removed from the mouth, the impression coping is unscrewed from the implant and placed, along with an implant analog, back into the impression. An open-tray transfer uses a specific impression coping that is designed to emerge through the impression tray. When the impression is ready to be removed from the mouth, the impression coping is unscrewed and pulled out in the impression. The open-tray method is considered the more accurate transfer method and is indicated when large-span frameworks or bar structures are planned or when the implants are too divergent to easily remove the impression tray using the closed tray technique. A heavier bodied polyvinyl siloxane or polyether impression material is recommended. Before making the transfer impression, it is imperative that the clinician obtain a radiograph to confirm that the impression coping has been accurately seated on the implant platform. If the impression coping is not properly seated, the accuracy of the transferred location of the implant will be

incorrect. On completion of the transfer impression, an implant analog is screwed onto the impression coping to allow the fabrication of a laboratory cast.

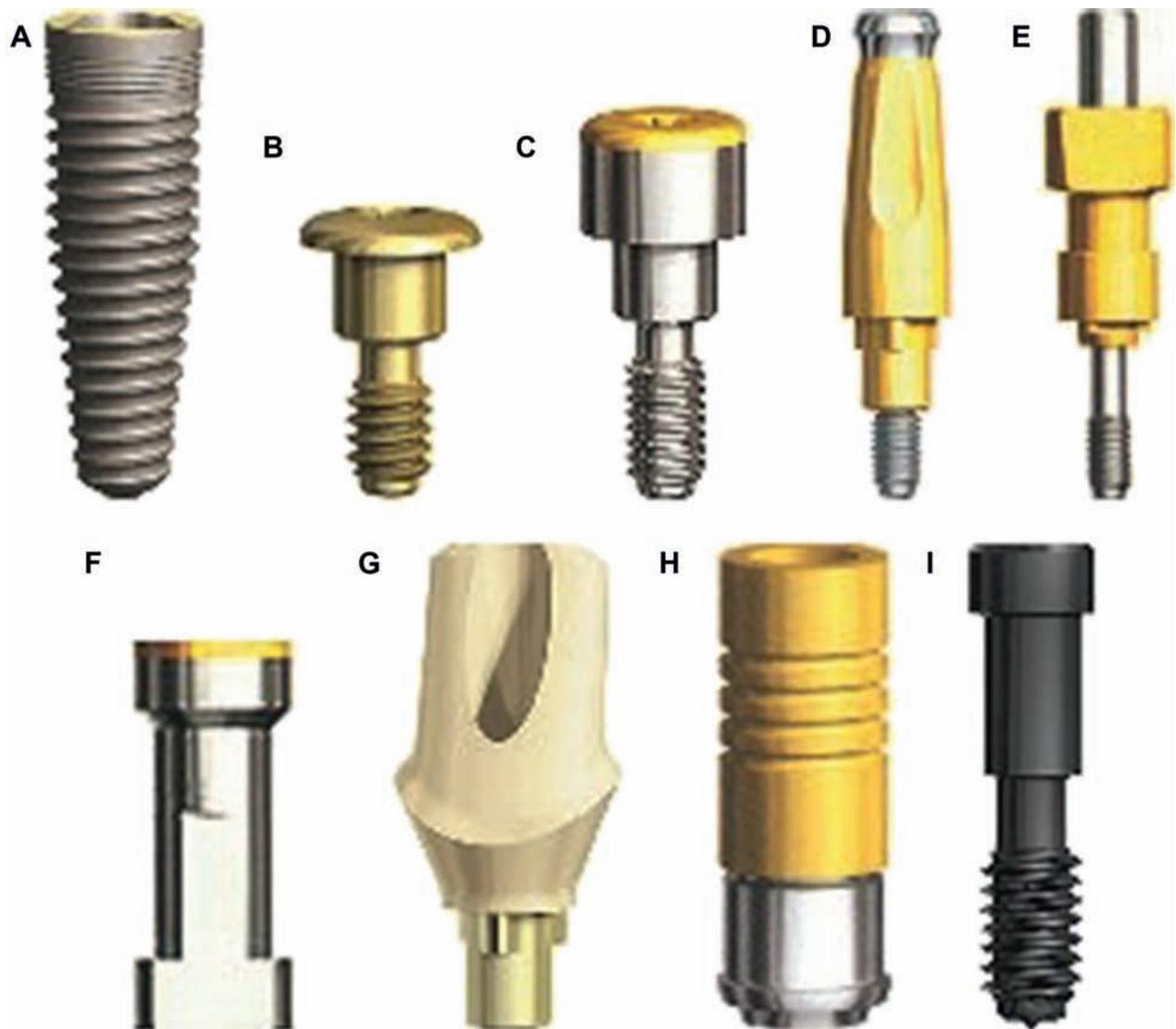


FIGURE VII-4. Implant restorative components. A, Implant fixture. B, Cover screw. C, Healing abutment. D, Closed tray impression post. E, Open tray impression post. F, Implant analog. G, Custom zirconia abutment. H, Waxable/castable abutment. I, Prosthetic screw. (Courtesy of Nobel Biocare USA, LLC, Yorba Linda, CA.)¹

IMPLANT ANALOG OR REPLICA

Implant analogs are manufactured to exactly replicate the top of the implant fixture (fixture analog) or abutment (abutment analog) in the laboratory cast. Both are screwed directly into the impression coping. The impression coping or analog component is then placed back into the impression (closed-tray transfer) or is maintained in the impression (open-tray transfer), and the impression is ready to be poured. It is tremendously beneficial to create a soft tissue mouldage in the impression before pouring. The soft tissue mouldage is an elastomeric product that simulates the soft tissue portion on the dental cast. This allows the laboratory technician to have an accurate and flexible representation of the soft tissue. The laboratory technician then has a working model that can be used to fabricate either the abutment or the framework for the intended prosthetic design.

IMPLANT ABUTMENT

The abutment is the portion of the implant that supports or retains a prosthesis or implant superstructure. A *superstructure* is defined as a metal or zirconia framework that attaches to either the implant platform or the implant abutments and provides retention for a removable prosthesis (eg, a cast or milled bar retaining an overdenture with attachments) or the framework for a fixed prosthesis. Abutments are described by the method in which the prosthesis or superstructure is retained to the abutment. Abutments can be divided into 3 main categories: 1) screw retained, 2) cement retained, and 3) prefabricated attachment abutments. A screw-retained abutment uses a screw to retain the prosthesis or superstructure, and a cement-retained abutment uses cement to retain the prosthesis or superstructure. A prefabricated attachment abutment (eg, Locator or O-ring attachments) helps retain a removable prosthesis.

Because of the unique set of circumstances presented by each implant case, manufacturers have become very creative in offering many different options within each of the described categories. Currently, computer-aided design (CAD)-computer-aided manufacturing (CAM) technology is becoming more prevalent. The ability to design an abutment or superstructure specifically for the individual situation and mill that same component with tremendous accuracy in either titanium or zirconium has made a major impact in implant prosthetics.

PROSTHESIS-RETAINING SCREW

Prosthesis-retaining screws are intended to attach prosthetic abutments, screw-retained crowns, or frameworks to the implant fixture or implant abutment. The screws are generally made of titanium, titanium alloy, or gold alloy, and are sized specifically to the type, size, and design of the implant or abutment system. The screws typically have a hex or square design to accept a specific size and shape of wrench or driver. Most prosthesis screws are tightened to the specific tolerance using a torque wrench or handpiece. The torque value is measured in newton-centimeters and typically ranges from 10 to 40 Ncm.

Implant Prosthetic Options

OPTIONS FOR THE EDENTULOUS PATIENT

Completely edentulous patients can benefit greatly from an implant-retained or implant-supported prosthesis. Three basic implant options exist for the edentulous patient. The options include 1) the implant and soft tissue-supported overdenture, 2) the all implant-supported overdenture, and 3) the complete implant-supported fixed prosthesis.

- The implant-supported and soft tissue-supported overdenture can be used in either the maxilla or mandible, although the mandibular overdenture is typically the most requested. The principle is to have the implants (2 to 4 implants, ideally 4 in the maxilla) help retain and support the overdenture, in conjunction with the soft tissue of the edentulous ridge. In these cases, it is imperative to follow a strict prosthetic protocol in fabricating an overdenture, ensuring that the prosthesis maximizes the soft tissue support and the patient enjoys the retentive advantage of the implants without overloading the implants and their attachments (Fig VII-5). Both the clinician and the patient must understand the need to monitor the fit of the overdenture over time. Timely relines to maintain the soft tissue support are extremely important. The attachment assemblies should also be monitored, with the attachment inserts replaced regularly to maximize their retentive opportunity. For a maxillary overdenture, it is possible to eliminate the palatal portion of the denture when at least 4 implants are present in good quality bone and reasonable depth is present in both the buccal vestibule and the palatal vault. It is recommended that a metal framework be incorporated into the denture bases to add additional strength to the overdentures. With the increased retention and security, patients often are able to engage in much more vigorous functions and can easily fracture an acrylic-only denture base.

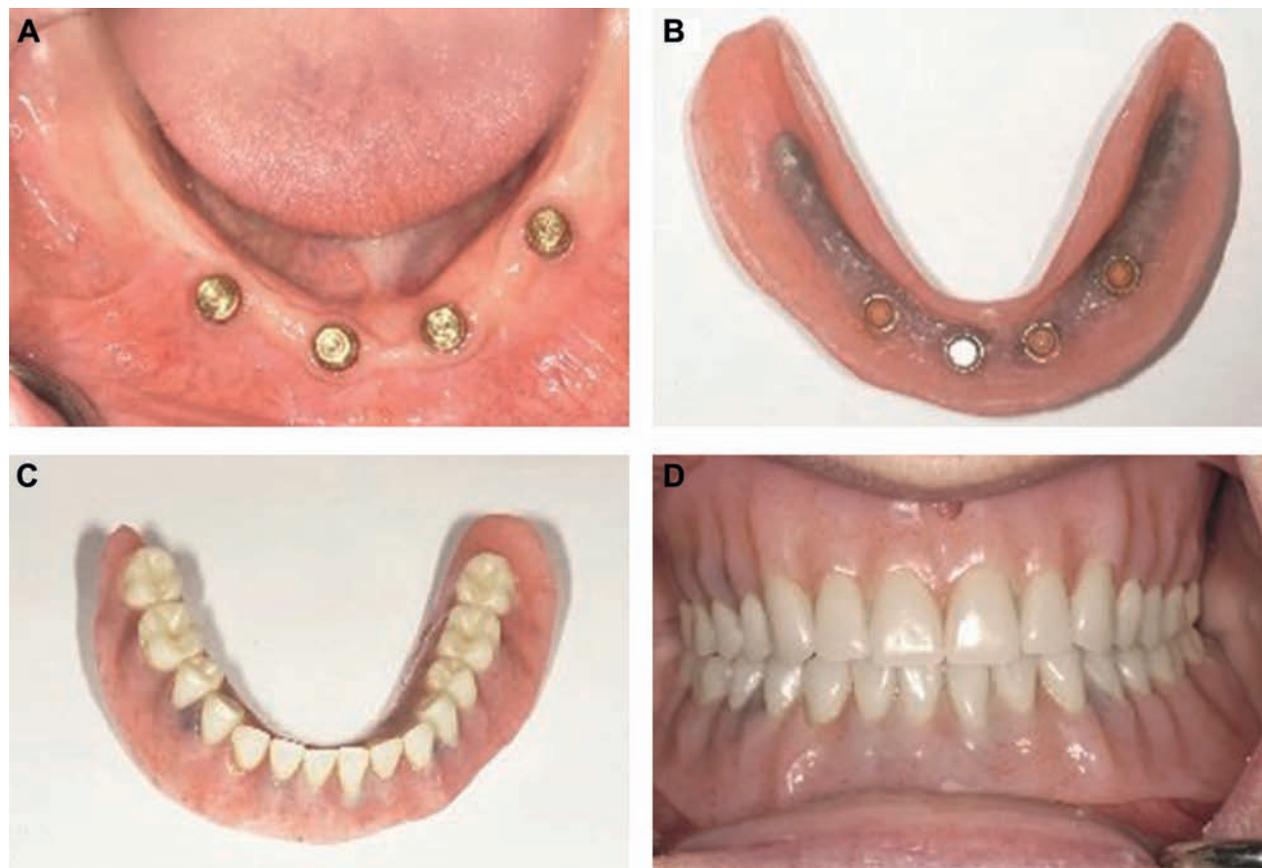


FIGURE VII-5. Implant and prosthetic treatment of the edentulous mandible with implant and soft tissue-supported overdenture. *A*, Four implants with Locator attachments in place for an implant-retained overdenture. *B*, *C*, The overdenture has been reinforced with a cast metal framework. *D*, The completed maxillary conventional denture opposed by a mandibular, Locator-retained overdenture.¹

- The all implant-supported overdenture offers the patient increased retention and support, with little need for soft tissue support. Typically, a minimum of 4 implants are required for the mandible, and 6 implants are recommended for the maxilla to support the entire load. The typical design is either a cast or milled bar, with retentive abutments attached to the bar in strategic locations that engage the overdenture (Fig VII-6). The goal with implant placement and bar fabrication is to maximize the anteroposterior spread of the implants and the bar with its attachments. The advantage of using a bar structure is that its length can be cantilevered up to 1.5 times the anteroposterior spread of the implants, thereby adding additional posterior support to the overdenture. In the maxilla with 6 implants, the design can be 1 continuous bar or 2 individual bars, each supported by 3 implants. The clinician must be aware of the interarch spatial requirement (approximately 15 to 17 mm) for an all implant-supported overdenture. Again, it is important to monitor the overdenture and its attachment assemblies over time. Metal frameworks can be used to strengthen the denture bases. Specialized framework designs can be cast to fit precisely to the fabricated bar, increasing retention and stability and reinforcing the denture base.

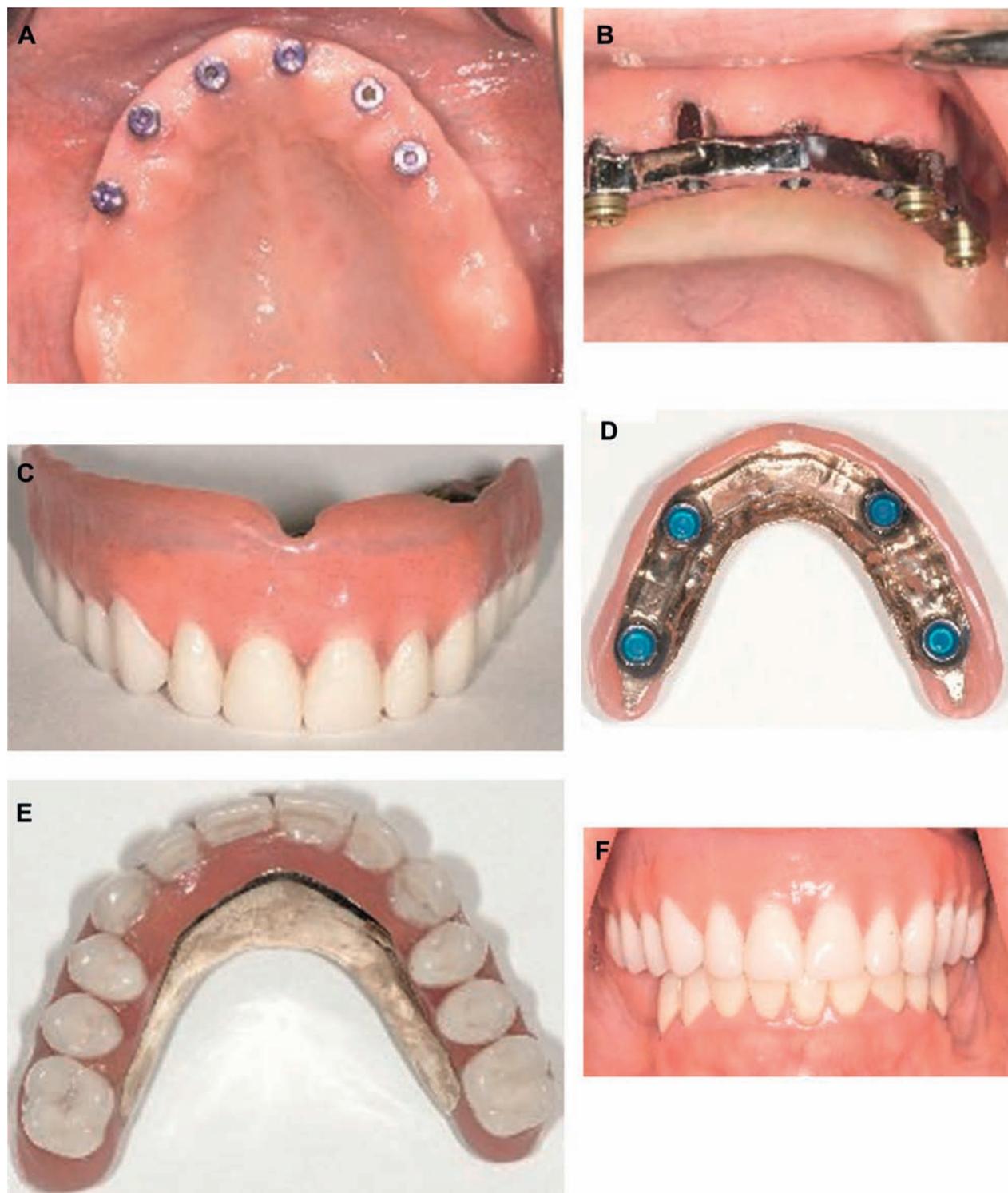


FIGURE VII-6. Treatment of an edentulous maxilla with an all-implant-supported overdenture. *A*, Maxilla with 6 implants. *B*, Milled titanium bar with 4 Locator attachments. *C* to *E*, Maxillary overdenture with open palate and internal casting that fits accurately to the milled bar. *F*, Final result.¹

- The complete implant-supported fixed prosthetic option can be achieved in 2 basic designs. The first design is a fixed partial denture, which is either screw retained or cement retained to 6 to 8 implant abutments. This design mimics that of the conventional crown and bridge. This option is typically best suited for the patient who has lost little bone and just requires replacement of missing teeth. The more common scenario is one in which the patient is missing bone, soft tissue, and teeth and the prosthesis must be designed to replace

all 3 (Fig VII-7). The second design is commonly referred to as a *hybrid prosthesis*. A hybrid prosthesis uses a cast or milled framework, which accepts acrylic, resin, or porcelain to create the replacement of the patient's missing bone, gingival tissue, and teeth. These frameworks are usually fabricated using CAD-CAM technology to mill either titanium or zirconium. Once the material has been milled, the choice for soft tissue and tooth replacement can be determined. The most economic version is one in which denture acrylic and denture teeth are used. The more sophisticated options use laboratory resin or layered porcelain to replace the soft tissue and either layered porcelain directly fused to the framework or cement-retained individual crowns cemented directly onto the framework. The hybrid prosthesis is most often screw retained and can, therefore, be easily retrieved by the clinician.

Consideration must be given to the ease and cost of repair for the various hybrid options. The acrylic hybrid is the most straightforward and least expensive hybrid to repair. The laboratory resin hybrid is slightly more difficult and more expensive to repair. The all-ceramic hybrid designs are the most difficult and most expensive to repair.

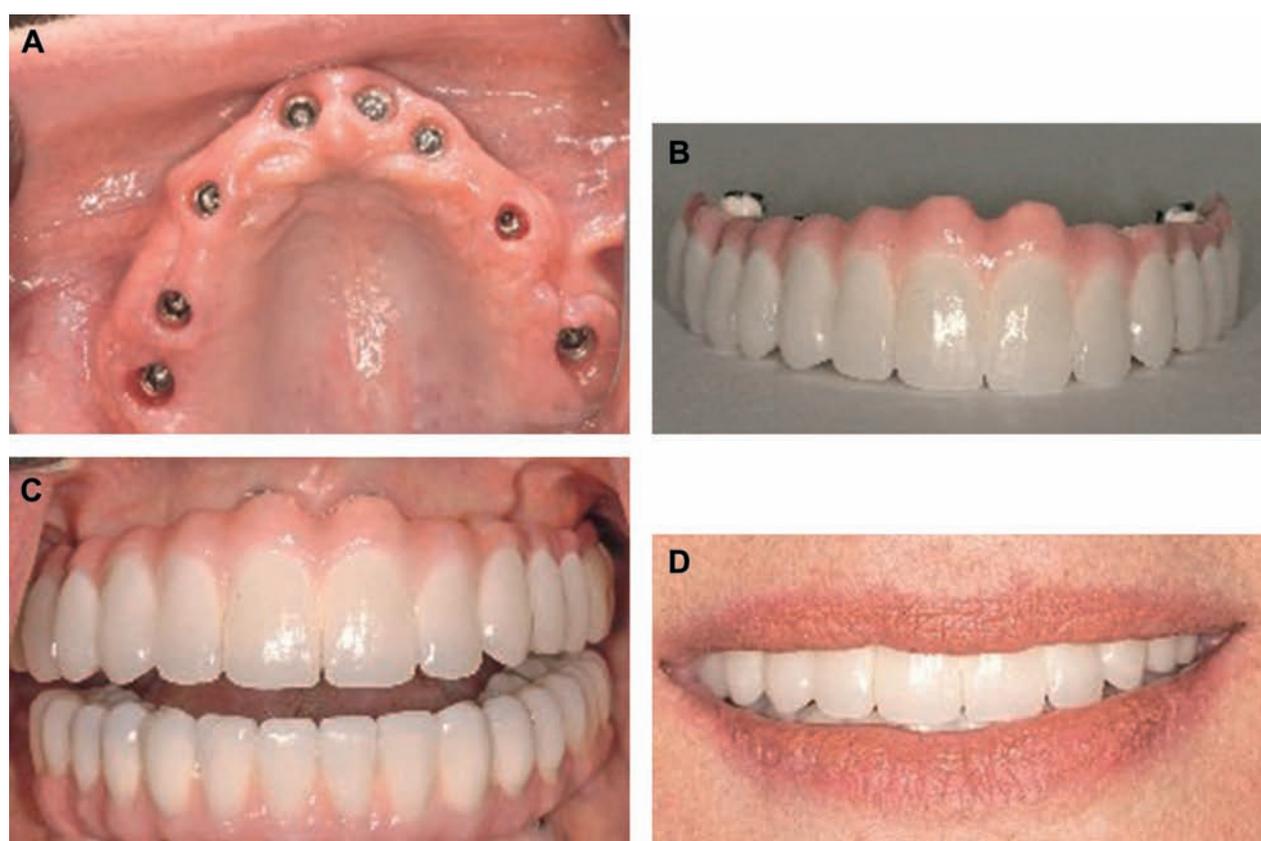


FIGURE VII-7. Treatment of edentulous maxilla with fixed, implant-supported prosthesis. A, Maxilla with 8 implants. B, Hybrid prosthesis fabricated with a milled titanium framework and porcelain applied to replace both the gingiva and teeth. C, Completed maxillary and mandibular hybrid prostheses. D, Esthetic result of the case.¹

OPTIONS FOR THE PARTIALLY EDENTULOUS PATIENT

The options for partially edentulous patients can be divided into 2 different categories: 1) a single missing tooth and 2) 2 or more missing adjacent teeth. Multiple options exist for restoration in each of these situations (Figs VII-8). The single missing tooth can be restored using either a cement-retained crown on an abutment or a screw-retained crown seated and screwed directly to the implant platform. The cement-retained crown can be fabricated as a full cast gold, a porcelain fused to metal, or an all-ceramic crown. The abutment to which the crown is cemented can be either a prefabricated stock abutment or a custom abutment made from either titanium or zirconium. The zirconium abutment and all-ceramic crown combination are typically used in the anterior region to maximize esthetics.

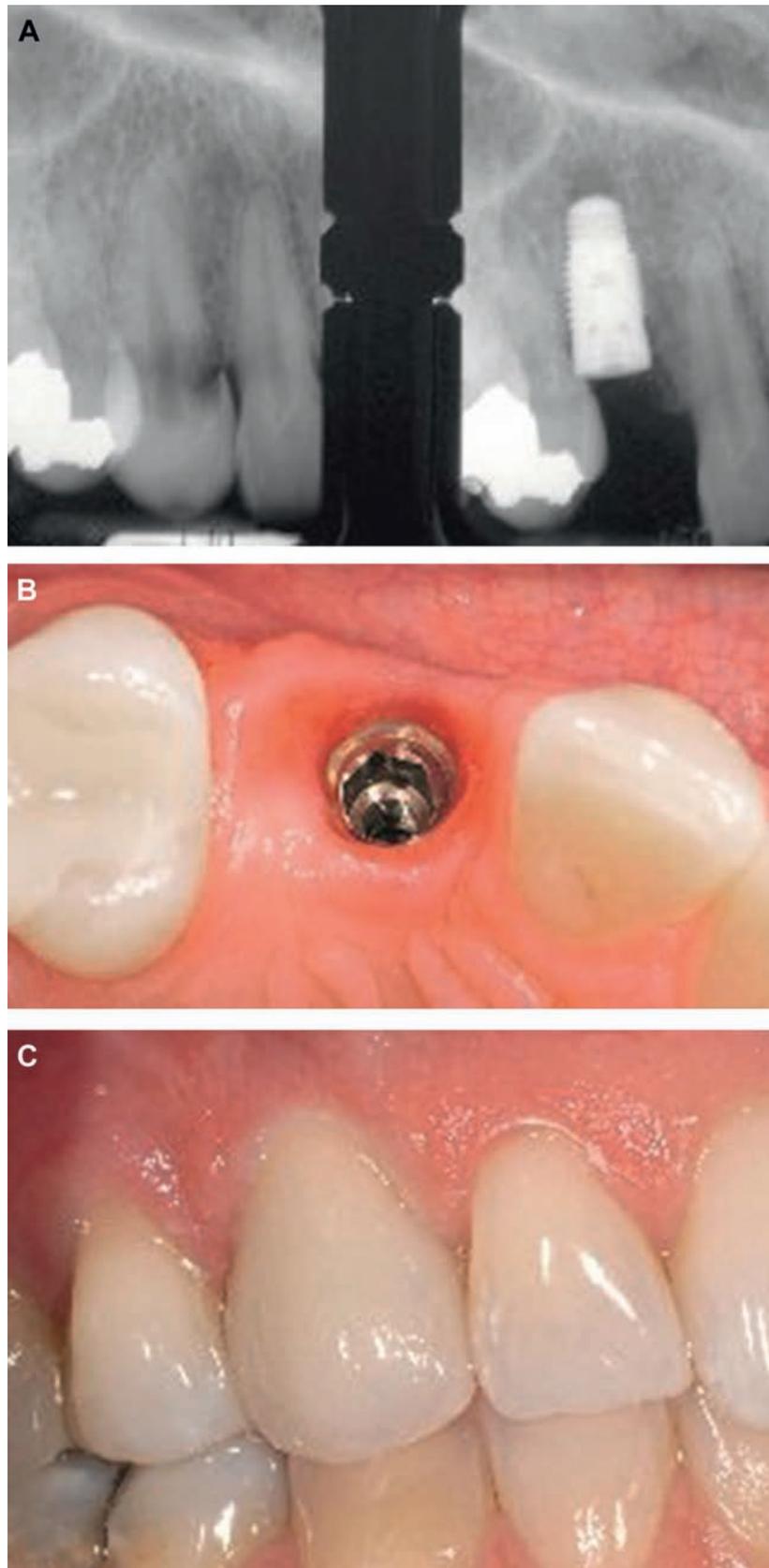


FIGURE VII-8. Single tooth replacement. A, Radiograph showing nonrestorable tooth before (*Left*) and after (*Right*) extraction with implant in place. B, Implant after the uncovering and healing period and ready for restoration. C, Final result. **(Fig 8 continued on next page.)**



FIGURE VII-8 (cont'd). D, Final radiograph.¹

Two or more adjacent missing teeth can be replaced with cement-retained or screw-retained individual crowns or splinted crowns. In patients missing more than 2 adjacent teeth, the implants can serve as abutments for a fixed partial denture (eg, 2 implants to support a 3-unit fixed partial denture); again, this can be cement retained or screw retained. Both titanium and zirconium can be used for the framework of the fixed partial denture. In some clinical situations, the prosthesis can be used to replace not only the missing teeth but also the missing bone and soft tissue. Just as in the completely edentulous patient, a hybrid prosthesis can be used effectively in the partially edentulous patient. Implants can be used to assist in retaining a removable partial denture. This option allows for increased retention and can eliminate unsatisfactory framework clasps in the patient who has concerns about esthetics (Figs VII-9 to VII-11).

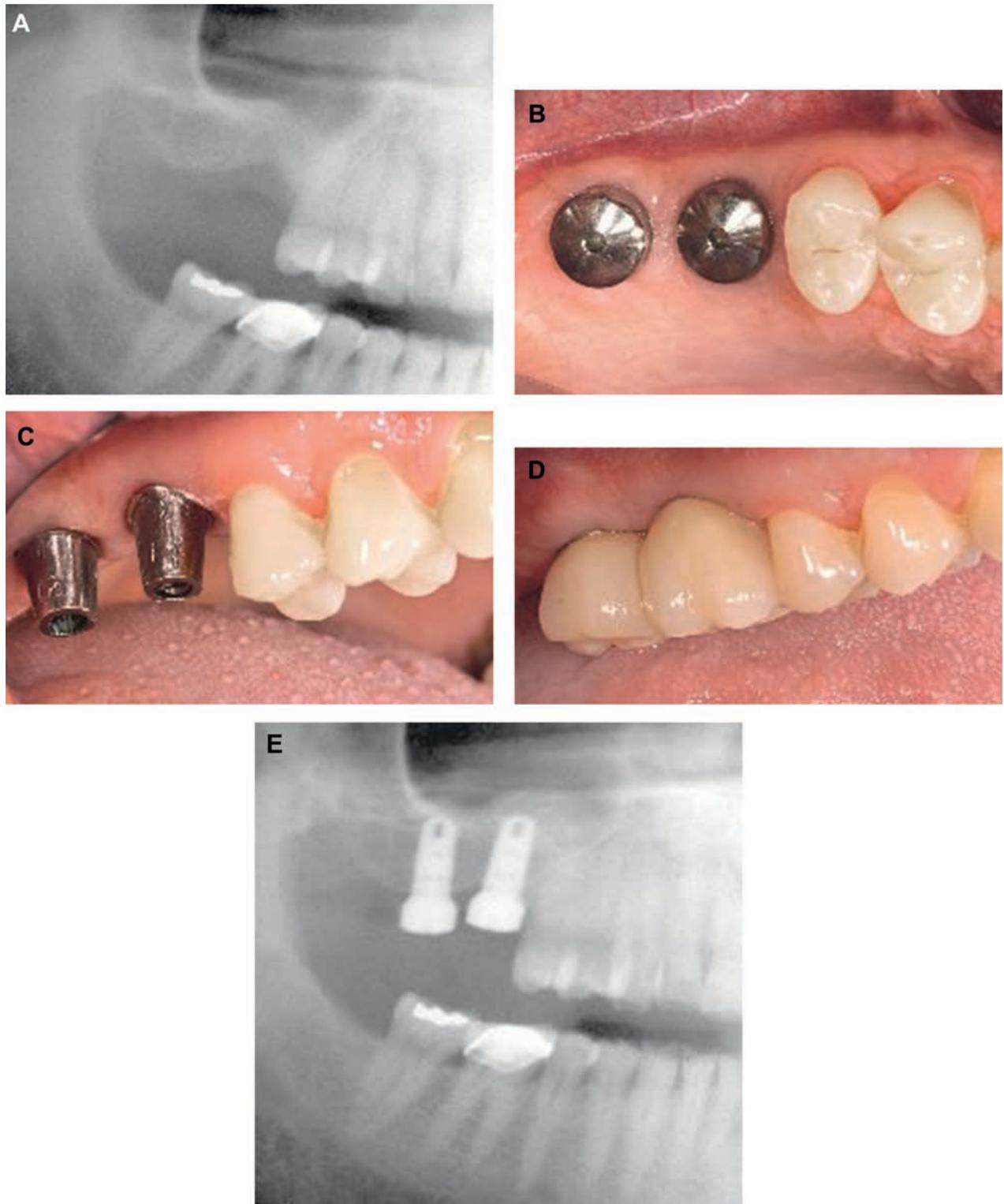


FIGURE VII-9. Replacement of 2 adjacent posterior maxillary teeth. *A*, Pretreatment radiograph. *B*, View 6 months after implant placement and 3 weeks after uncovering and placement of the healing abutment. *C*, Final abutment in place for cement-retained porcelain-fused metal (PFM) crowns. *D*, Final cement-retained PFM crown restoration. *E*, Final radiograph.¹

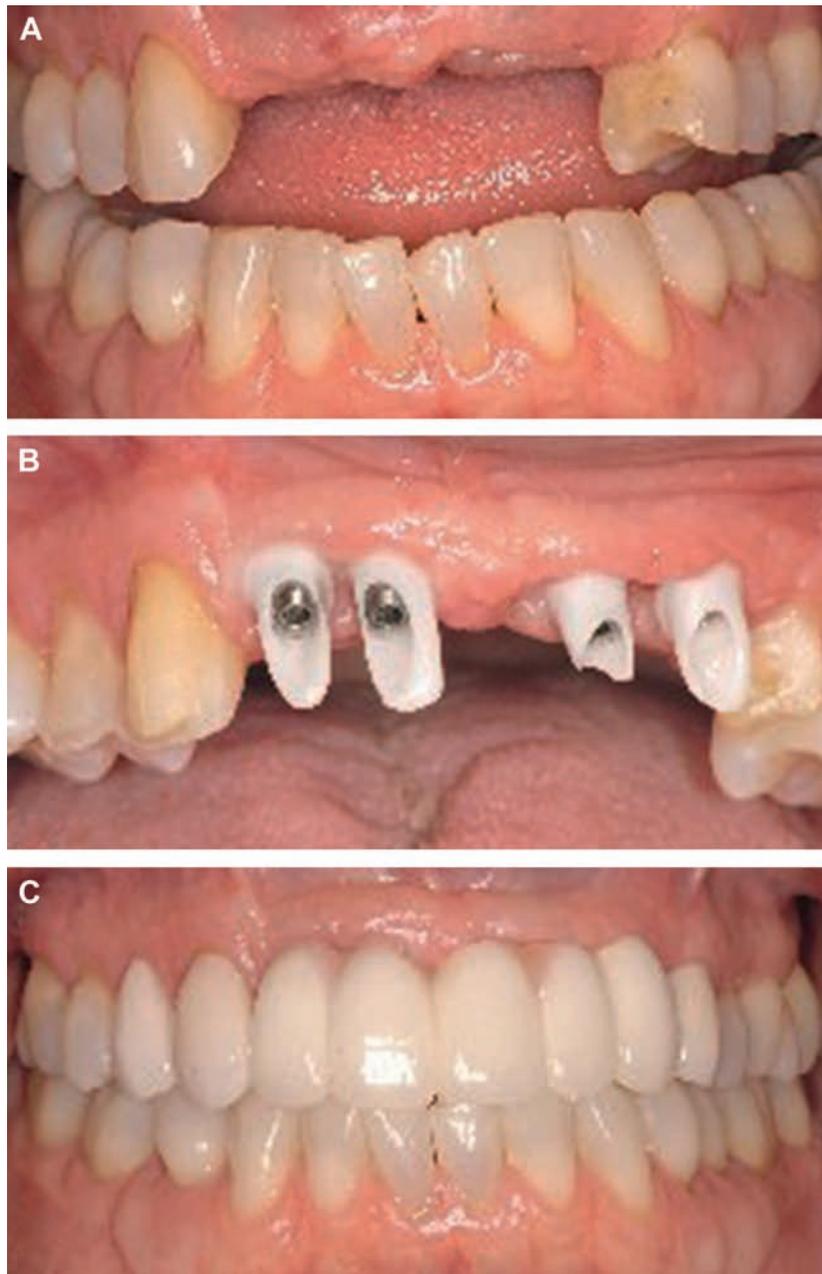


FIGURE VII-10. Replacement of 5 anterior maxillary teeth. *A*, Pretreatment view. *B*, Four computer-aided design–computer-aided manufacturing custom zirconia abutments in place for a cement-retained fixed partial denture. *C*, Final result.¹

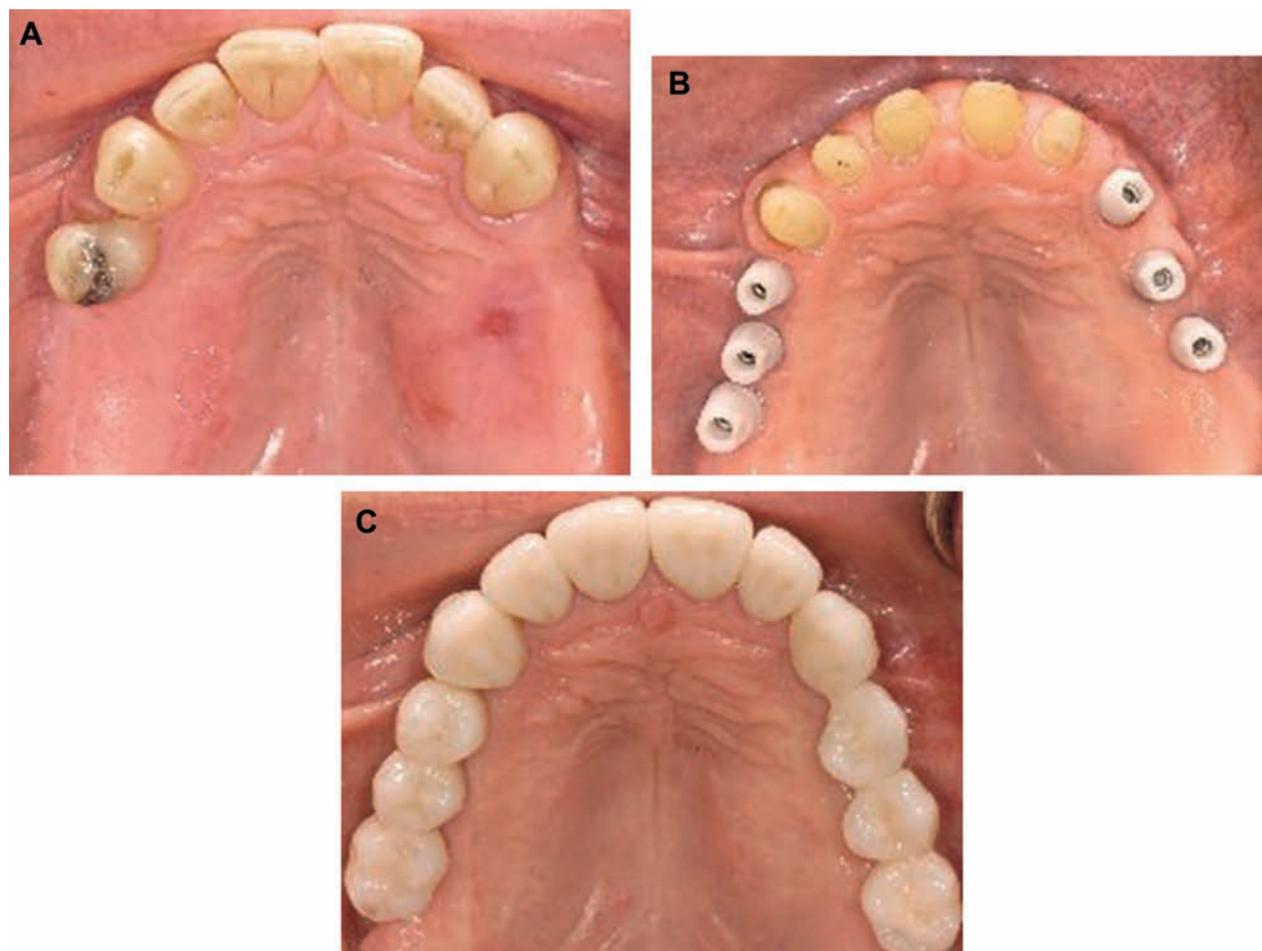


FIGURE VII-11. Restoration of bilateral posterior edentulous maxilla. *A*, Pretreatment view. *B*, Six zirconia abutments in place for 2 three-unit fixed partial dentures and 5 natural teeth prepared for individual all-ceramic crowns. *C*, Final restorations in place.¹

Prosthetic Complications

Just as with any dental procedure, implant prosthetic complications occasionally occur. The cause of most prosthetic complications can be attributed to a mechanical overload of the implant–prosthetic complex or in response to a noxious biologic insult. The complications can easily be divided into 3 categories:

- *Peri-implant complications:* If the load-bearing capacity of the implant–bone complex is exceeded by the applied load, either a mechanical complication ensues or, worse, a biologic response. If the forces are not managed, the stresses can be transferred through the implant–prosthetic complex and cause bone loss around the implant body. If left unattended, this can continue until the implant eventually fails. Secondly, if the soft tissue interface is violated (eg, retained cement, lack of hygiene), the same sequelae could occur.
- *Component complications:* Components complications (eg, screws, abutments, bars, or attachments) are almost always associated with excessive mechanical overload. In most cases, the overload is too great or transferred at an angle that is destructive to the implant–prosthetic complex, or both. Complications can be as routine as a component coming loose or as detrimental as fracturing of the component. On rare occasions, a manufacturing error can result in a component being mechanically compromised.
- *Structural complications:* Structural complications typically include insults to the metal, porcelain, acrylic, resin, or denture teeth. The complication can sometimes be straightforward and readily adjusted or repaired. However, in some cases, structural failure can be catastrophic and require the prosthesis to be remade.

Complex Concerns

Implant dentistry is characterized by clinical variability. An infinite range of clinical scenarios seems to exist. Often, the patient is seeking implantation as a last resort and is desperate. Frequently, patients present with failing dental rehabilitation efforts and are now searching for restorative solutions that are far more complex. Many patients present after having been edentulous for many years, have experienced profound bone loss, and can no longer function with conventional dentures. Trauma patients and patients with craniofacial or developmental anomalies also present with complex prosthetic needs. The next section presents examples of some of the more challenging clinical situations and how oral-maxillofacial surgeons can still help the restorative dentist make implant dentistry available for the patient.

Reference

1. Hupp JR, Ellis E III, Tucker MR: Contemporary Oral And Maxillofacial Surgery (ed 6). St. Louis, MO, Elsevier, 2014

Section VIII Implants in Special and Complex Clinical Situations

The previous sections focused primarily on the clinical evaluation and the surgical and prosthetic approaches for basic dental implant care. The previous sections also discussed the clinical situations in which adequate bone and soft tissue exist and in which implants can be placed into an area of bone without jeopardizing anatomic structures such as the maxillary sinus or the inferior alveolar nerve. However, commonly, patients present with situations in which the placement of implants becomes much more complex. In some cases, it can be advantageous to place an implant at the time of extraction. In many cases, the bone and soft tissue present are inadequate for routine implant placement and require tissue augmentation or modification to allow for implant placement. This section focuses on the considerations for the types of cases that benefit from immediate implant placement and the cases in which preparatory bone and/or soft tissue augmentation could be beneficial before implant placement. These types of surgical procedures are performed by oral-maxillofacial surgeons with many years of advanced basic science and surgical training and experience in tissue grafting, bone and soft tissue reconstruction, as well as implant placements in non-routine situations.

Immediate Postextraction Placement of Implants

When it is possible to plan implant placement before tooth extraction, consideration should be given to the most desirable time for implant placement. The implant can be placed immediately (ie, at the time of extraction), early (ie, 2 months after extraction), or late (ie, >6 months after extraction). Each of these times has its indications, advantages, and disadvantages.

The primary advantage of immediate placement is that this usually provides the overall shortest healing time by combining tooth extraction with surgical implant placement. Placing a provisional restoration at the same time as the implantation procedure can provide a good opportunity for maintenance of the soft tissue anatomy and the best immediate and long-term esthetic results. The primary disadvantage of immediate placement is related to the difference in the anatomy of the root or roots of the extracted tooth compared with the shape and size of the implant and the health of the extracted tooth and surrounding soft tissue. This is particularly true of a multi-rooted tooth that is being replaced by an implant. Even in the case of an incisor, the difference in the shape of the root of the natural tooth and that of the implant creates some difficulty in implant placement. Another disadvantage is that if the implant is exposed to occlusal forces, the immediate and long-term stability of the implant can be jeopardized.

Immediate placement can be considered if the tooth to be removed is not infected and can be removed without the loss of alveolar bone. A critical component in the success of this technique is to complete the extraction of the tooth with minimal bone removal and without distorting or weakening the bony support. Initial implant stability at the time of placement is also critical to long-term success. When the implant is placed, at least 4 mm of the implant apex should be seated in firm bone to provide the critically important initial stability (Fig VIII-1). Surgical guides are extremely helpful in placing the implant. Drilling the implant site at the correct angulation can sometimes be difficult, because the drills can be easily deflected off the walls of the socket when a guide is not used (Fig VIII-2). The implant should be countersunk slightly below the height of the crestal bone to compensate for the resorption of bone that results from any extraction. In the esthetic zone (maxillary anterior), the platform of the implant is ideally placed 3 mm below the free gingival margin. This allows for the development of an optimal emergence profile of the final restoration and soft tissue maintenance. In general, the implant should also be positioned 1 mm palatally to the center of the extracted tooth root. This will account for the anticipated facial bone and soft tissue remodeling that decreases the facial crestal volume.

The gap between the implant and the residual tooth socket must be evaluated and managed according to its size. If the gap is less than 1 mm and the implant is stable, often no treatment modification is needed. If the gap is greater than 1 mm, grafting with a particulate bone material could be indicated. At present, the need for this is controversial. In

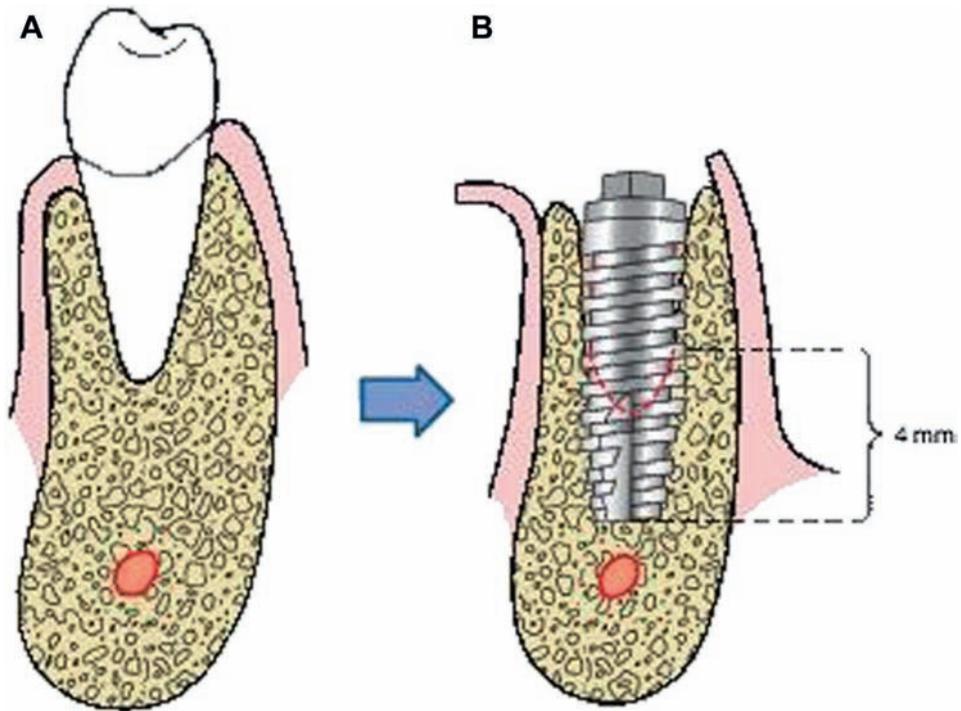


FIGURE VIII-1. A, B, An implant placed into a fresh extraction socket must have a precise fit along the apical 4 mm of the implant. The implant should be countersunk below the crest of the bone. Gaps between the implant and tooth socket are most often grafted with autogenous or allogeneic bone, with or without bone morphogenetic protein.¹

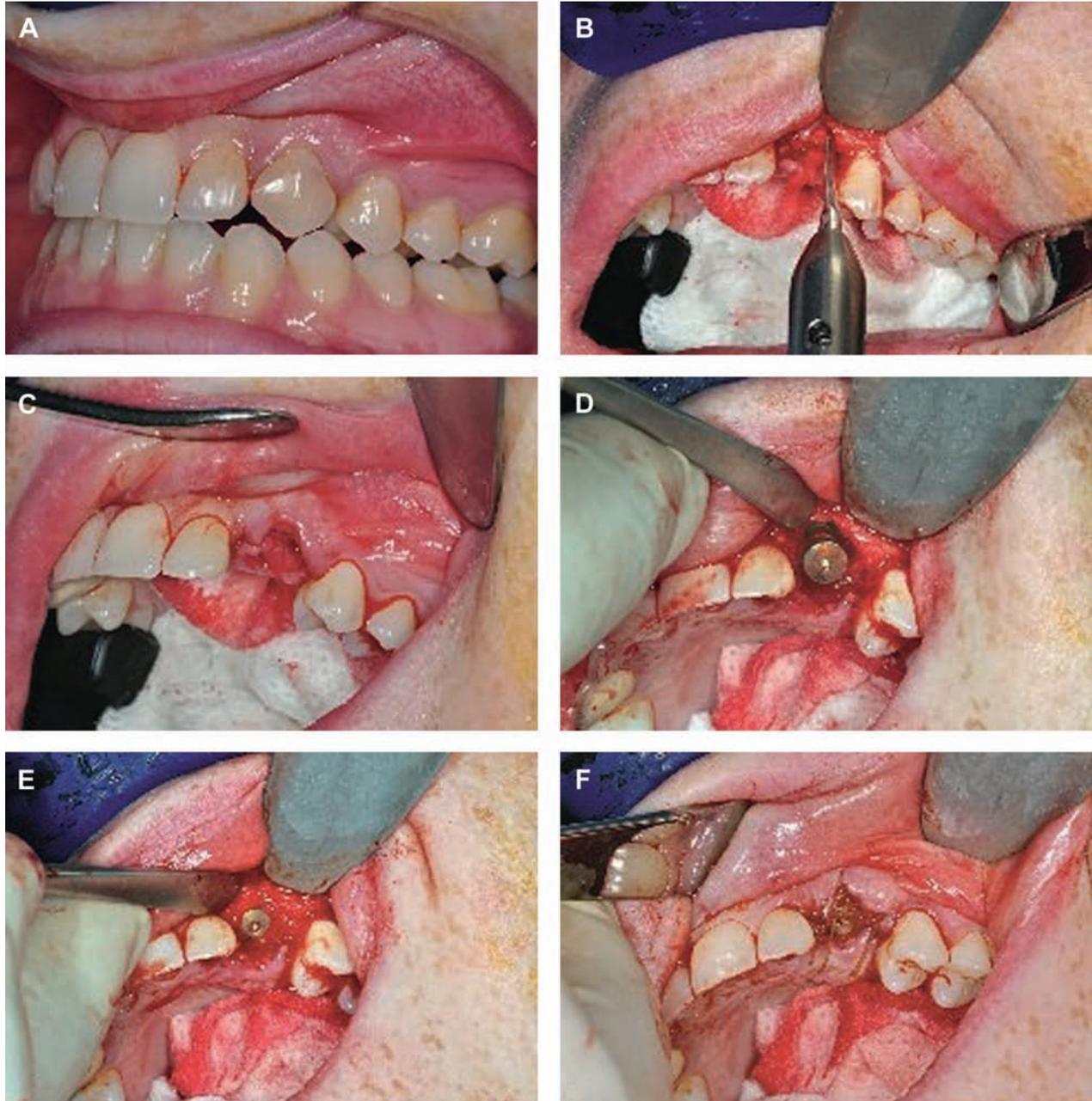


FIGURE VIII-2. Immediate postextraction placement of implant. *A*, The upper left canine before extraction of the tooth owing to fracture and root resorption. *B*, Atraumatic extraction using periosteal elevators results in minimal soft tissue or bone loss. *C*, Extraction site. *D*, Implant placed into extraction site. The implant is in precise contact with bone at the apex, but a small gap exists between the superior portion of the implant and the crestal aspect of the extraction site. *E*, Grafting with freeze-dried bone. *F*, Resorbable collagen membrane placed over the implant and graft and maintained with resorbable chromic suture. **(Fig 2 continued on next page.)**

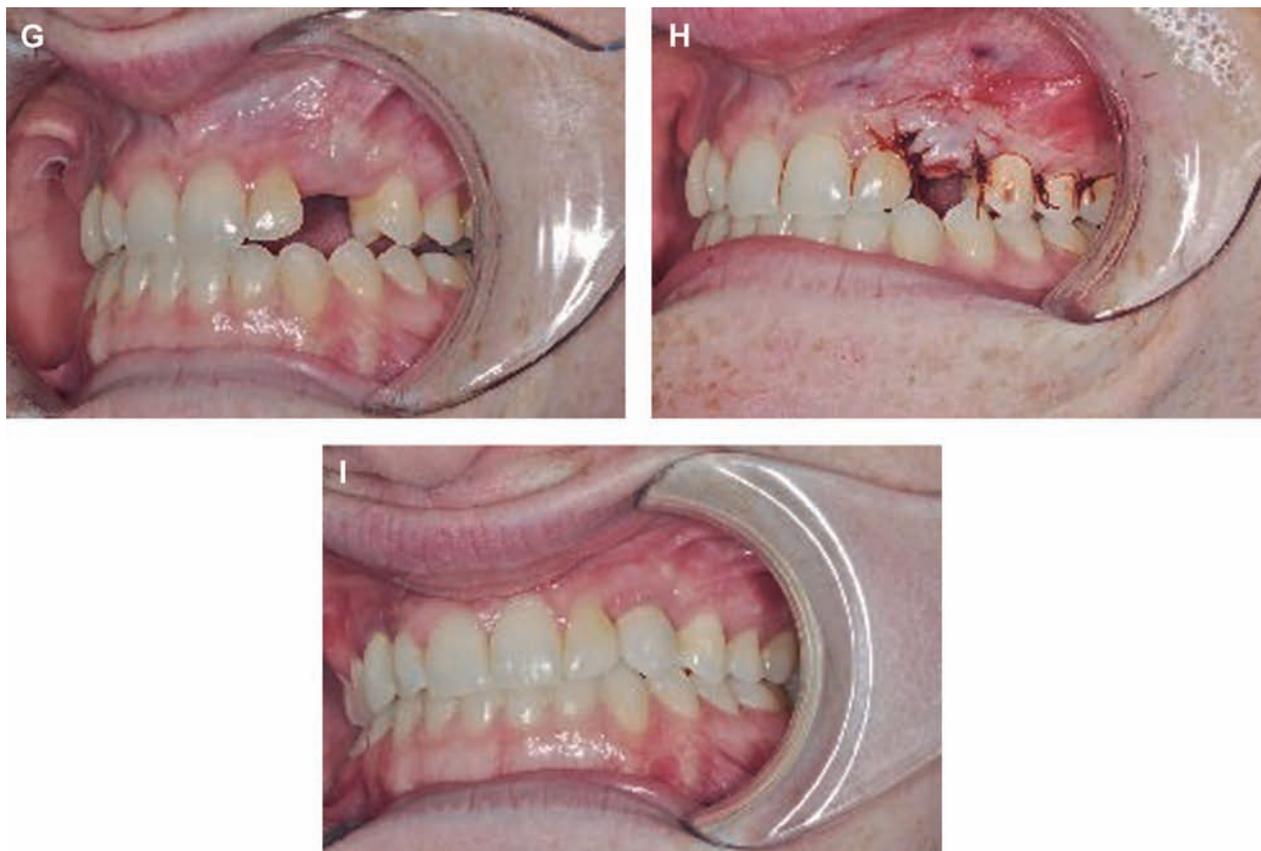


FIGURE VIII-2 (cont'd). *G*, Healed implant site. *H*, Implant uncovered. *I*, Final restoration.¹

most cases, using flapless, atraumatic extraction techniques, primary closure might not be possible or desirable. In such situations, a resorbable collagen pellet can be placed over the implant and held in place with a “figure-of-eight” suture. The surgeon and restorative dentist can consider extending the time allowed for integration before loading.

In very isolated cases, restoration at the time of implant placement can be considered. It is extremely important to ensure that the restoration is in ideal firm contact with the adjacent teeth, which will help reduce unfavorable loading on the implant until it is osseointegrated.

Grafting Bone and Bone Substitutes

Frequently, the areas to be restored with implants have insufficient bone available for implant placement. This can be a result of extraction and bone atrophy, sinus pneumatization, previous trauma, congenital defects, or removal of pathologic lesions. In these cases, the bone will need to be augmented to provide adequate support for implant placement. Several potential sources of graft material can be considered, depending on the volume and configuration of bone needed.

AUTOGENOUS GRAFTS

Autogenous bone can be harvested from several anatomic areas. Intraorally, bone can be harvested from the mandibular symphysis, ramus, or maxillary tuberosity areas. Bone in the tuberosity is primarily cancellous, but in the ramus-posterior body area of the mandible, the bone is primarily cortical. The symphysis provides the best intraoral source for a reasonable volume of cortical and cancellous bone (Fig VIII-3). When more bone is required for situations such as an atrophic edentulous mandible or bilateral sinus lifts, an extraoral site should be considered if autogenous bone is to be used. The most common site of graft harvest is the anterior iliac crest. Other areas from which bone is sometimes harvested include the anterior proximal tibia, fibula, and skull.

ALLOGRAFTS

Allogeneic bone grafts procured from cadavers are processed to achieve sterility and decrease the potential for an immune response. The sterilization process destroys the osteoinductive nature of the graft; however, the graft will

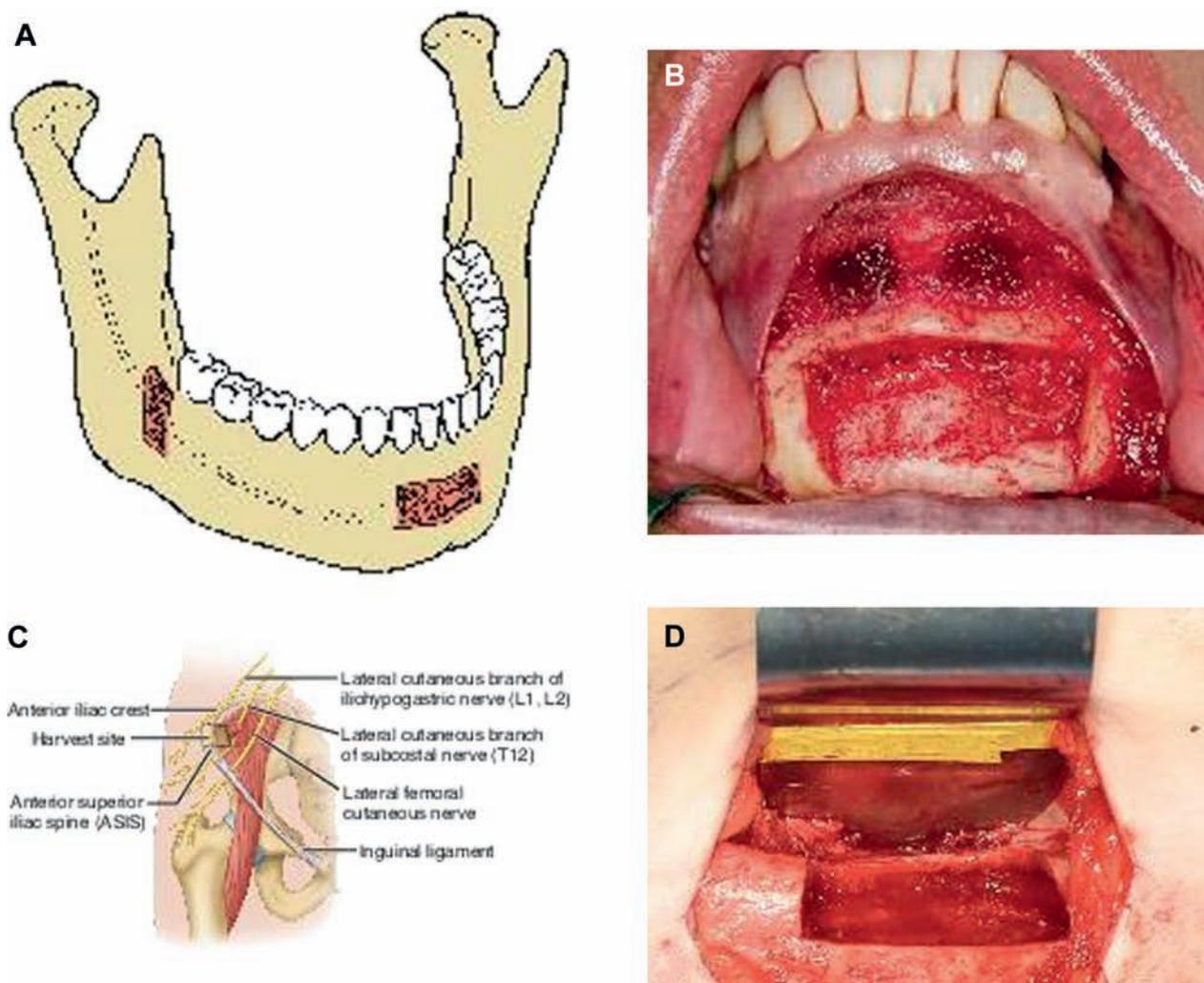


FIGURE VIII-3. Sites of autogenous bone graft harvest. *A*, Graft sites from the posterior body or ramus and symphysis regions. *B*, Clinical photograph of harvest from symphysis area. *C*, Anatomy of iliac crest harvest. *D*, Clinical photograph of iliac crest harvest. (C from Bagheri SC, Jo C: *Clinical Review of Oral and Maxillofacial Surgery*. St. Louis, MO, Mosby, 2008.)¹

provide a scaffold, allowing bone ingrowth (osteoconduction). Bony incorporation, followed by remodeling and resorption, occurs during the healing phase. Granular forms of allogeneic graft material provide increased surface area and improved adaptation within the graft and are the most commonly used for augmenting alveolar ridge contour defects. The advantages of allogeneic bone grafting include the avoidance of an additional donor site, unlimited availability, and that patients can undergo this type of procedure in an outpatient setting. The disadvantage is that a significant amount of grafted bone is resorbed, which results in a much smaller volume of bone available for implant placement.

XENOGRAFTS

Xenografts are derived from the inorganic portion of bone harvested from a species that is genetically different from the graft recipient. The most common source of xenografts is bovine bone. The advantages and disadvantages are similar to those of allografts, including significant postgrafting resorption.

BONE MORPHOGENETIC PROTEINS

One of the most exciting advancements in bone grafting has been the extensive research related to bone morphogenetic proteins (BMPs). BMPs are a family of protein factors that have been isolated and applied to reconstruction of the maxillofacial skeleton. These proteins have the ability to enhance bone graft healing and, in many cases, can substitute for other graft materials. Recombinant human BMP-2 has been isolated and has been produced and packaged for use in grafting procedures. The BMP is placed on carriers, usually absorbable collagen sponges, to facilitate

placement in the graft site. BMP can be positioned around implants within the extraction sites, aiding in osseointegration. In larger defects, the BMP is usually combined with osteoconductive allogeneic materials to expand the graft volume and to help place, shape, and contain the graft material. BMP with a collagen sponge carrier can be used for sinus lifting and reconstruction of non-load-bearing bony defects (Fig VIII-4). The obvious advantages include eliminating the need for donor site surgery and improved bone formation at the site of augmentation. The primary disadvantages include significant postoperative edema and the high cost of BMP.

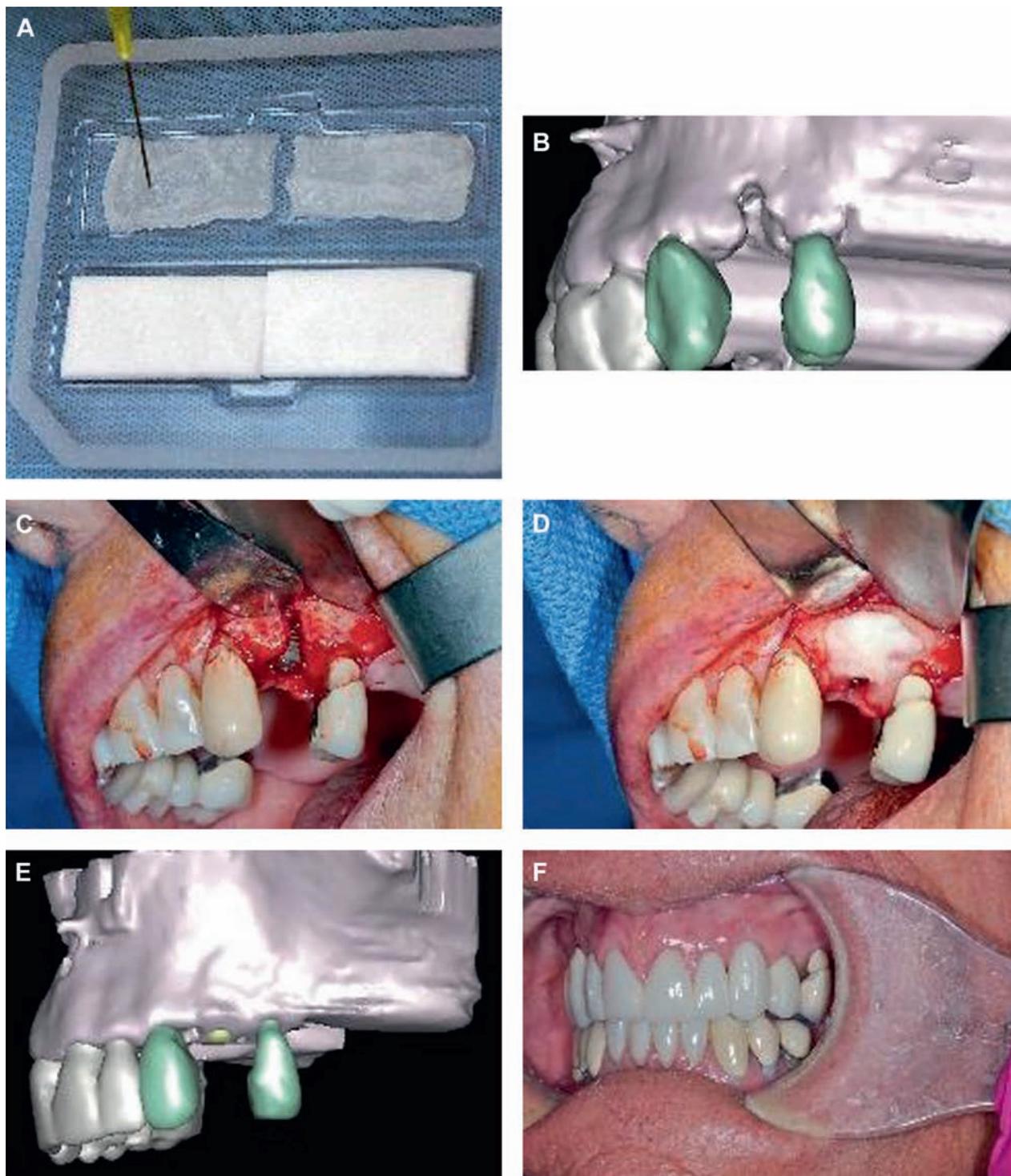


FIGURE VIII-4. Bone morphogenetic protein (BMP). *A*, Kit containing BMP in liquid form and collagen sponges. *B*, 3-dimensional computed tomography (CT) showing edentulous space with facial wall defect. *C*, Implant placed. *D*, Allogeneic bone graft material combined with BMP on a collagen sponge covering the bony defect. *E*, 3-dimensional CT scan showing excellent postoperative bone regeneration. *F*, Restored implant.¹

GUIDED-TISSUE PROCEDURES

Two problems associated with any type of grafting include containment and shaping of the graft material and prevention of fibrous tissue ingrowth during the healing phase. Placement of particulate grafts to augment alveolar ridges often requires some type of containment device or material to facilitate the ideal ridge size and shape. The materials used to contain and shape the graft can also be effective in eliminating the unfavorable invasion of soft tissue during healing.

Guided bone regeneration is a process that allows bone growth while retarding the ingrowth of fibrous connective tissue and epithelium. Many bone defects will regenerate with new bone if the ingrowth of the connective tissue from adjacent soft tissue can be prevented. Guided bone regeneration involves using a barrier that is placed over the bony defect to prevent fibrous tissue ingrowth, allowing the bone underlying the barrier time to grow and fill the defect (Fig VIII-5). This technique is particularly useful in the treatment of buccal dehiscence, in which labiobuccal (horizontal) augmentation of bone is required. Guided bone regeneration can be performed simultaneously with implant placement or before stage I. A variety of materials can serve as barriers to fibrous tissue ingrowth. Expanded polytetrafluoroethylene (Gore-Tex; W.L. Gore & Associates, Inc., Flagstaff, AZ) is the most extensively tested material. Resorbable materials are also now available, eliminating the necessity for removal. Thin, malleable titanium mesh is also a commonly used material facilitating maintenance of the graft shape and eliminating extensive fibrous ingrowth. Titanium mesh trays can be created by trimming and contouring flat titanium mesh at the time of surgery, or they can be fabricated before surgery using diagnostic mounted dental casts or computer-assisted design–computer-assisted manufacturing technology.

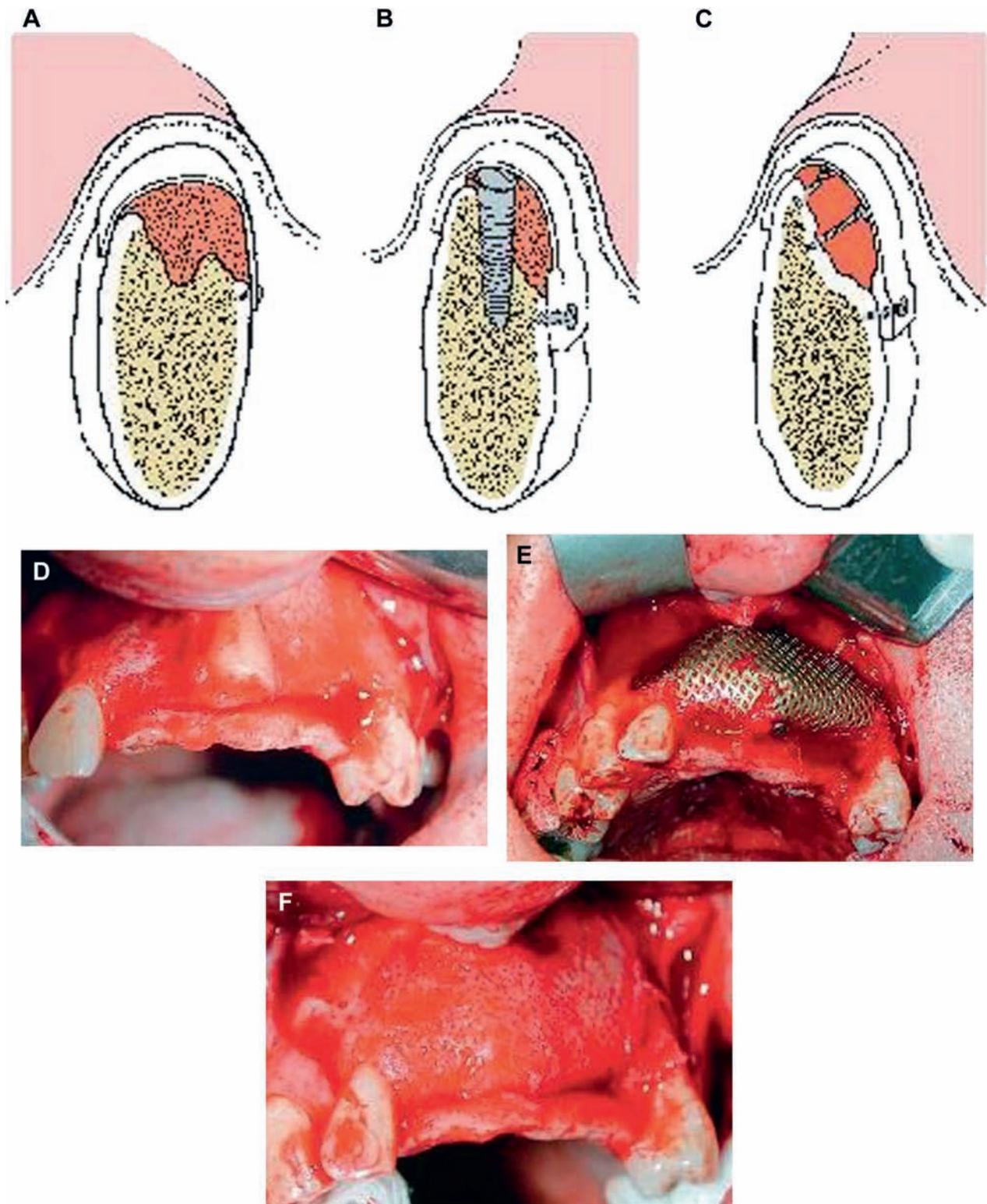


FIGURE VIII-5. Various applications of guided bone regeneration. *A*, Membrane and “filler material” such as allogeneic bone is used to augment the ridge. *B*, The same procedure as in shown in *A*, except that an implant has been placed simultaneously. *C*, The membrane is supported by screws that preserve the space beneath the graft to allow bone fill. *D*, Atrophic anterior maxillary ridge. *E*, Titanium mesh containing a graft on the anterior maxilla. *F*, Bone contour after removal of the mesh.¹

MANDIBULAR AUGMENTATION

Augmentation grafting adds strength to an extremely deficient mandible and improves the height and contour of available bone for implant placement in denture-bearing areas. Superior border augmentation with a bone graft is often indicated when severe resorption of the mandible results in an inadequate height and contour and the potential risk of fracture or when the treatment plan requires placement of implants in areas with insufficient bone height or width. Neurosensory disturbances from inferior alveolar nerve dehiscence at the superior aspect of the mandible can also be improved with superior border grafting. Sources of graft material include autogenous bone or allogeneic bone, or both, often combined with BMPs. Historically, autogenous bone has been the most biologically acceptable material used in mandibular augmentation. Disadvantages of the use of autogenous bone include the need for donor site surgery and the possibility of the significant resorption that occurs after grafting. The use of allogeneic bone eliminates the need for a second surgical site and has been shown to be useful in augmenting small areas of deficiency in the mandible. The use of allogeneic bone seems to be most effective in augmenting the width of the alveolar ridge but is much less effective in improving the height (vertical augmentation) of a deficient mandible. The current techniques for superior border augmentation of the mandible frequently involve some combination of grafting using a block of bone, supplemented with an allogeneic material such as freeze-dried bone mixed with BMPs, often contained in some type of mesh tray (Fig VIII-6).

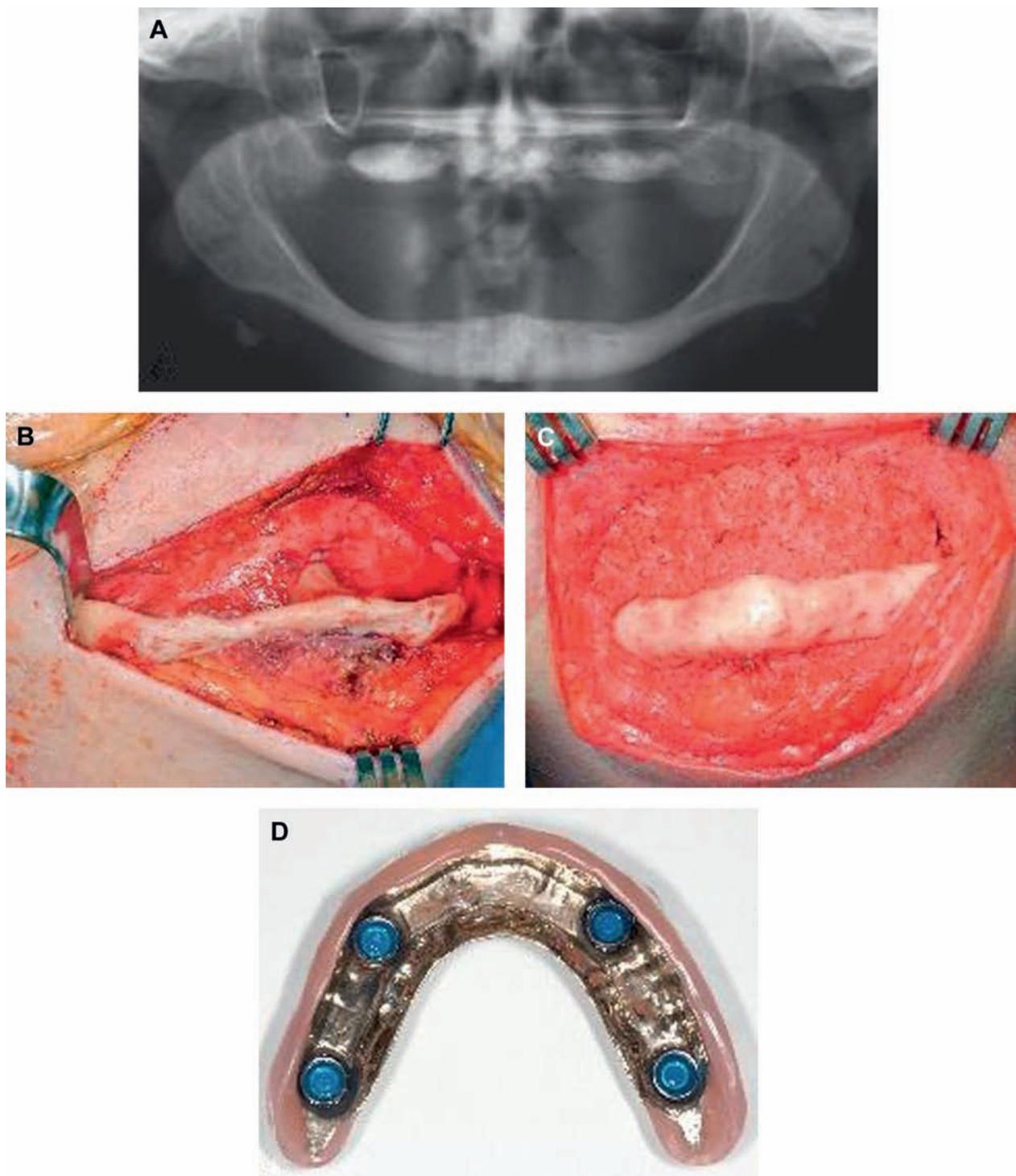


FIGURE VIII-6. Augmentation of atrophic edentulous mandible. *A*, Preoperative radiograph. *B*, Exposure of atrophic mandible through an extraoral approach. *C*, Bone graft in place. The bone graft was a combination of bone morphogenetic protein, stem cells harvested by aspiration of iliac crest marrow, and freeze-dried bone. *D*, Six-month postoperative radiograph. The maxillary bone graft and zygomatic implants were placed at the time of mandibular grafting. Note that the bone graft area was not as dense as the underlying bone. When implants are placed and stress is applied to the grafted bone, the density will increase.¹

MAXILLARY AUGMENTATION

Severe resorption of the maxillary alveolar ridge presents a significant challenge to the prosthetic reconstruction of the dentition. When moderate to severe maxillary resorption does occur, the larger denture-bearing area of the maxilla might allow for prosthetic rehabilitation without bony augmentation. In certain cases, a severe increase in the interarch space, loss of the palatal vault, interference from the zygomatic buttress area, and absence of posterior tuberosity notching can make it difficult to construct proper dentures, and augmentation should then be considered.

ONLAY BONE GRAFTING

Maxillary onlay bone grafting is indicated primarily in the presence of severe resorption of the maxillary alveolus that results in the absence of a clinical alveolar ridge and loss of adequate palatal vault form. Maxillary onlay grafting is usually accomplished by using some combination of autogenous bone (corticocancellous blocks or particulate marrow), allogeneic bone, and BMP, often contained in some type of mesh tray (Fig VIII-5). When blocks of corticocancellous bone are used, they can be secured to the maxilla with small screws, eliminating mobility and decreasing resorption (Fig VIII-7). Cancellous bone is then packed around the grafts to improve the contour. Implants can be placed at the time of grafting in some cases; however, placement is often delayed to allow initial healing of the grafted bone.

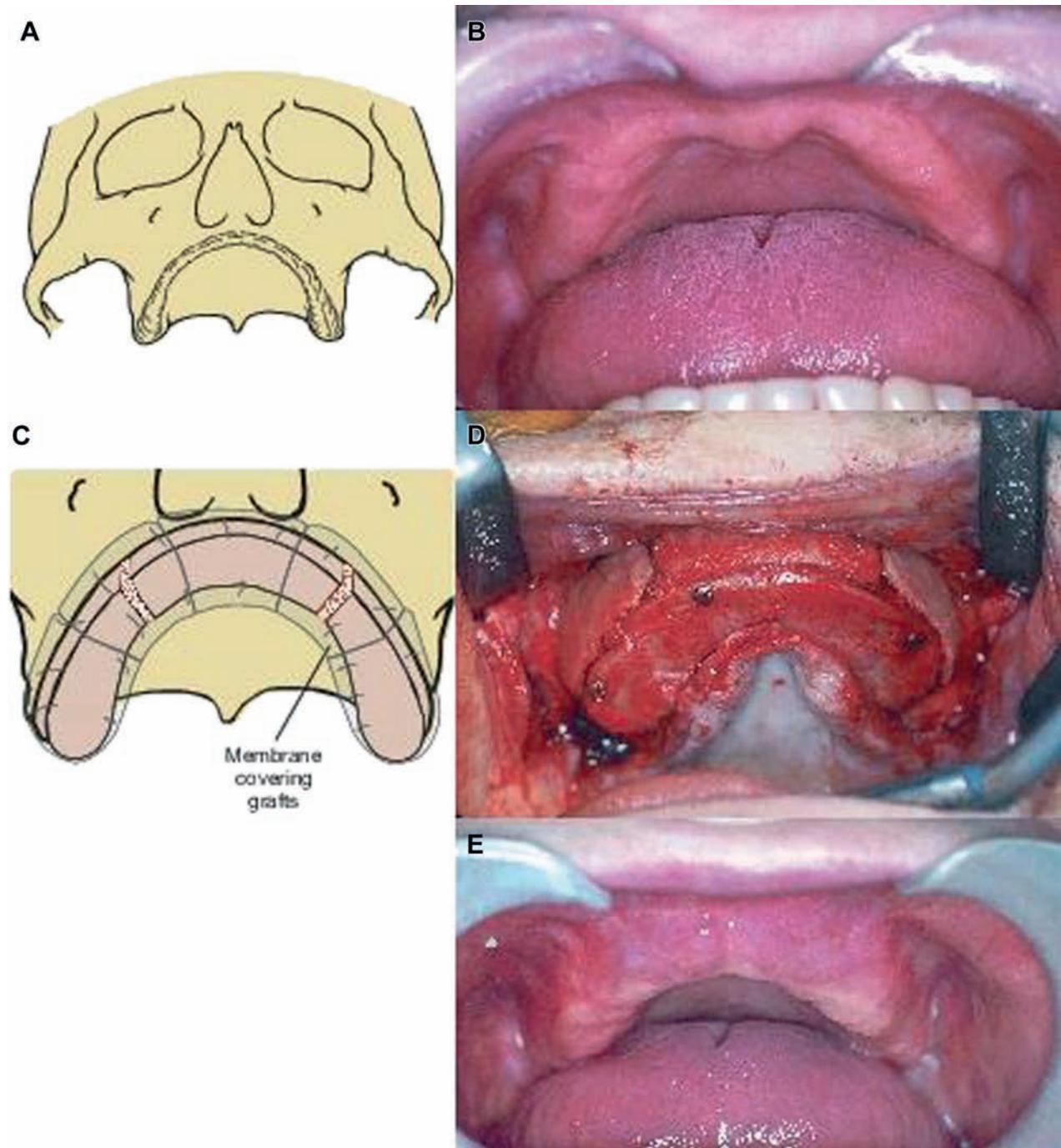


FIGURE VIII-7. Iliac crest onlay bone reconstruction of maxilla. *A*, Diagram of atrophic maxilla. *B*, Clinical photograph illustrating an inadequate alveolar ridge for reconstruction. *C*, Three segments of bone are secured in place. *D*, Stabilization of the onlay grafting with rigid fixation. Small defects have been filled with cancellous bone and bone morphogenetic protein. A resorbable membrane was then placed over the graft before tissue closure. *E*, Postoperative result demonstrating improved alveolar ridge height and contour.¹

SINUS LIFT GRAFTING

Rehabilitation of the maxilla using implants is frequently problematic because of the extension of the maxillary sinus into the alveolar ridge area. In many cases, the actual size and configuration of the maxilla will be satisfactory in terms of the height and width of the alveolar ridge area. However, extension of the maxillary sinuses into the alveolar ridge might prevent placement of implants in the posterior maxillary area because of insufficient bony support. The sinus lift is a bony augmentation procedure that places graft material inside the sinus cavity but under the membrane, augmenting the bony support in the alveolar ridge area.

When only a few millimeters of augmentation are needed, in conjunction with simultaneous implant placement, an indirect sinus lift is effective. This procedure relies on the lack of density found in maxillary cancellous bone. The initial drill is used to locate the angulation and position of the planned implant. The depth is drilled just short of the sinus floor. Osteotomes are then used to enlarge the site progressively. The osteotome is cupped on the end and compresses the walls of the osteotomy site; it also scrapes bone from the sides of the wall, pushing it ahead. The bone of the sinus floor is pushed upward, elevating the sinus membrane and depositing the bone from the lateral wall and apex of the osteotomy into the sinus below the membrane (Fig VIII-8). If needed, additional graft material can be introduced through the implant site.

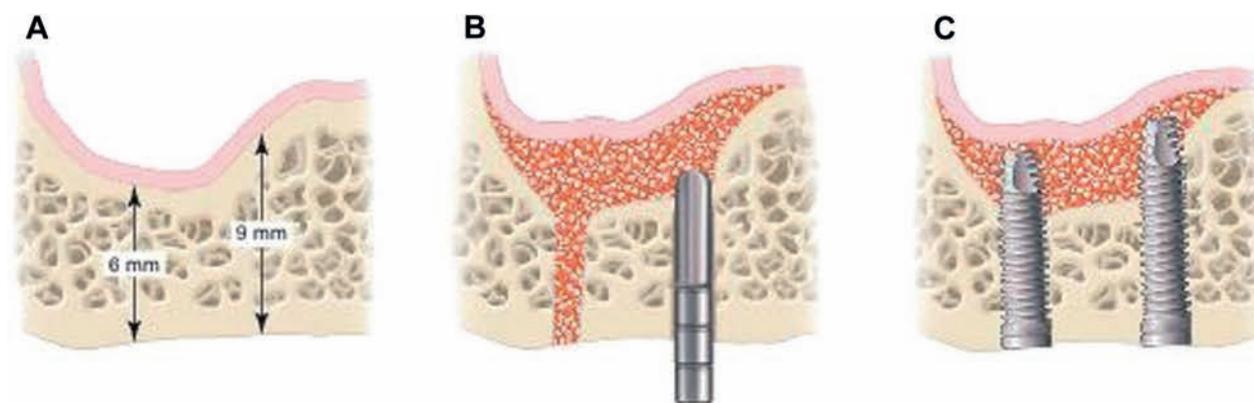


FIGURE VIII-8. Indirect sinus elevation procedure. A, Pneumatized sinus with adequate bone for primary stability. B, After drilling the pilot holes, osteotomes were used to enlarge the osteotomy and place the graft material. C, The pressure created by the graft material as it is inserted into the osteotomy expands the intact sinus membrane and elevates the floor of the sinus, allowing implant placement.¹

When more bony augmentation is needed, an open approach to the sinus is necessary. In this technique, an opening is made in the lateral aspect of the maxillary wall, and the sinus lining is carefully elevated from the bony floor of the sinus (Fig VIII-9). After elevation of the sinus membrane, the graft material is placed on the floor of the sinus, below the sinus membrane. Allogeneic bone, autogenous bone, xenogeneic bone, and BMP or a combination of these materials can be used as the graft source. Perforation of the sinus membrane can occur during exposure of the maxillary sinus floor. Perforations are usually covered with redundancy of the elevated membrane and a “patch” of resorbable membrane material. These measures allow placement of the graft material with protection from a direct sinus communication. If insufficient bone is available to provide initial implant stability, the graft should be allowed to heal for 3 to 6 months, after which the first stage of implant placement can begin in the usual fashion described in previous sections. If enough bone is available to obtain initial implant stability (usually 4 to 5 mm), implant placement can be accomplished simultaneously with sinus grafting. This procedure can be performed as outpatient surgery. A properly relieved removable prosthesis can usually be worn after surgery, during the healing period.

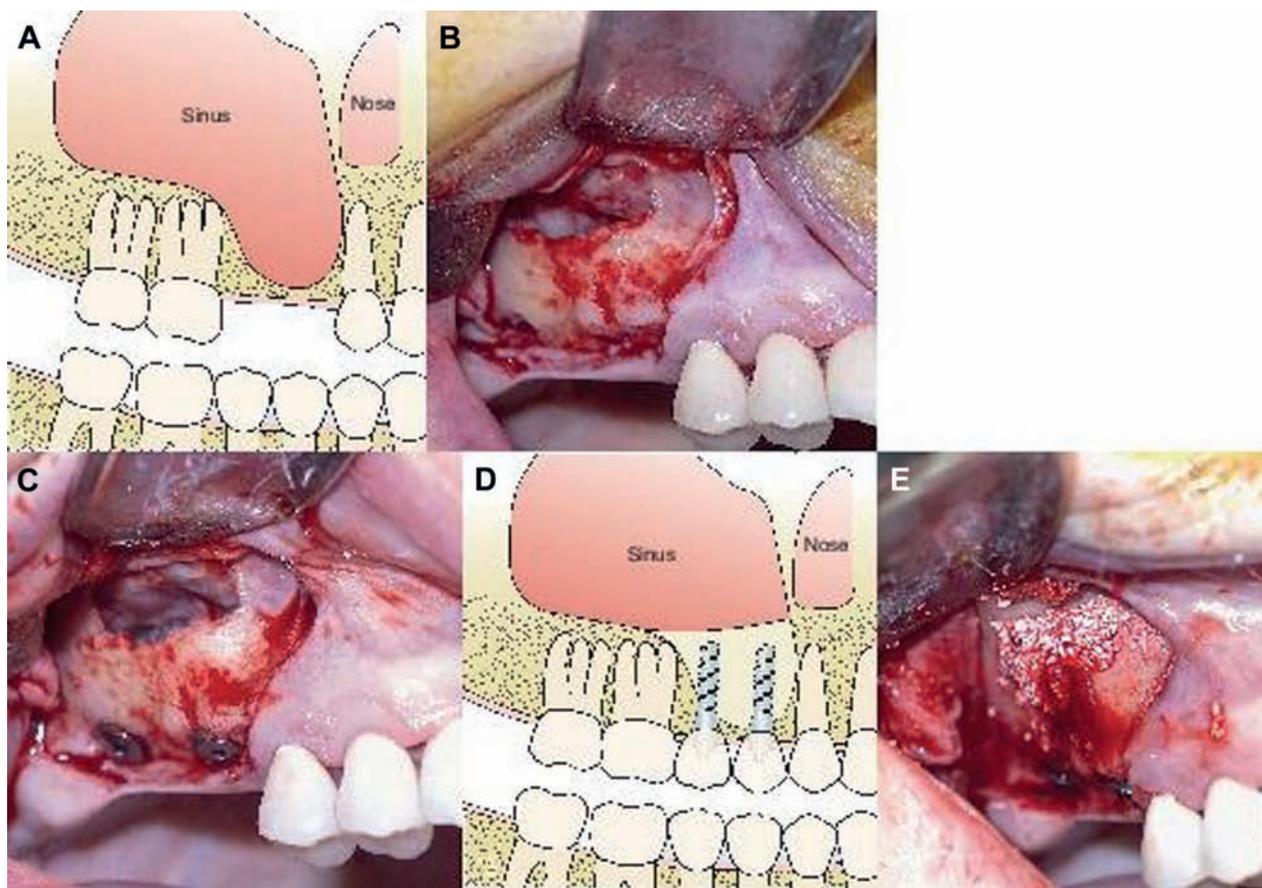


FIGURE VIII-9. Sinus lift procedure. *A*, Diagram illustrating pneumatization of the maxillary sinus into the alveolar ridge with inadequate bone support for reconstruction. *B*, A bone window provides access, and the sinus membrane is elevated. *C*, Implants are placed, which protrude into the sinus. *D*, Diagram depicting elevation of the sinus membrane, implant placement, and grafting of the area around the implants below the sinus membrane. *E*, Graft (a combination of autogenous bone and allograft material) in place.¹

ALVEOLAR RIDGE DISTRACTION

Trauma, congenital defects, and resection of bony pathologic conditions often create a bone defect inadequate for immediate reconstruction with implants. Considerable soft tissue defects, including the loss of attached gingiva, keratinized tissue, or mucosa, frequently accompany the bony discrepancy. Distraction osteogenesis has been used to correct these alveolar deficiencies. Distraction osteogenesis involves cutting an osteotomy in the alveolar ridge (Fig VIII-10). An appliance is then screwed directly into the bone segments. After an initial latency period of 5 to 7 days, the appliance is gradually activated to separate the bony segments at approximately 1 mm daily. The gradual tension placed on the distracting bony interface produces continuous bone formation. Additionally, adjacent tissue, including the mucosa and attached gingiva, expands and adapts to this gradual tension. Because the adaptation and tissue genesis involves a variety of tissue types, in addition to bone, this concept should also include the term *distraction histogenesis*. The distracted segment and newly generated bone (termed *regenerate*) is allowed to heal for 3 to 4 months. The distraction appliance is then removed, and the implants are usually placed at the time of distractor removal. Additional bone augmentation could still be required. Horizontal distraction of the alveolus to increase the width, followed by implant placement, has also been completed successfully.

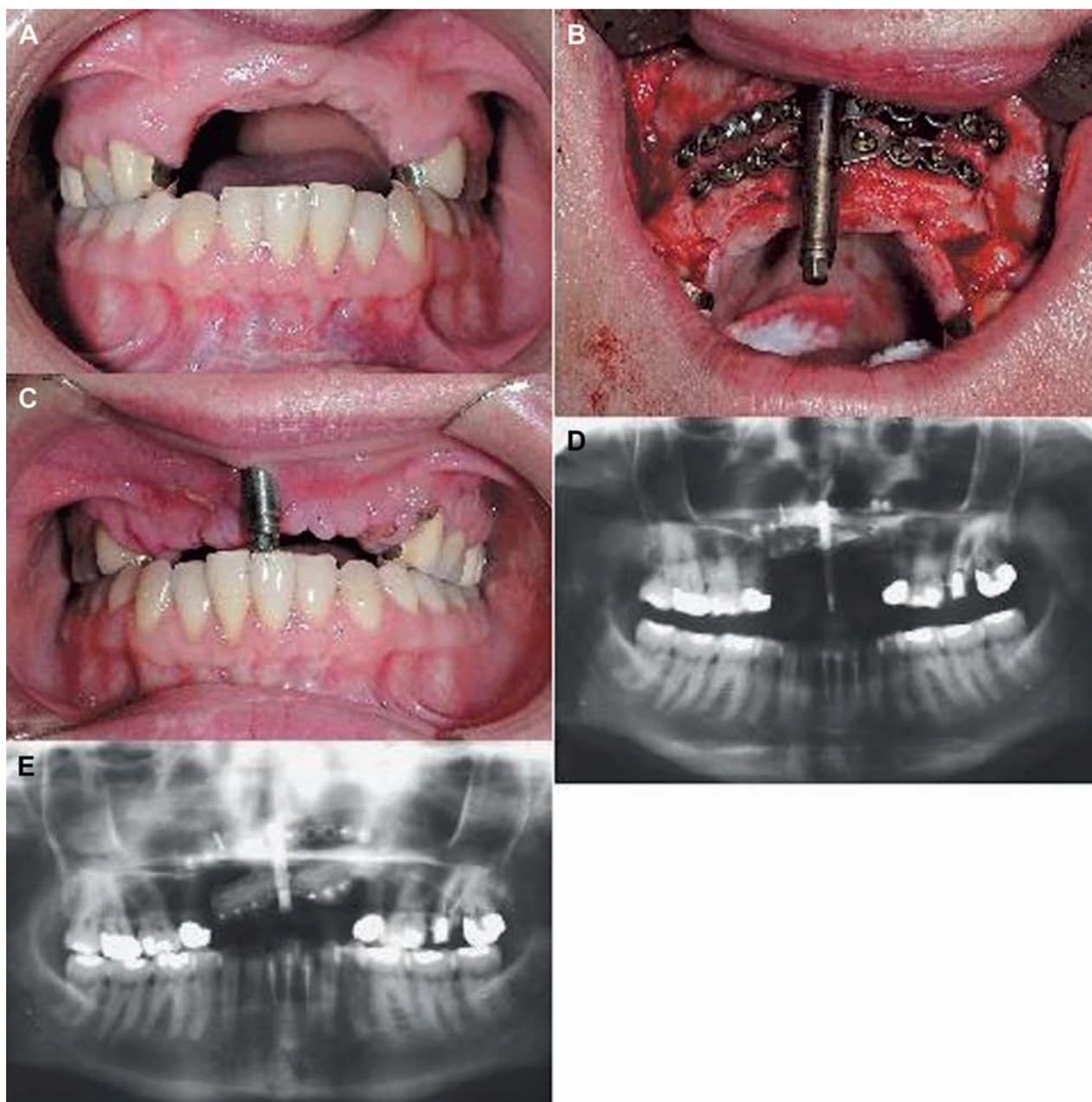


FIGURE VIII-10. Alveolar distraction osteogenesis. *A*, Pronounced vertical alveolar deficiency of the anterior maxilla. *B*, Positioning of distractor on the alveolus. *C*, Improved alveolar positioning is evident with distraction of the segment at 2 weeks. *D*, Preoperative radiograph illustrating vertical alveolar deficiency. *E*, Postdistraction radiograph indicating improved alveolar height.¹

Diagnostic Imaging and Virtual Treatment Planning for Implants

The increasing availability and use of computed tomography (CT) and cone-beam CT (CBCT) scanning, along with significant software advances, have dramatically changed how implant cases are planned from both surgical and prosthetic standpoints. CBCT scans with 3-dimensional (3D) reconstruction allow detailed visualization of the bony anatomy in all 3 planes of space. Cross-sectional viewing of the bony anatomy allows for detailed analysis of all important anatomic structures, including ridge size and shape, the position of the maxillary sinus in relation to the ridge, and location of the inferior alveolar nerve or adjacent tooth roots (Fig VIII-11; see Fig III-2). Proprietary software that facilitates the integration of the desired final prosthetic result with the underlying bony anatomy is available. Using computer technology to “virtually visualize” the underlying bone anatomy, the planned final prosthetic result, the need for bone grafting, and the position and angulation of implant placement can be planned with extreme precision (Fig VIII-12). Using rapid prototyping 3D printing technology, a surgical guide can then be created with laser polymerization of resin. Guide cylinders that exactly match the size of the surgical drills used for implant site preparation can be imbedded in the surgical guide. The guide, which is securely fixed to either the maxilla or the mandible, dictates the exact position, angulation, and depth of each implant. In some cases, it is possible to place implants through the surgical guide, which can provide an index for the internal or external retention configurations of the implant. This allows the prosthetic provisional restoration to be constructed before surgery and delivered immediately at implant placement.

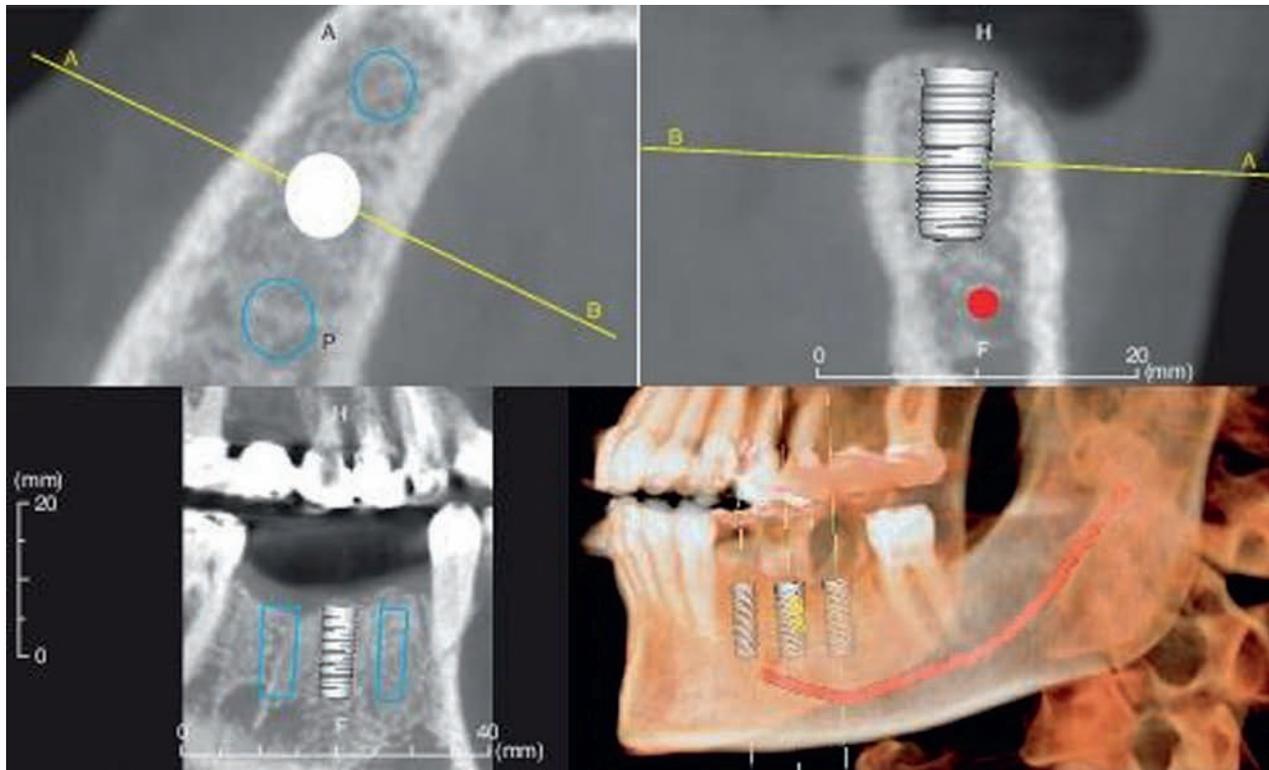


FIGURE VIII-11. Cone-beam computed tomography image showing 3-dimensional reconstruction and cross-sectional views of the mandible, identifying the site of planned implant placement and the relationship to the inferior alveolar nerve.¹

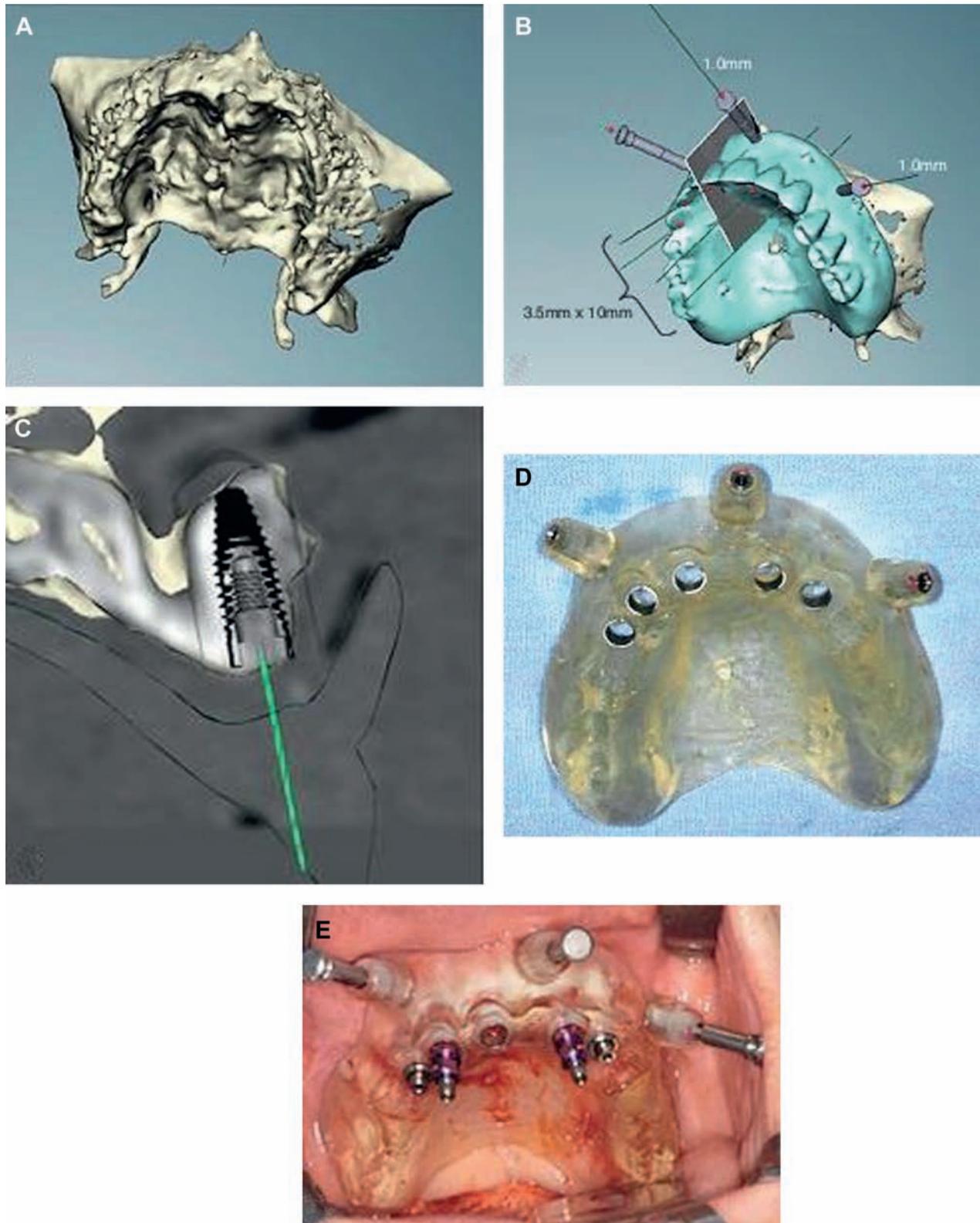


FIGURE VIII-12. Computer-assisted virtual treatment planning. *A*, 3-dimensional view of the maxilla created from cone-beam computed tomography data. *B*, "Virtual" prosthesis placed over the maxillary anatomy. The ideal position and angulation of implant placement can be determined. Individual cross-sections can be evaluated. *C*, Cross-sectional view of the anterior maxilla, with the virtual implant placed to view the position, angulation, and adequacy of bone support in this area. *D*, Computer-designed surgical guide dictating exact placement of the implants. *E*, Surgical guide rigidly fixed with anchor pins into position at the time of surgery to ensure precise placement of the implants.¹

Special Implants

ZYGOMATIC IMPLANTS

The implications of pneumatization of the maxillary sinus and the possible need for grafting have been discussed earlier in this section. Some situations exist in which grafting of the sinus floor might not be feasible. Such cases include patients with compromised health or those who are reluctant to undergo staged surgery requiring multiple surgical procedures and prolonged treatment times. Patients who have had large portions of their maxilla removed to treat pathologic entities such as cancer could require special types of implants to retain a maxillary prosthesis. In these cases, the use of the zygomaticus implant can be considered. The implants are extremely long, ranging from 35 to 55 mm. The implants are placed intraorally, with exposure to the crest of the alveolar ridge and the body of zygoma and visual access to the maxillary sinus. After the membrane is reflected, the implant traverses the maxillary sinus, with the tip engaging the body of the zygoma and the external hex fixture emerging in the second premolar or first molar area of the maxilla (Fig VIII-13). The portion of the implant embedded just medial to the alveolar crest or zygomatic bone undergoes osseointegration similar to that of other implants. The posterior zygomatic implants are usually combined with 4 anterior implants, all supporting a fixed prosthesis (see Fig VIII-18).

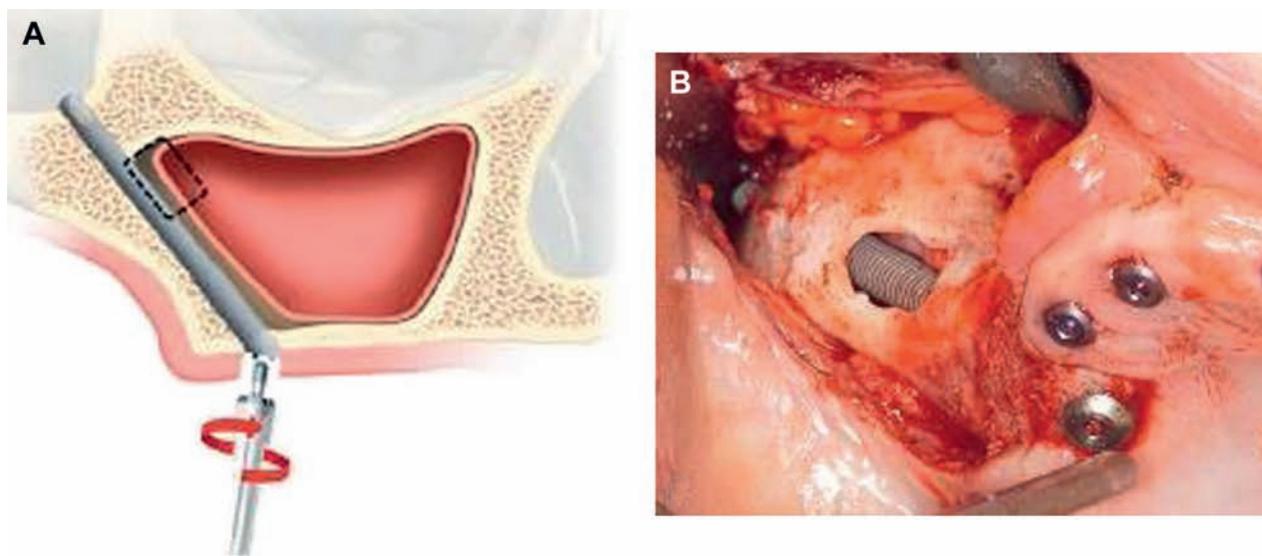


FIGURE VIII-13. Zygomaticus implant. *A*, Diagram showing placement of zygomatic implant. The implant engages the body of the zygoma, medial alveolar ridge, and lateral aspect of the maxilla. *B*, Clinical photograph of placement of the zygomatic implant. (*A*, Courtesy of Nobel Biocare USA, LLC, Yorba Linda, CA.)¹

EXTRAORAL IMPLANTS

Recognizing the success of implants for oral applications, maxillofacial prosthodontists and surgeons have expanded the use of titanium fixtures to extraoral applications. Extraoral implants are now used to anchor prosthetic ears, eyes, and noses for patients with defects resulting from congenital conditions, trauma, or pathologic conditions (Fig VIII-14).



FIGURE VIII-14. A, Congenitally absent ear with unsatisfactory autogenous reconstruction. B, Endosseous implants placed into the temporal bone with framework. C, Implant-supported prosthetic ear. (Courtesy of Dr Peter Larsen.)¹

Examples of Complex Cases

Complex cases often require the combination of many components of advanced imaging, treatment planning, surgical and prosthetic treatment techniques. The following are 5 examples of cases requiring the combination of several treatment options:

1. Missing anterior teeth requiring grafting and implant placement (Fig VIII-15)
2. Edentulous spaces in the maxilla and mandible augmented with autogenous grafting (Fig VIII-16)
3. Edentulous space in the mandible augmented with BMP and allogenic bone grafting (Fig VIII-17)
4. A totally edentulous mandible requiring grafting (Fig VIII-18)
5. Nonrestorable maxillary dentition restored with conventional anterior implants and posterior zygomaticus implants (Fig VIII-19)

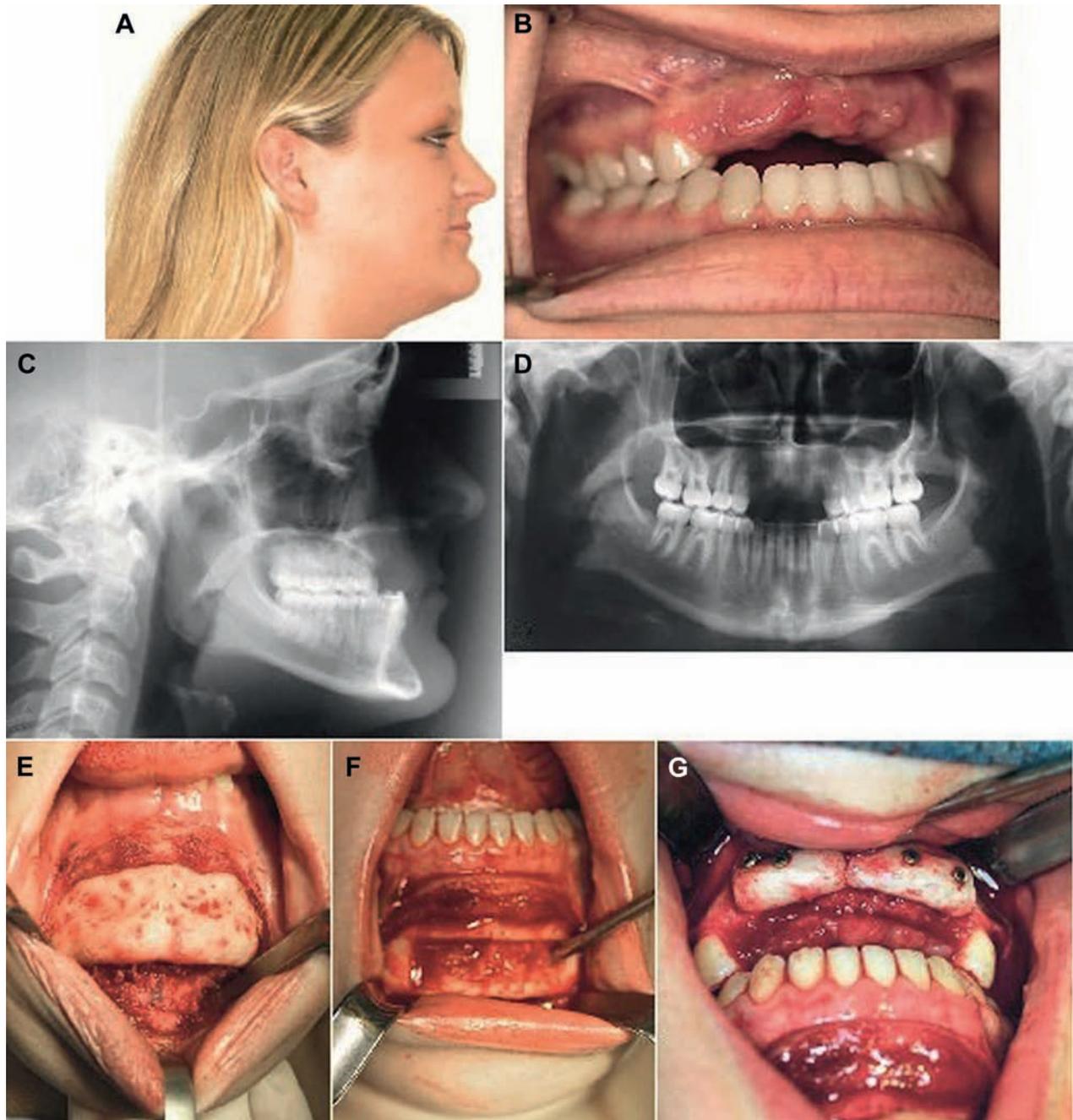


FIGURE VIII-15. Missing anterior teeth requiring grafting and implant placement. *A*, Preoperative patient profile. Note the mid-face deficiency. *B*, Anterior maxilla after extraction of nonrestorable teeth. *C*, Lateral cephalometric radiograph. Note the maxillary deficiency compared with the mandible. *D*, Panoramic radiograph. *E*, Surgical exposure of mandibular symphysis. *F*, Bone harvest from mandibular symphysis. *G*, Fixation of symphyseal bone harvest to the facial wall of the anterior maxilla. (**Fig 15 continued on next page.**)

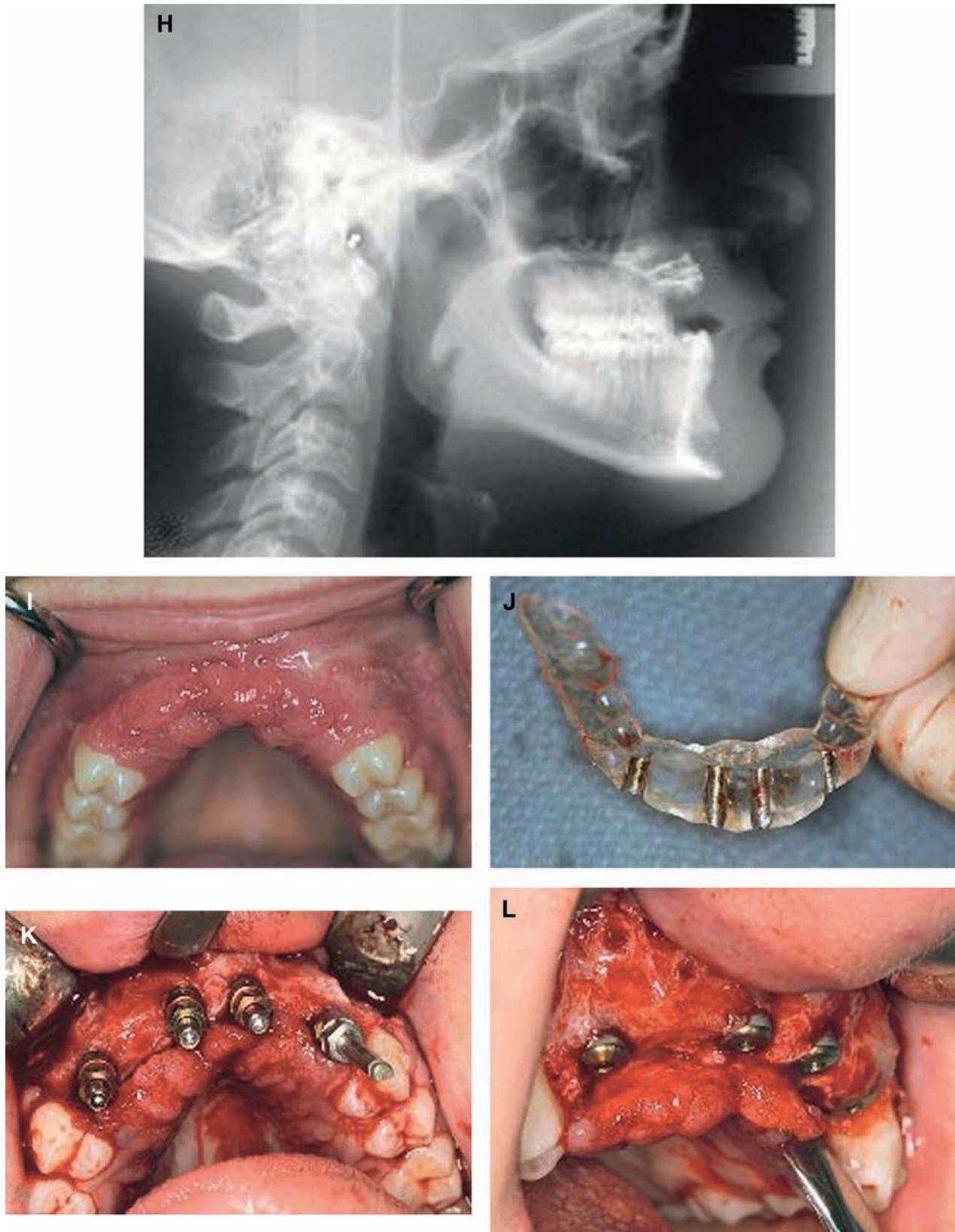


FIGURE VIII-15 (cont'd). *H*, Lateral cephalometric radiograph with the bone graft in place. *I*, Occlusal view of the maxillary arch after grafting. *J*, Surgical guide for implant placement. *K*, Implants placed. *L*, Implant cover screws placed for a 2-stage healing process. (**Fig 15 continued on next page.**)

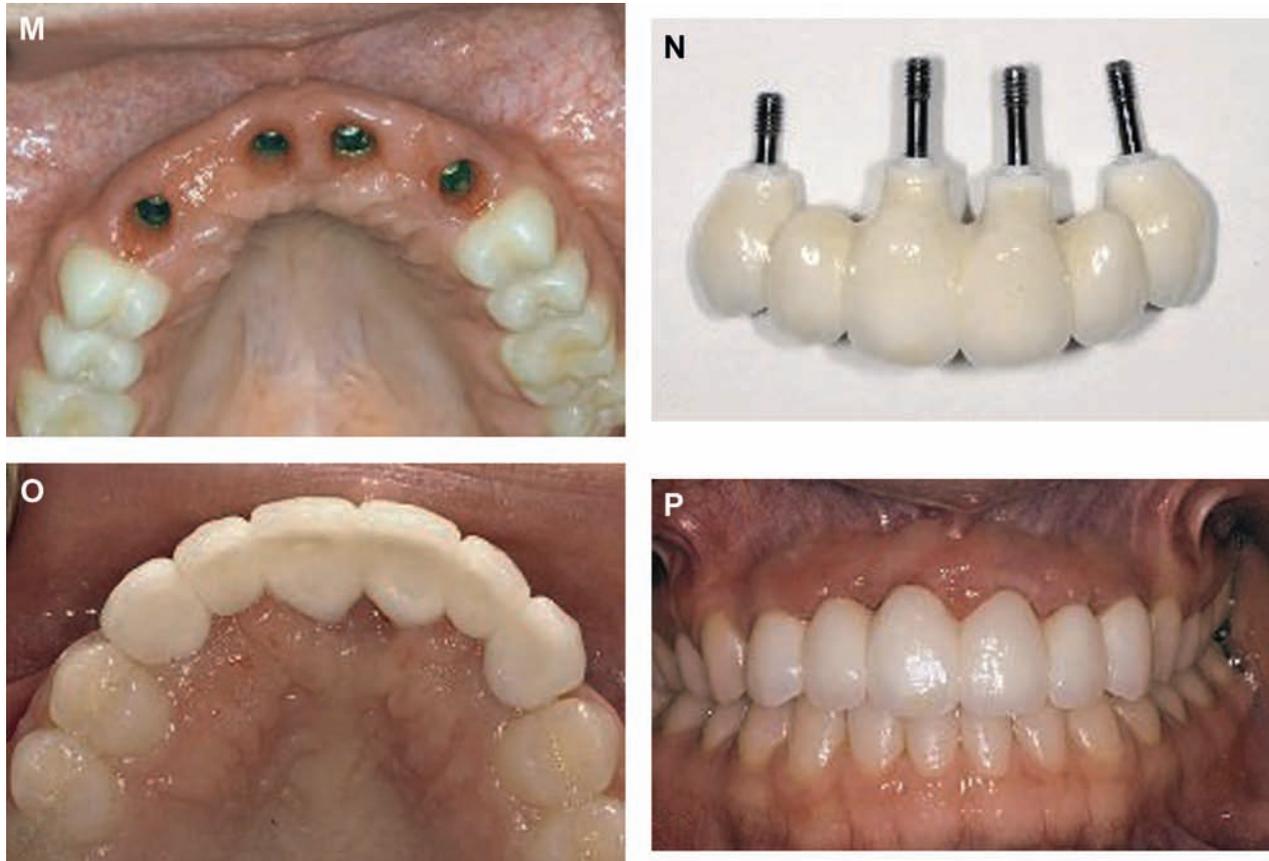


FIGURE VIII-15 (cont'd). *M*, Healing abutment removed 6 months after implant placement. *N*, An implant-supported, all-zirconia, screw-retained, fixed partial denture. *O*, Occlusal view of the final prosthesis in place. *P*, Final prosthetic result. (**Fig 15 continued on next page.**)



FIGURE VIII-15 (cont'd). Q, Final full-face photograph. R, Final profile photograph. (Fig 15 continued on next page.)

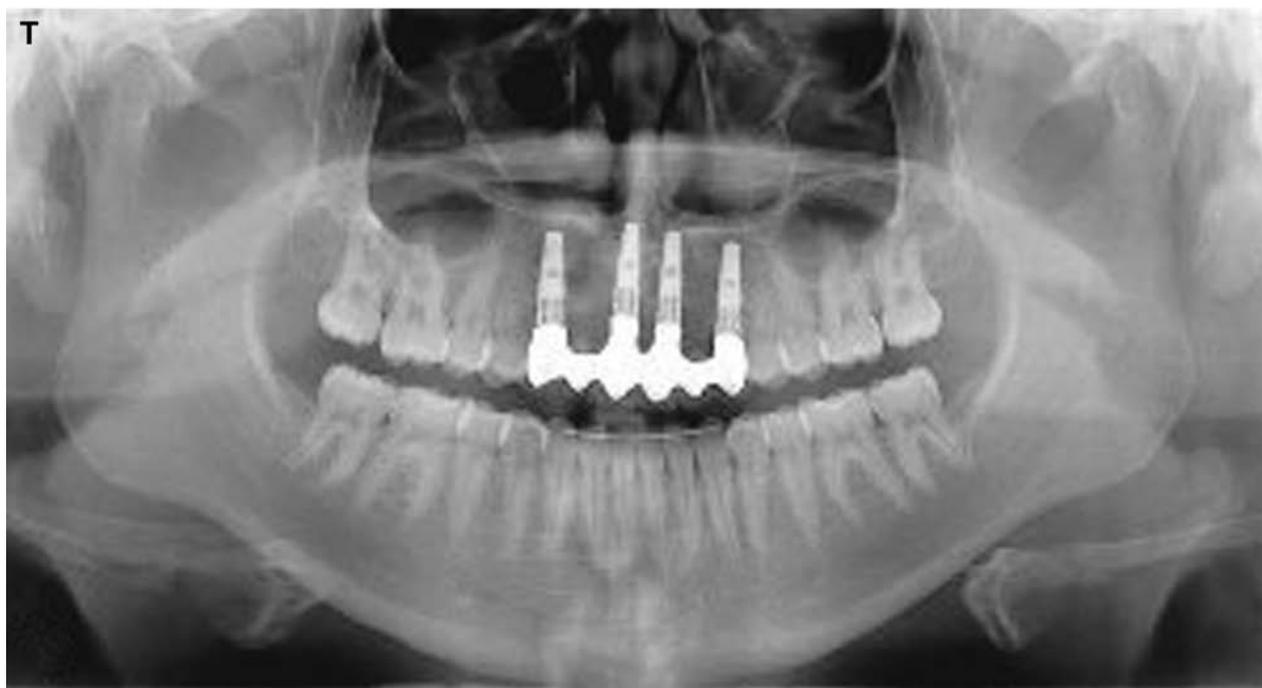


FIGURE VIII-15 (cont'd). *S*, Final lateral cephalometric radiograph. *T*, Final panoramic radiograph.¹

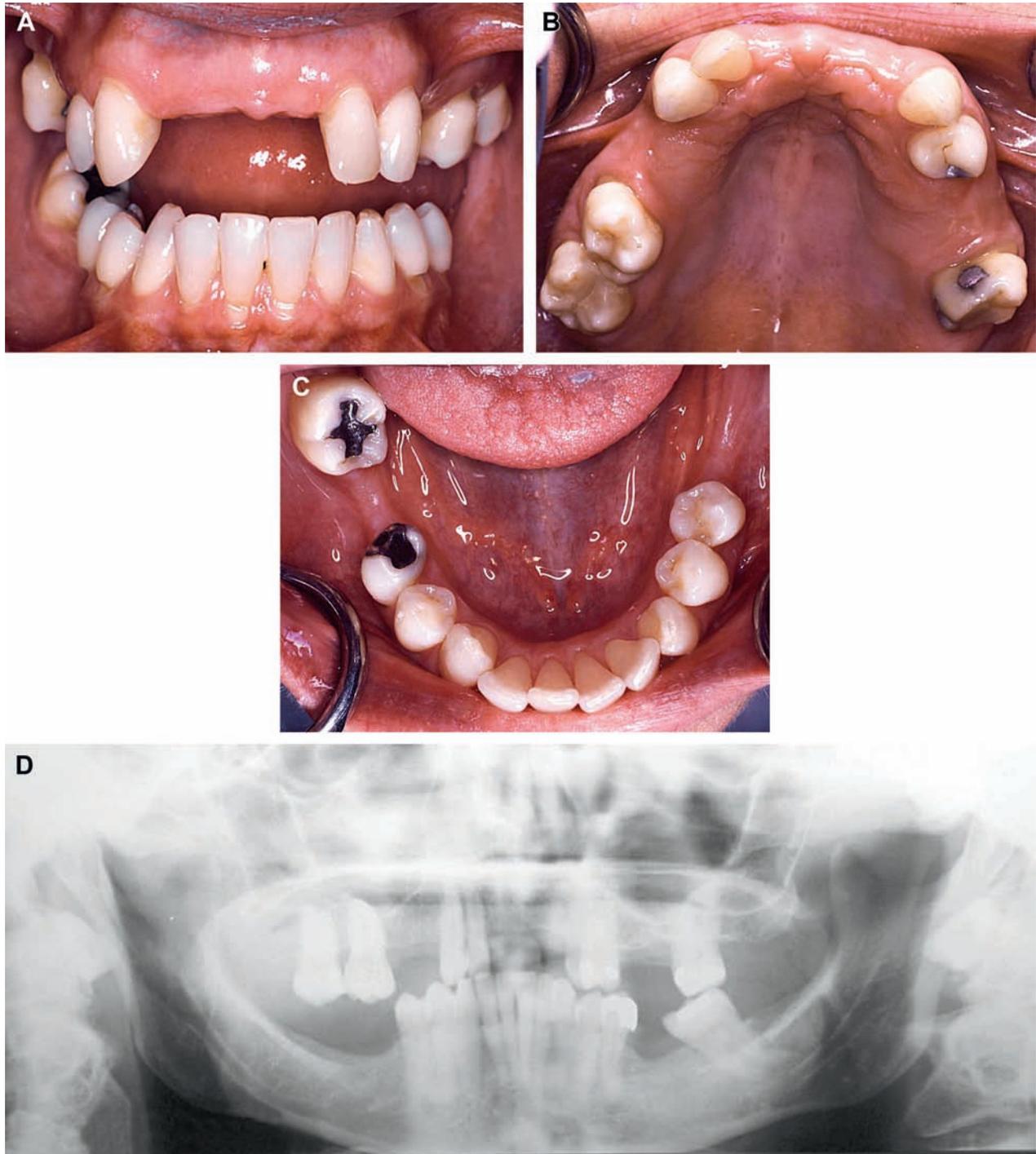


FIGURE VIII-16. Edentulous spaces in maxilla and mandible augmented with autogenous grafting. *A*, Preoperative frontal view. *B*, Preoperative occlusal view of maxilla. *C*, Preoperative occlusal view of mandible. *D*, Preoperative panoramic radiograph. Note the pneumatized maxillary sinuses and atrophic posterior mandibular anatomy. **(Fig 16 continued on next page.)**

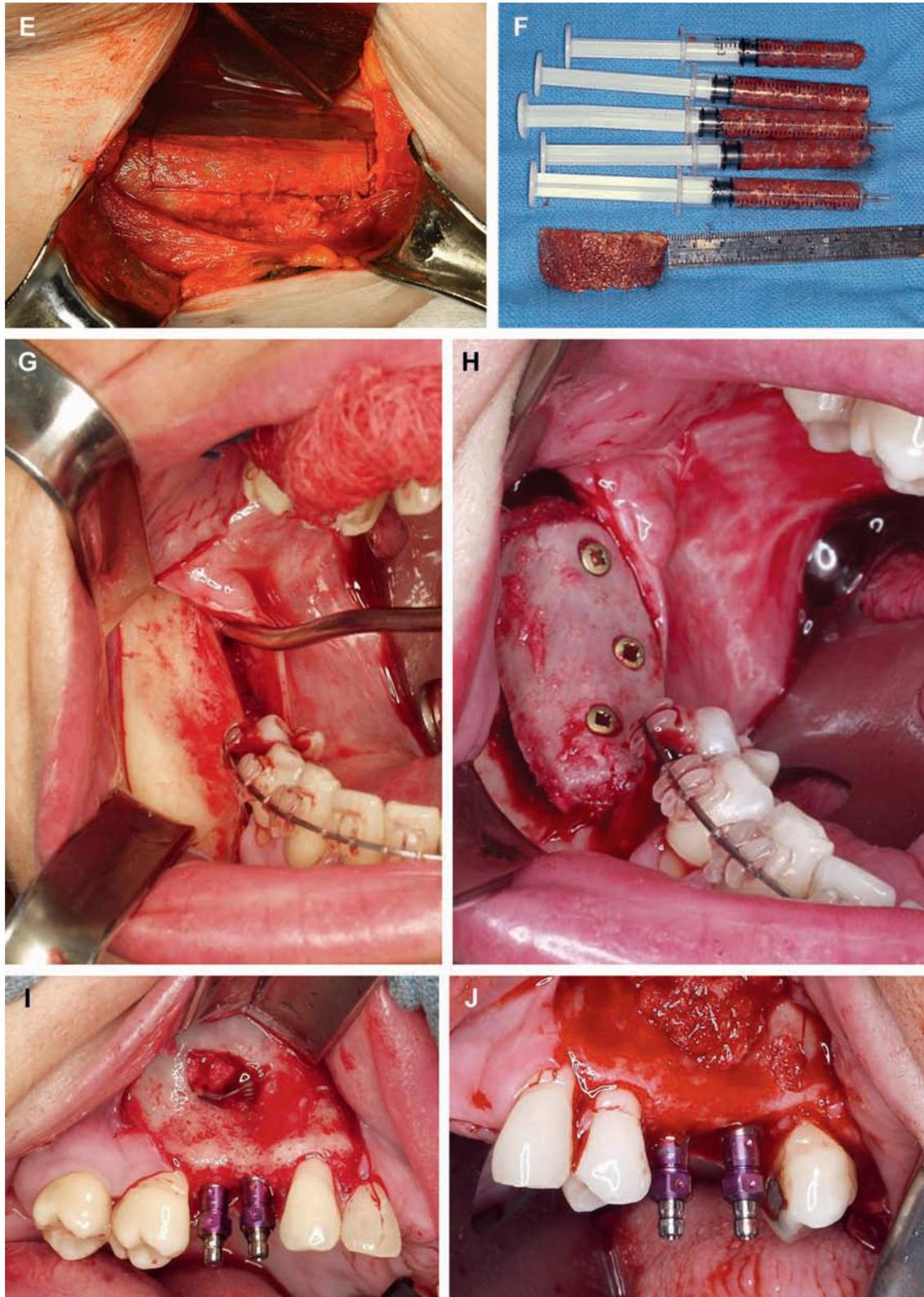


FIGURE VIII-16 (cont'd). *E*, Iliac crest exposure and initiation of cortical bone harvest. *F*, Cortical and cancellous bone harvested from iliac cresta. *G*, Surgical exposure of atrophic posterior mandible. *H*, Fixation of the cortical bone graft. *I*, Simultaneous implant placement and sinus lift prior to placement of the bone graft. *J*, Completion of the graft placement in the maxillary sinus. (**Fig 16 continued on next page.**)

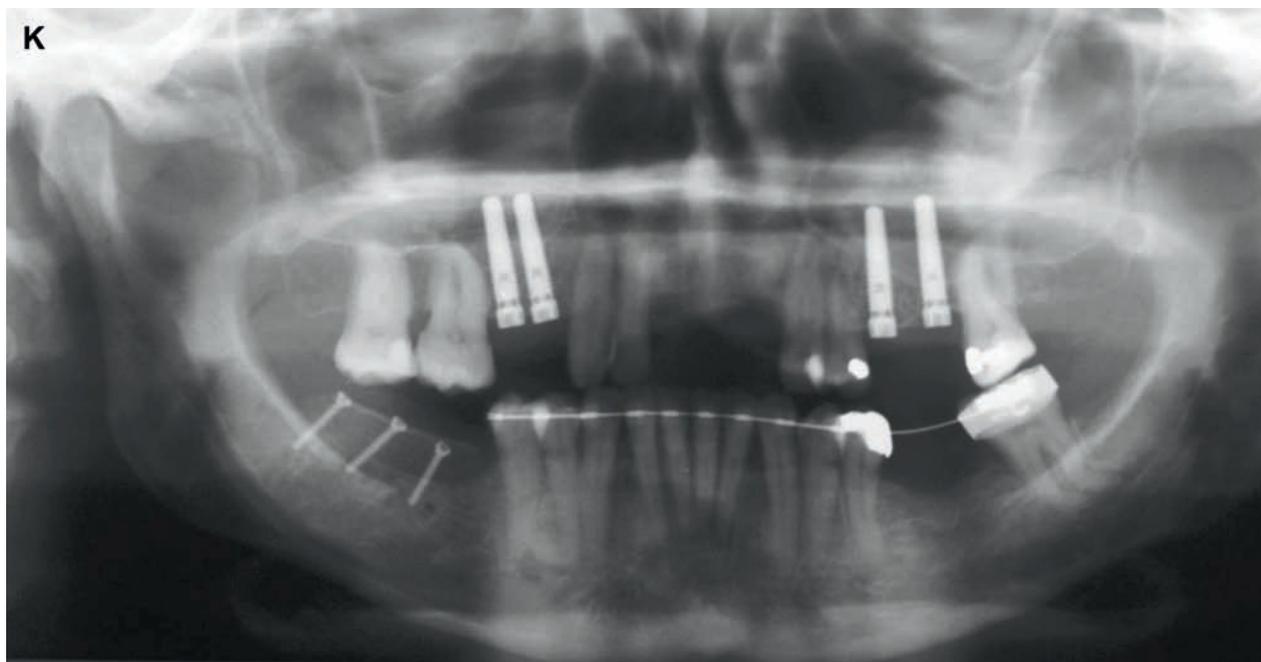


FIGURE VIII-16 (cont'd). *K*, Panoramic radiograph after grafting. *L*, Mandibular implant placement. (**Fig 16 continued on next page.**)

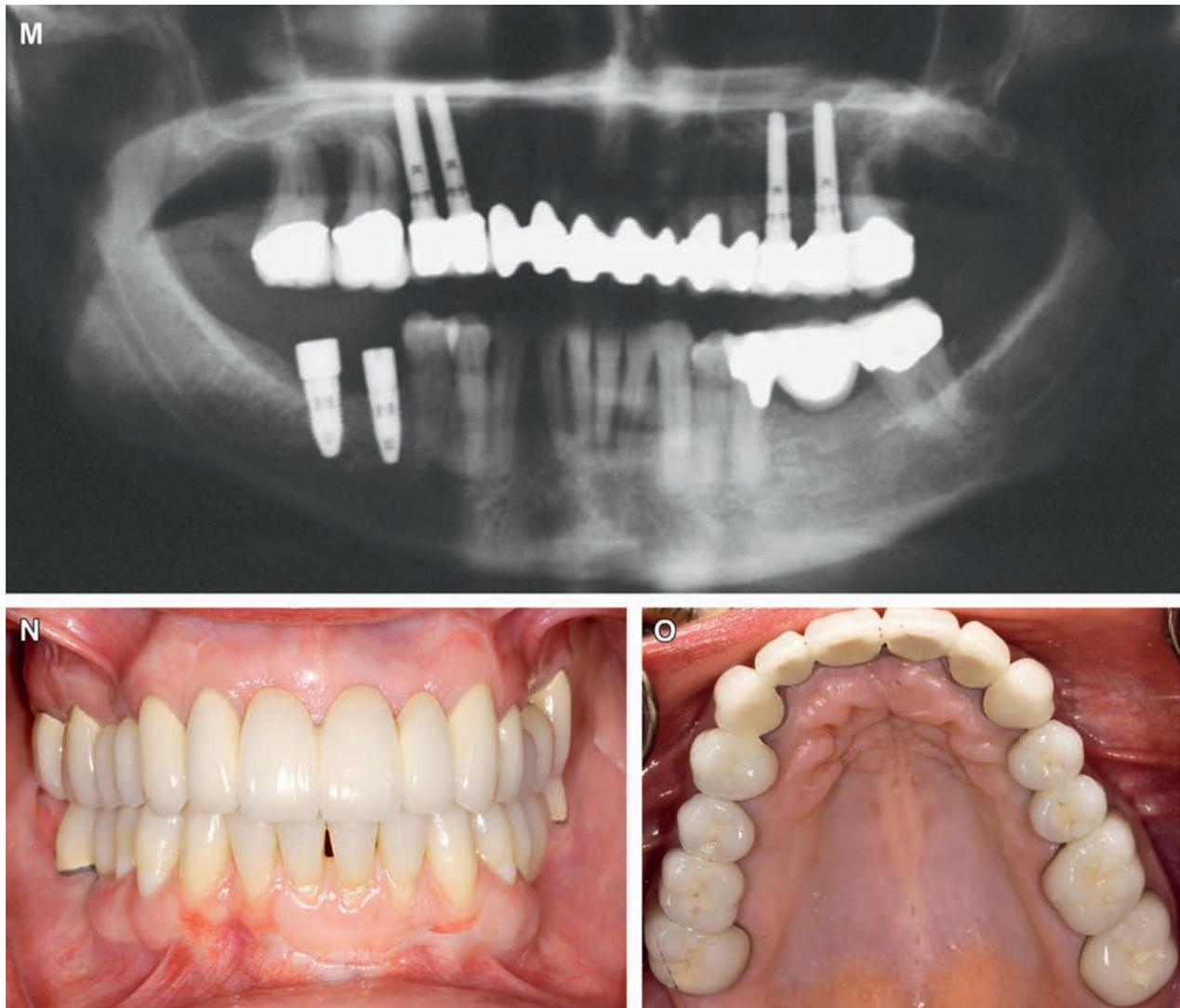


FIGURE VIII-16 (cont'd). M, Radiograph after placement of mandibular implants. N, Frontal view of the completed prosthetics. O, Occlusal view of the completed maxillary prosthetics. (Fig 16 continued on next page.)

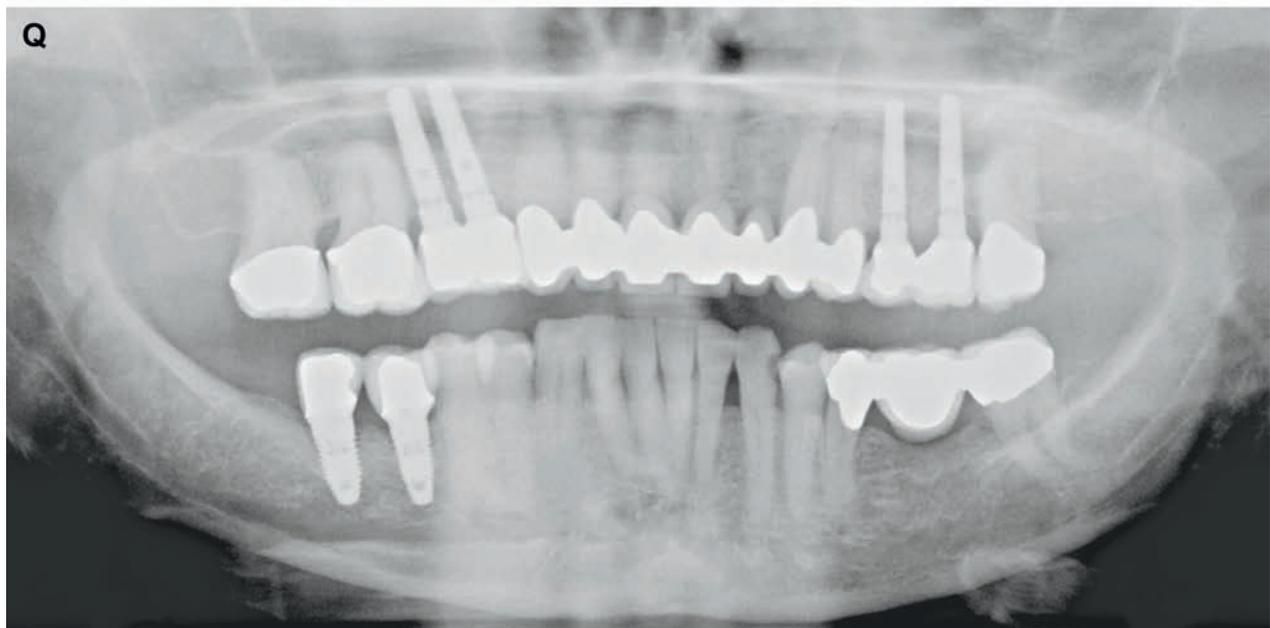


FIGURE VIII-16 (cont'd). P, Occlusal view of the completed mandibular prosthetics. Q, Final radiograph.

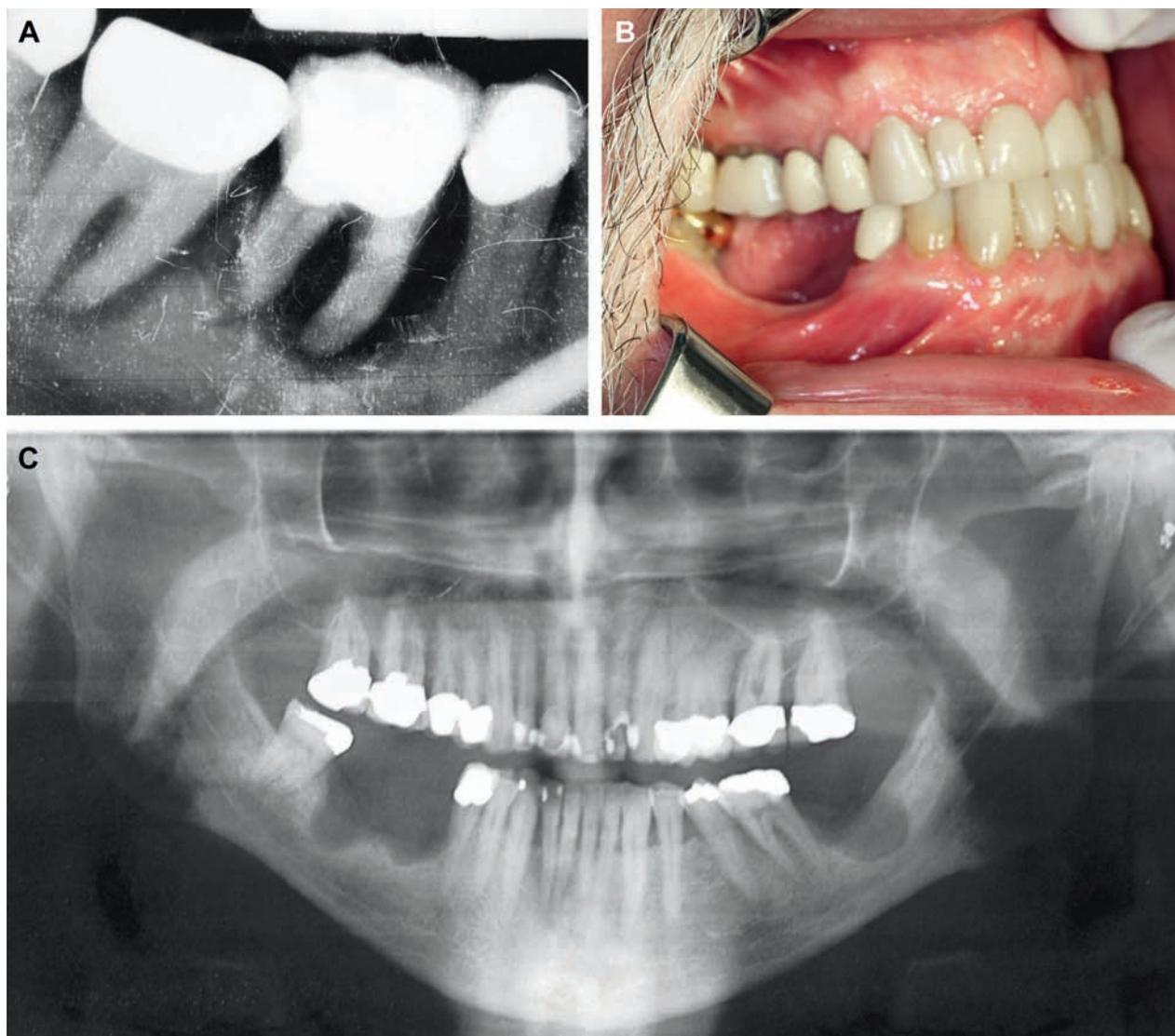


FIGURE VIII-17. Edentulous space in mandible augmented with BMP and allogenic bone graft. *A*, Periapical of right posterior mandibular teeth demonstrates advanced focal periodontal bone loss. *B*, Lateral view of the posterior right mandible 5 months after extraction of the first and second molars. *C*, The left posterior mandible is healing following extraction of the second molar. **(Fig 17 continued on next page.)**



FIGURE VIII-17 (cont'd). *D*, Surgical view of the cupped-out right mandibular defect. *E*, Packaging of the bone morphogenetic protein (BMP). *F*, View of the absorbable collagen sponges (ACS) that have been impregnated with the sterilely reconstituted recombinant BMP 2 (rhBMP-2). After 15 minutes, the BMP becomes adherent to the moistened collagen sponges. *G*, Collagen sponges cut into small strips and mixed with particulate corticocancellous bone. (**Fig 17 continued on next page.**)

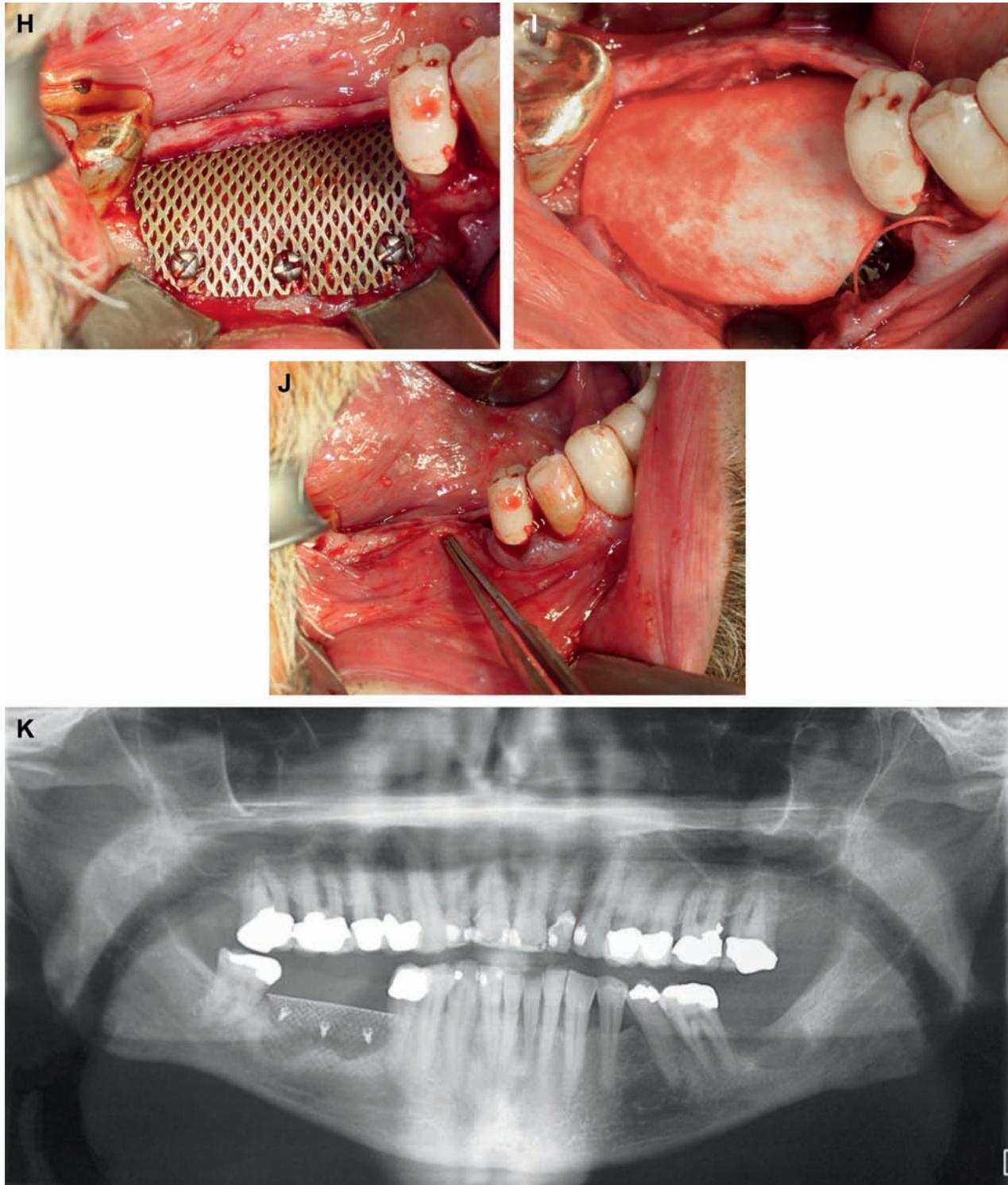


FIGURE VIII-17 (cont'd). *H*, Fine titanium mesh contoured to an ideal alveolar ridge form and packed with BMP on ACS with particulate bone. The "titanium crib" is secured to the native ridge with 1.2-mm self-drilling screws. *I*, A type I collagen membrane is laid over the titanium crib prior to closure. This serves as an internal dressing and scaffold should there be any slight leakage or wound separation. *J*, Tension-free primary soft tissue closure. *K*, One-week postoperative panoramic radiograph showing titanium crib and graft re-establishing normal alveolar ridge height. (**Fig 17 continued on next page.**)

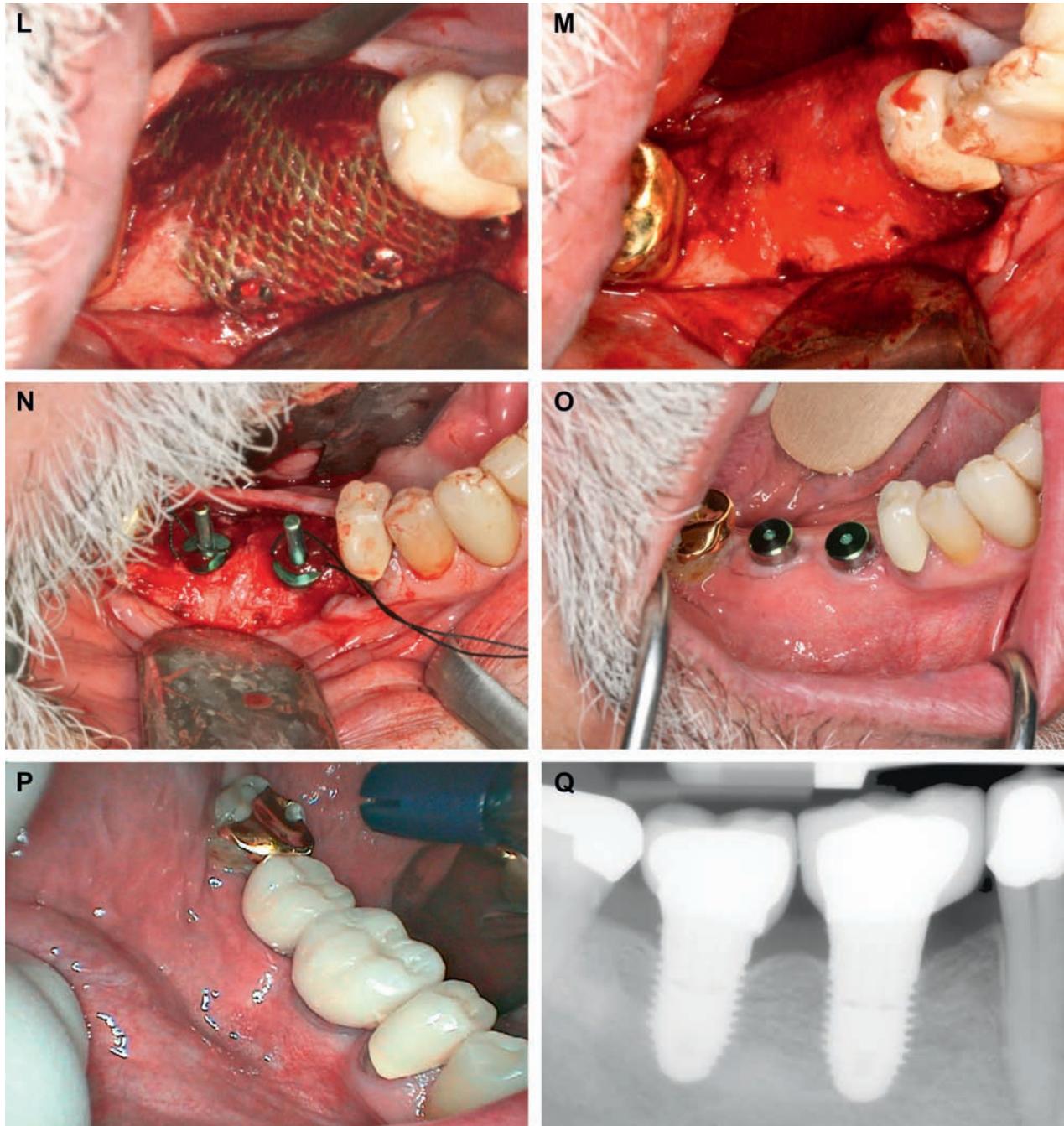


FIGURE VIII-17 (cont'd). *L*, View of titanium crib at surgical re-entry 8 months after grafting. *M*, Right mandibular ridge with matured regenerated bone. *N*, Lateral view of the prepared wide-diameter (6 mm) osteotomy sites, with guide pins checking spacing, parallelism, and alignment with opposing natural dentition. *O*, Appearance of right mandibular ridge 10 days postoperatively with 5-mm high healing abutments. At placement, the implants demonstrated good primary stability and, thus, allowed single staging and optimizing soft tissue healing. *P*, Individually restored molar implants. *Q*, One-year follow-up periapical film. Note the improved bone quality on the distal aspect of the premolar.

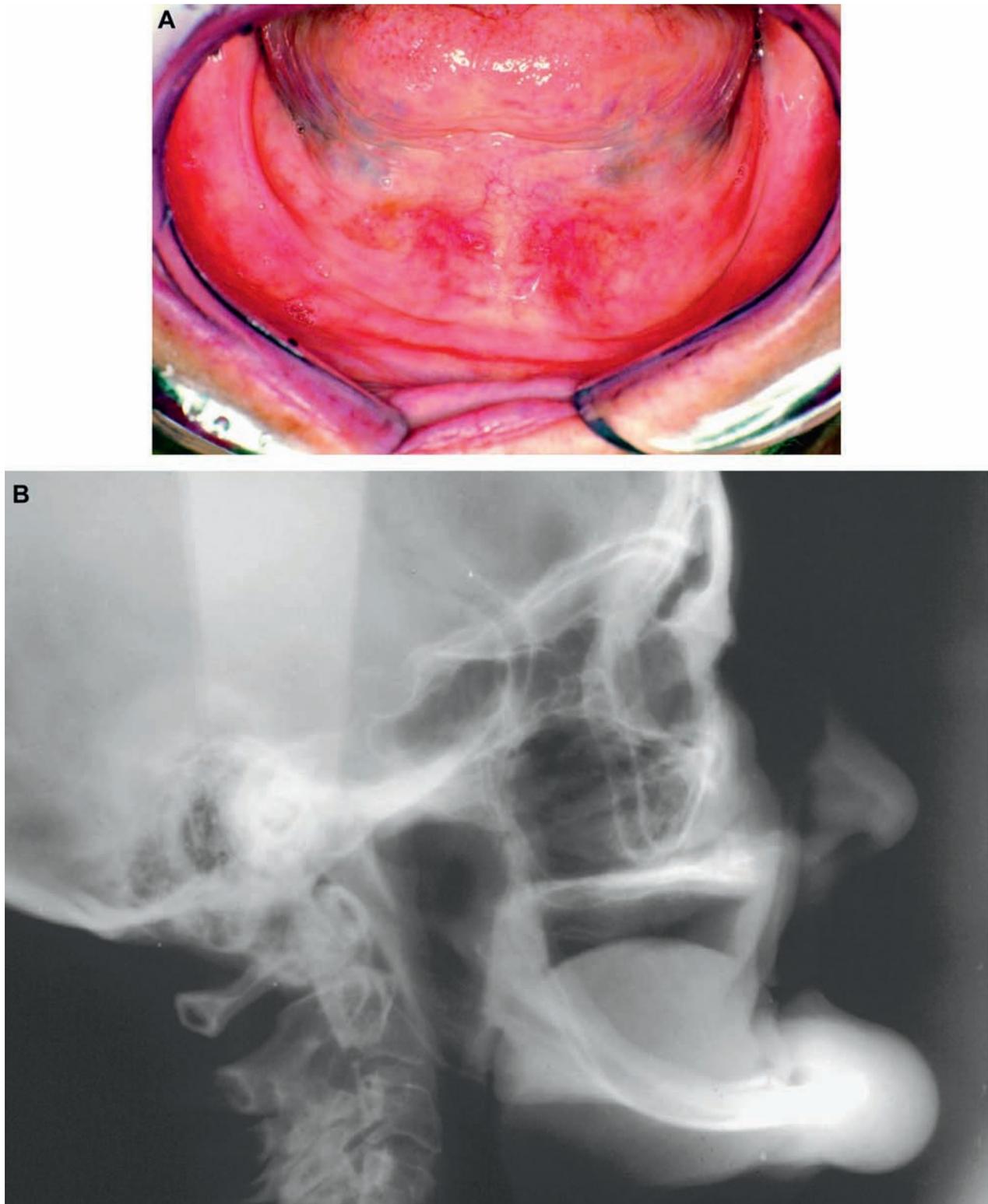


FIGURE VIII-18. Totally edentulous mandible requiring grafting. *A*, Initial clinical photo of severely atrophic mandible. *B*, Lateral cephalometric radiograph. **(Fig 18 continued on next page.)**

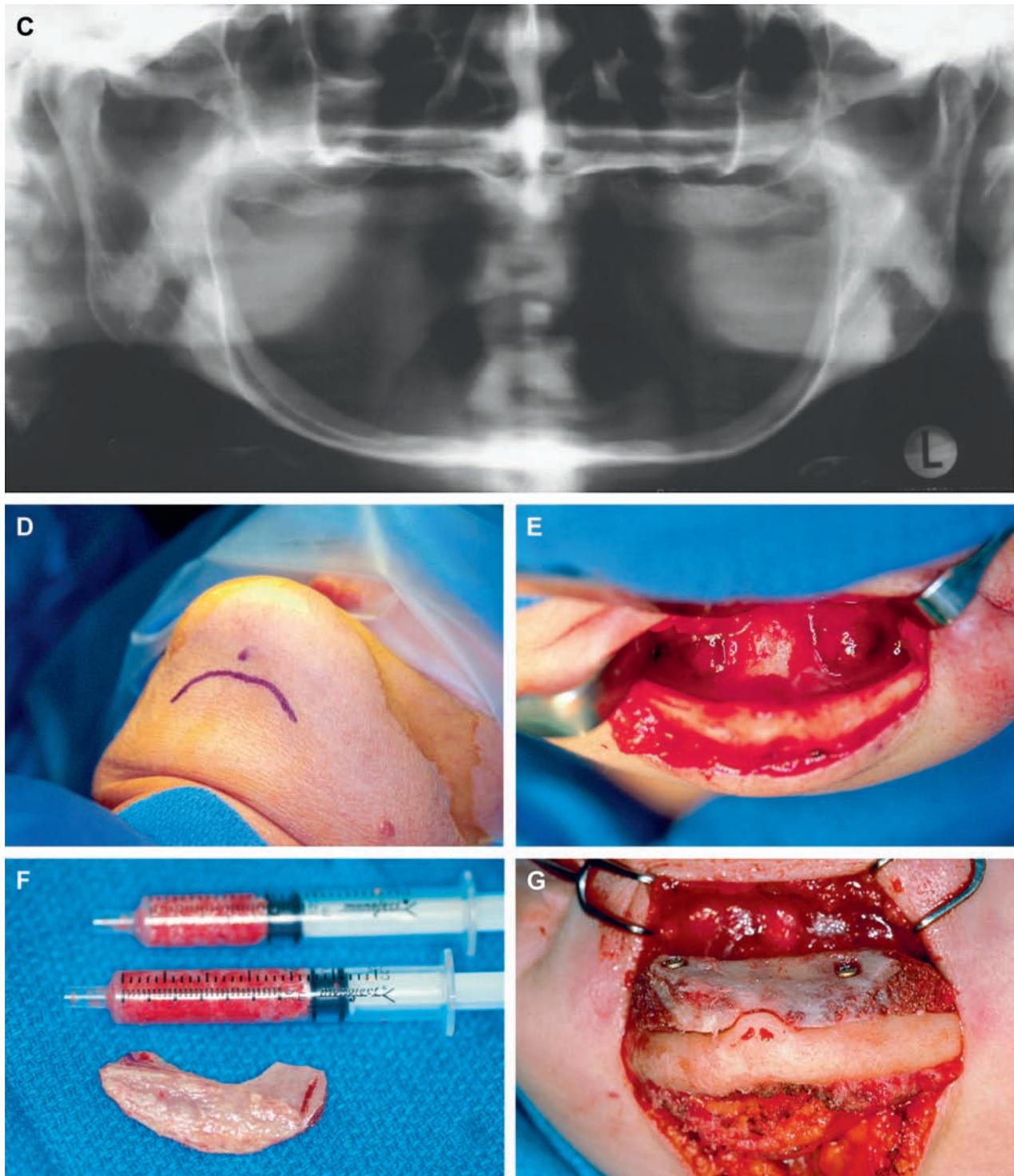


FIGURE VIII-18 (cont'd). C, Panorex showing extreme atrophy of entire mandible. D, Extraoral approach for bone grafting. E, Exposure of anterior mandible. F, Autogenous bone harvested from the iliac crest. The graft includes a corticocancellous block as well as additional marrow. G, Grafts in place. (Fig 18 continued on next page.)

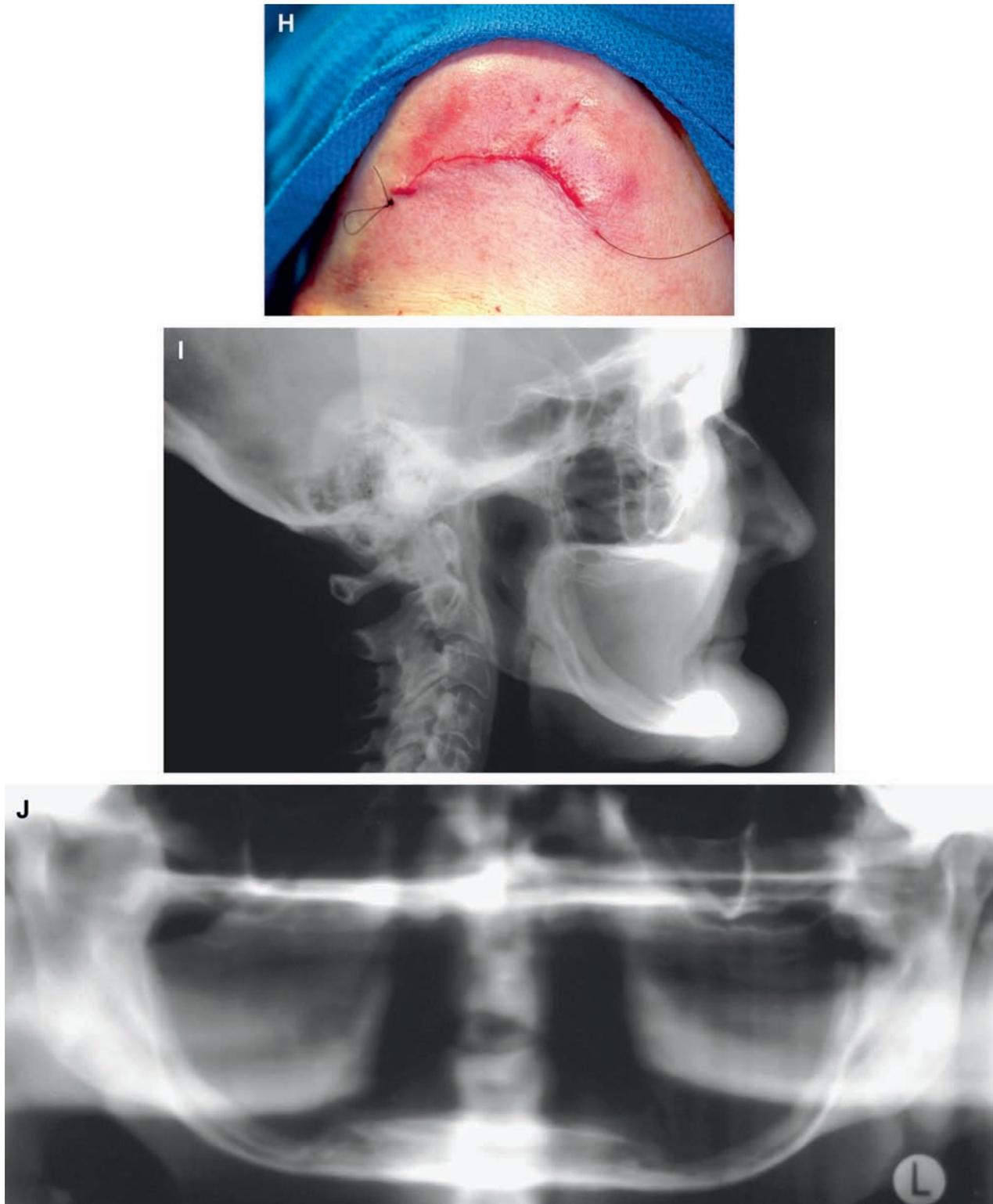


FIGURE VIII-18 (cont'd). *H*, Wound closure. *I*, Cephalometric radiograph after grafting. *J*, Panorex radiograph after graft placement. (Fig 18 continued on next page.)

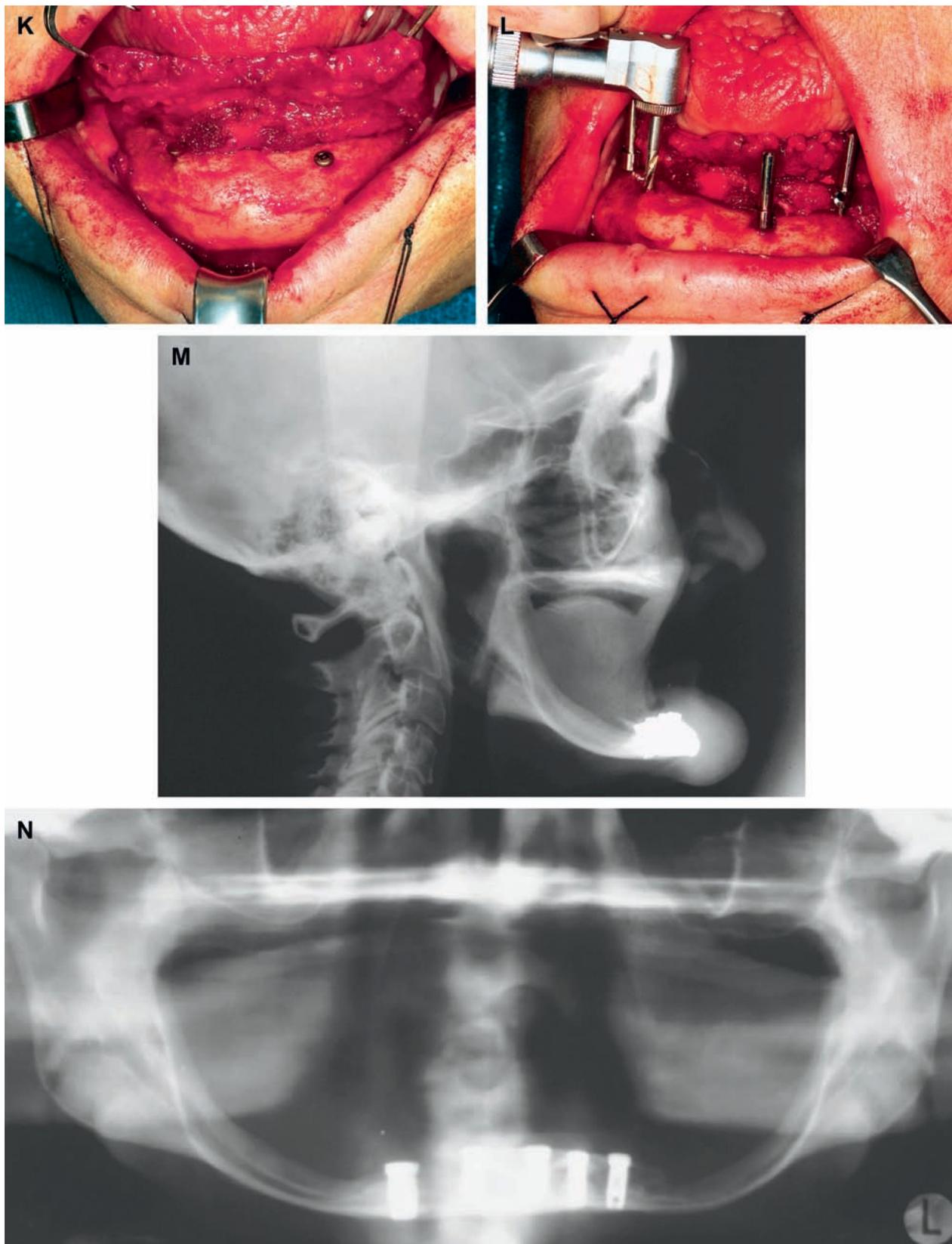


FIGURE VIII-18 (cont'd). *K*, Intraoral exposure of anterior mandible at time of implant placement. *L*, Placement of implants. *M*, Cephalometric radiograph after implant placement. *N*, Panorex after implant placement. (**Fig 18 continued on next page.**)

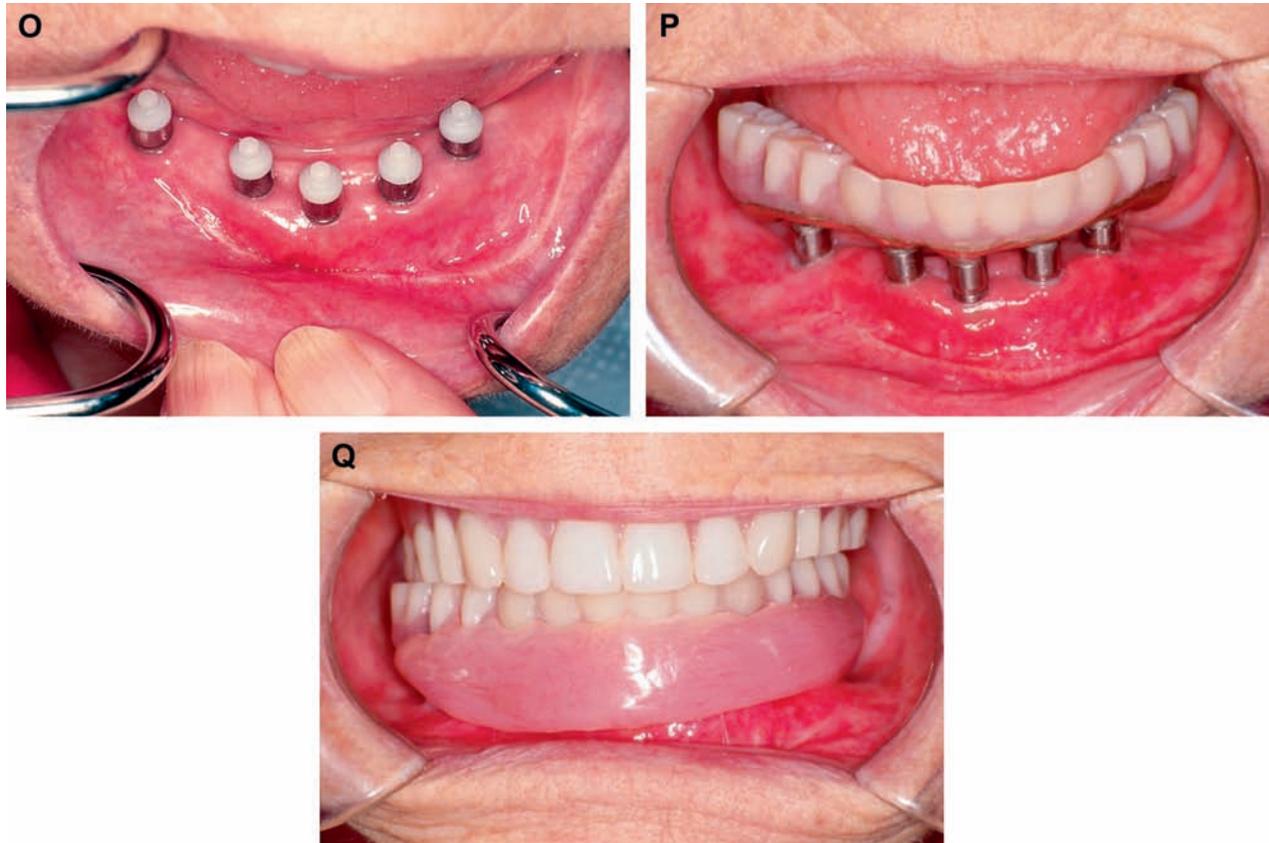


FIGURE VIII-18 (cont'd). *O*, Implants uncovered, ready for restoration. *P*, Prosthesis totally supported by implants. The prosthesis is elevated due to increased interarch space resulting from maxillary and mandibular atrophy. *Q*, Prosthetic overlay to fill space between mucosa and prosthesis and to add support to lower lip area.

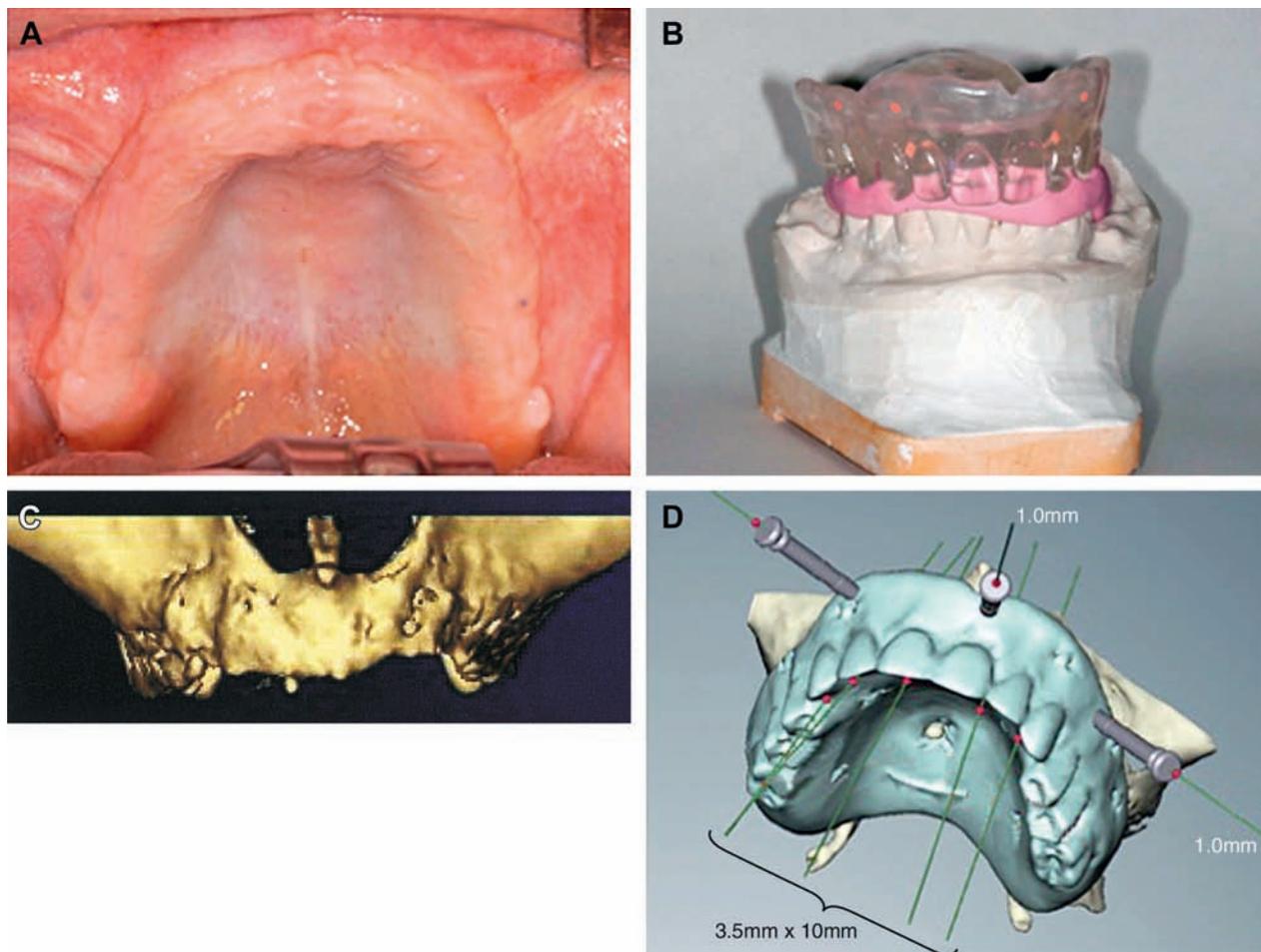


FIGURE VIII-19. Nonrestorable maxillary dentition restored with conventional anterior implants and posterior zygomaticus implants. *A*, Occlusal view of edentulous maxilla. *B*, Radiographic guide (duplicated from the approved transitional denture) and bite registration. *C*, 3-dimensional reconstruction of edentulous maxilla. *D*, Virtual planning for implant placement in edentulous maxilla with the simulated prosthesis in place. (Fig 19 continued on next page.)

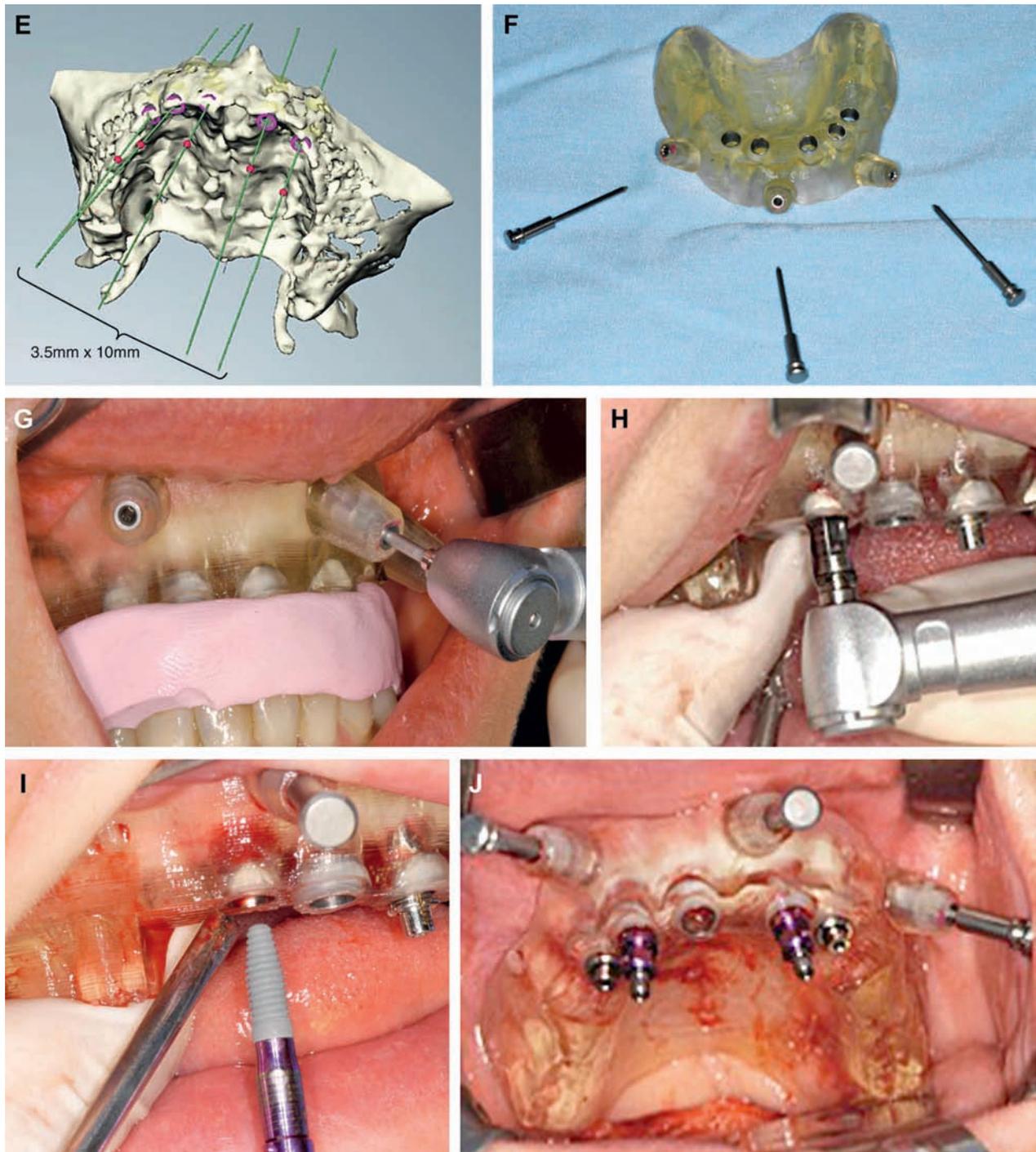


FIGURE VIII-19 (cont'd). *E*, Virtual implant placement. *F*, Surgical guide and fixation pins. *G*, Surgical guide in place with bite registration and insertion of fixation pins. *H*, Surgical guide in place with mixture mounts. *I*, Implant drill preparing osteotomy. *J*, Placement of the implant. (**Fig 19 continued on next page.**)

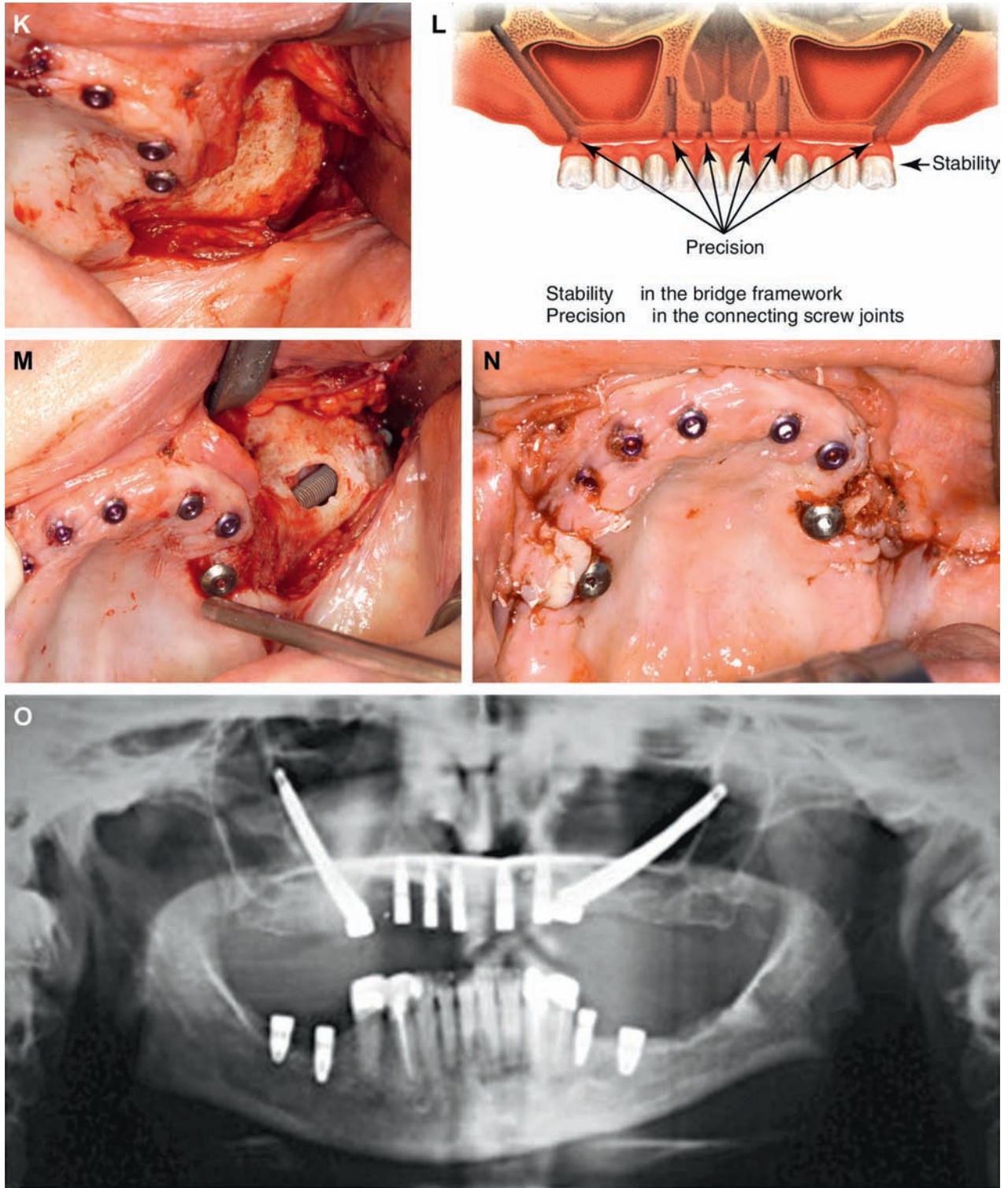


FIGURE VIII-19 (cont'd). *K*, Surgical exposure for placement of the zygomatic implant. *L*, Diagram of the intended surgery—a combination of zygomatic implants and endosseous implants. *M*, Placement of zygomatic implant. *N*, Immediately after surgery, after placement of all implants. *O* and **(Fig 19 continued on next page.)**

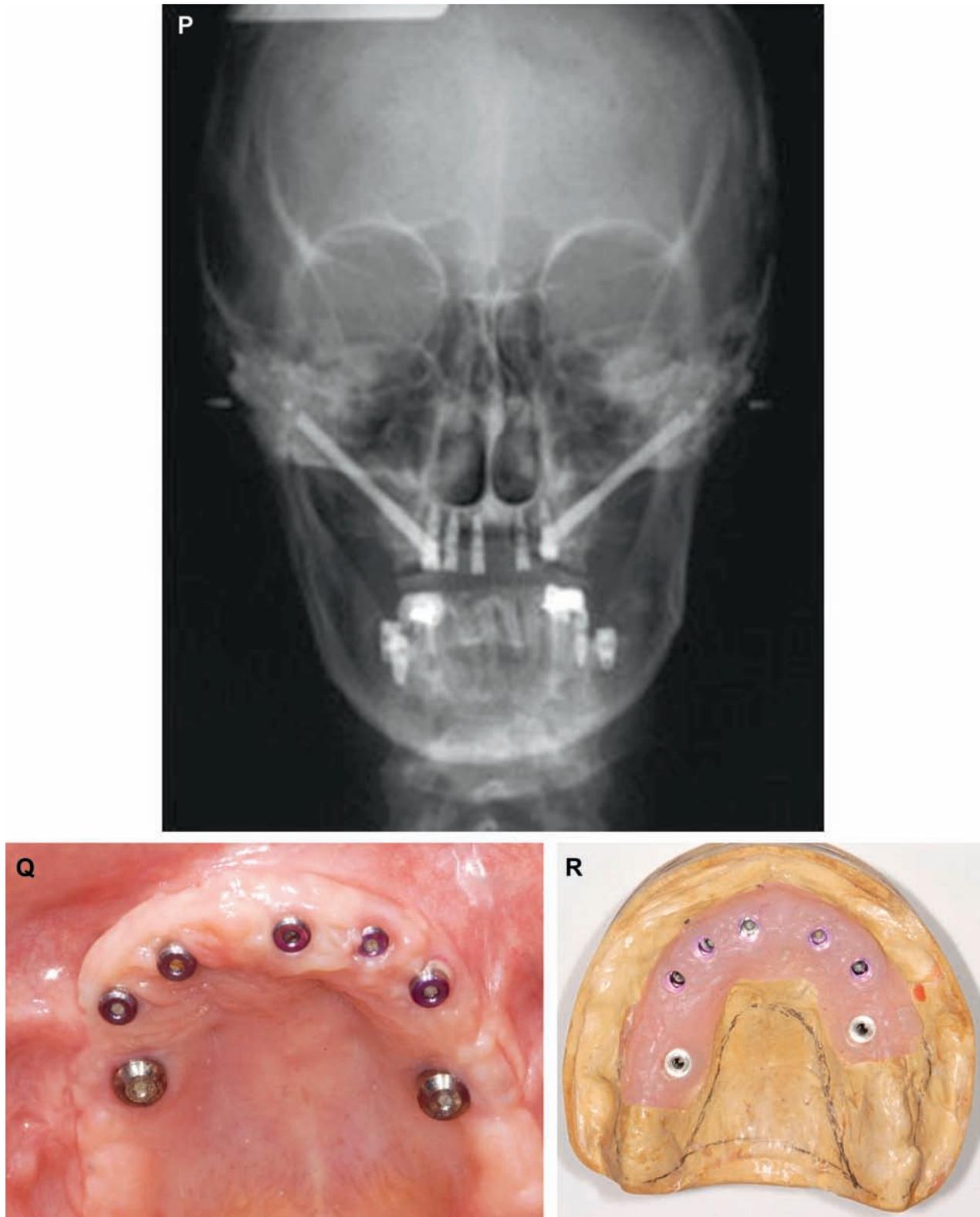


FIGURE VIII-19 (cont'd). *P*, Radiographs of implants placed. *Q*, Occlusal view of maxilla after 6 months of healing. *R*, Laboratory cast of maxilla. (**Fig 19 continued on next page.**)



FIGURE VIII-19 (cont'd). *S*, Computer design of planned zirconia framework for hybrid prosthesis. *T*, Preparation for an open-tray transfer impression. *U*, Impression transfers in place for impression of mandible. *V*, CAD-CAM (computer-aided design and computer-aided manufacturing) zirconia framework. *W* and *X*, Completed porcelain to zirconia hybrid prosthesis. *Y*, Completed prosthetics. *Z*, Patient's smile at completion of treatment. (L, Courtesy of Nobel Biocare USA, LLC, Yorba Linda, CA.)

Acknowledgments

Portions of this guide have been adapted from Larsen PE, McGlumphy EA: Chapter 14: Contemporary implant dentistry, *in* Hupp JR, Ellis E III, Tucker MR (eds): Contemporary Oral and Maxillofacial Surgery, ed 5. St. Louis, MO, Mosby, 2008. In addition, significant portions were adapted from Narcisi EM, Tucker MR: Implant treatment: Basic concepts and techniques. Chapter 14, *in* Hupp JR, Ellis III E, Tucker MR (eds): Contemporary Oral and Maxillofacial Surgery, ed 6. St. Louis, MO, Elsevier, 2014; and Tucker MR, Narcisi EM, Ochs MW: Implant treatment: Advanced concepts and complex cases. Chapter 15, *in* Hupp JR, Ellis III E, Tucker MR (eds): Contemporary Oral and Maxillofacial Surgery, ed 6. St. Louis, MO, Elsevier, 2014. Some of the case material used for the figures was provided by Dr Daniel B. Spagnoli, Southport, NC.

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Reference

1. Hupp JR, Ellis E III, Tucker MR: Contemporary Oral And Maxillofacial Surgery (ed 6). St. Louis, MO, Elsevier, 2014