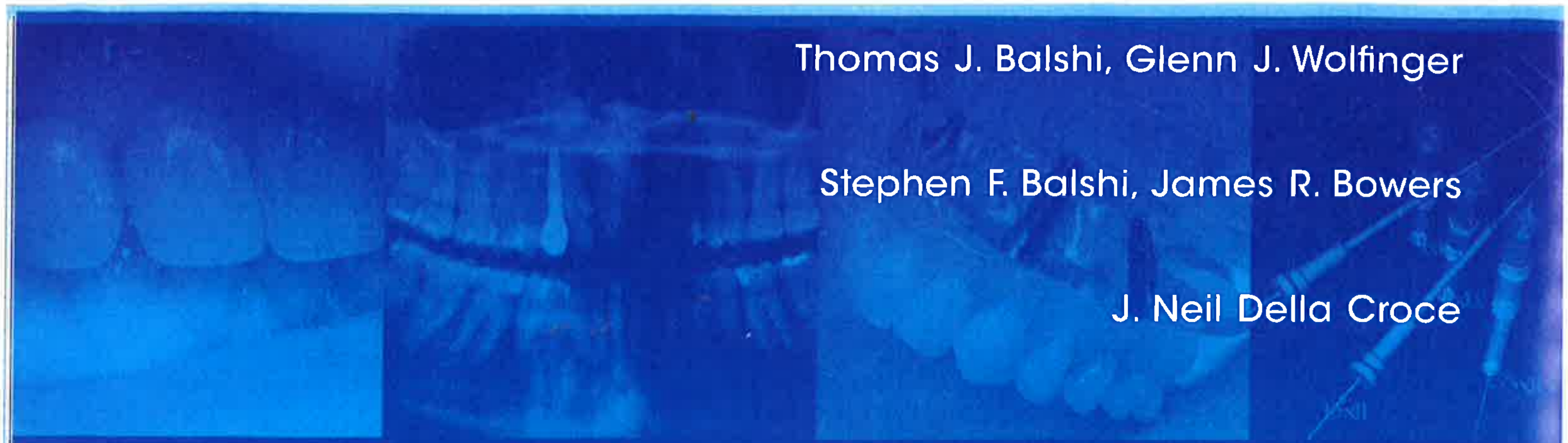
SECOND EDITION

Dental Implants

The Art and Science

CHARLES A. BABBUSH
JACK A. HAHN
JACK T. KRAUSER
JOEL L. ROSENLICHT

SAUNDERS
ELSEVIER



Thomas J. Balshi, Glenn J. Wolfinger

Stephen F. Balshi, James R. Bowers

J. Neil Della Croce

CHAPTER 19

TEETH IN A DAY AND TEETH IN AN HOUR: IMPLANT PROTOCOLS FOR IMMEDIATE FUNCTION AND AESTHETICS

A Brief Examination of Osseointegration

With the introduction of the concept of osseointegration to North American clinicians in the early 1980s, Professor Per-Ingvar Brånemark, a Swedish orthopedic surgeon, initiated a major paradigm shift in treatment protocols for partially or fully edentulous patients. Prior to Brånemark's landmark breakthrough, insufficient understanding of the critical elements needed at the bone-implant interface led to frequent implant fixture failure. Endosseous implants such as blades and tripodial pins often led to fibrous encapsulation, mobility, chronic inflammation, bone loss, and infection. With a clear understanding of what is needed at the bone-implant interface, Brånemark was able to articulate to the profession those factors that lead to both success and failure of endosseous implants, and in doing so, gave birth to modern implant dentistry.

Osseointegration may be defined broadly as the dynamic interaction of vital bone with the surface of a biocompatible implant in the absence of an interposing fibrous connective tissue layer.[1-2] Without successful osseointegration at the bone-implant interface, endosseous implants invariably fail.

In 1985 Brånemark described the potential causes of failure of bone-to-implant integration: "In unsuccessful cases non-mineralized connective tissue, constituting a kind of pseudoarthrosis, forms in the border zone at the implant. This development can be initiated by excessive preparation trauma, infection, loading too early in the healing period before adequate mineralization and organization of hard tissue has taken place, or supraluminal loading at any time, even many years after integration has been established. Once lost, osseointegration cannot be reconsistituted."[1]

Critical to Brånemark's original protocol was an initial period during which implant fixtures remained submerged and out of function in order to eliminate implant micromovement, a process likely to lead to fibrous tissue encapsulation rather than true bone-to-implant contact.[1] To a large degree, Brånemark's original delayed protocol is still followed by many clinicians. In addition, Brånemark's second-stage protocol (implant exposure and abutment connection) also called for a delay in prosthetic loading until soft tissue healing was complete around the newly installed transmucosal abutments.

Increasingly, however, clinicians and researchers have questioned whether the conventional two-stage implant protocol with delayed loading, and its consequent lengthy treatment time from implant placement to final prosthesis, is an absolute requirement for successful osseointegration. Brånemark's concerns regarding excessive preparation trauma and infection in diminishing implant survival cannot be challenged. Nevertheless, in today's increasingly fast-paced, aesthetically conscious society, patient demand to shorten treatment time from implant placement to final restoration has increased steadily over the past decade. The question for researchers and clinicians alike is whether accelerated loading is possible without violating the need for primary implant stability. Can dental implants accept immediate occlusal loads, thereby significantly decreasing treatment times, and still create an environment conducive to successful osseointegration and long-term survival?

Immediate Loading: What the Evidence Says

The viability of immediately loading endosseous implants has been an area of considerable interest to dental researchers for many years. In 1990, Schnitman et al. placed multiple Brånemark implants between the mandibular mental foramina and two additional implants distal to the foramina.[3] The two distally positioned implants and one anterior implant were placed into immediate function through attachment to a fixed-detachable prosthesis. According to the investigators, this treatment protocol was successfully applied to seven patients without any adverse effects on long-term implant therapy. In 1997 these same investigators published 10-year results for Brånemark implants immediately loaded in the mandible with fixed prostheses at implant placement.[4] In this latter study, a total of 63 Brånemark 3.75-mm implants of various lengths were placed, 28 of which were immediately loaded, providing support for fixed provisional restorations. Thirty-five adjacent implants were submerged for a 3-month period. Of the 28 immediately loaded implants, 4 eventually failed and 100% of the standard two-stage protocol fixtures osseointegrated. The 10-year survival rate for the immediately loaded implants was 84.7% and 100% for the submerged implants.

In 1997 Balshi and Wolfinger published a preliminary report examining immediate loading of Brånemark implants placed in 10 patients with edentulous mandibles.[5] One hundred thirty implants were placed, with a minimum of 10 implants in each mandible. In each patient, abutments were connected to 4 implants immediately after insertion, 2 between the mental foramina and 2 distally. The remaining implants remained submerged for 3 months. The 4 implants with abutment connections were immediately loaded with all-acrylic resin-fixed prostheses ("conversion" prostheses).[6] Seven to 10 days later the conversion prostheses were temporarily removed for suture removal and final plaster impressions. At 6 weeks, metal frameworks replaced the all-acrylic conversion prostheses because it was thought that the metal-reinforced prostheses would provide superior distribution load to the implant fixtures. At second-stage surgery, all 10 patients experienced a prosthesis survival rate of 100%. Thirty-two of the 40 immediately loaded implants were stable at second-stage surgery, yielding an 80% survival rate, versus a 98% survival rate for the unloaded implants at second-stage surgery.

In 2003 Balshi et al. published five-year results of their previously reported 1997 study, adding an additional 24 patients with edentulous mandibles treated with a simplified protocol for immediate loading.[7] In the simplified protocol group, 144 implants were placed between 1997 and 2000. A mean of 6 implants were placed in each mandible in both healed and fresh extraction sites. Two significant changes in this modified protocol group were instituted: (1) An increasing number of implants were loaded immediately, using fewer overall implants per arch. All implants were loaded immediately for the last patients in this test group. (2) The all-acrylic resin conversion prostheses were not disturbed during the initial 3 months of treatment following implant placement.

The results of Balshi's 2003 study proved instructive. All 10 of the original patients who reached second-stage surgery had a 100% prosthesis survival rate 5 years later. Two additional implants originally unloaded failed after second-stage surgery but no further immediately loaded implants within this original group failed at the 5-year follow-up. In the added simplified protocol group, no prosthesis failed. Of the immediately loaded implants in this group, 97% survived at the end of the first year. Unlike the initial group, there was no statistically significant difference between the immediately loaded and submerged implants in the simplified protocol (P =.423). In examining the data from this study, the authors suggest the following: (1) Undisturbed splinting of immediately loaded implants with an all-acrylic conversion prosthesis is critical during the initial 3-month healing period following implant placement to prevent unwanted implant micromotion at the bone-to-implant interface. (2) In vitro comparison of force distribution to the implants between the acrylic-resin versus metal-reinforced prostheses showed no differences, suggesting no reason to convert to a metal-reinforced material during critical early healing.[7] (3) In immediately loaded implant full-arch reconstruction, implants placed in the characteristically dense bone between the mental foramina, with the potential for bicortical anchorage, exhibit an increased potential for long-term survival when compared to posterior positioned implants.

A number of studies have also examined the effect implant surface structure may have on implant survival rates of immediately loaded implants. In 2004 Rocci et al. compared immediately loaded TiUnite oxidized titanium implants (Nobel Biocare, Kloten, Switzerland) to machine-surfaced Brånemark System implants for posterior mandibular partial fixed bridges.[8] After 1 year of prosthetic load, the cumulative success rate for the TiUnite fixtures was 95.5% versus 85.5% for the machine-surfaced implants, despite the fact that there were more smokers and more implants placed in type 4 bone in the TiUnite group. A second study by Glauser et al. examined long-term results of immediate loading of Brånemark System TiUnite implants placed mainly in soft bone.[9] In this study, 102 Brånemark System Mk IV TiUnite implants (38 maxillary and 64 mandibular) were inserted primarily in posterior regions of the jaws and loaded at the time of implant insertion. At the end of 4 years of loading, 3 stable maxillary implants were removed at 8 weeks secondary to postoperative infection in the adjacent area that had a guided bone regenerative procedure. No other implants were lost, with a net cumulative implant success rate of 97.1% at 4 years. A third prospective study by Banden et al. examined 18-month results of 111 Brånemark System TiUnite implants placed into maxillary or mandibular posterior quadrants, areas known for low bone density.[10] In this study, implants were splinted and placed into function within 9 but no longer than 16 days following implant insertion. Of the 111 implants, only 1 failed, yielding an overall survival rate of 99.1%. No prosthesis in this study failed. In each of these 3 studies, the combination of rigid splinting plus oxidized titanium fixture surfaces generated results equivalent to those seen in Brånemark's traditional two-stage submerged protocol.

In 2005 Balshi et al. reported resonance frequency analysis (RFA) results of 164 maxillary and 112 mandibular implants immediately loaded and splinted according to a strictly defined treatment protocol termed "Teeth In A Day."[11] Resonance frequency analysis is a noninvasive technique in which mechanical vibration is used to record bone-implant stiffness parameters and hence is a measure of implant stability.[12] RFA readings were obtained at implant insertion and on days 30, 60, and 90, time points considered crucial for successful initiation of osseointegration. In this study, RFA values consistently decreased in value through day 30, indicating intense bone remodeling. This initial decrease was followed by consistent increases in RFA values through day 60, suggestive of significant osteoblastic bone regenerative activity occurring at the implant-bone interface. At the end of 90 days, increased RFA values indicative of positive implant stability correlated strongly with 99.1% and 97.5% mean implant survival values in the mandible and maxilla, respectively. According to the authors, the Teeth In A Day protocol, calling for immediate cross-arch splinting of all inserted implants, allows for application of functional, evenly distributed loads, resulting in increased RFA values during critical early time periods.

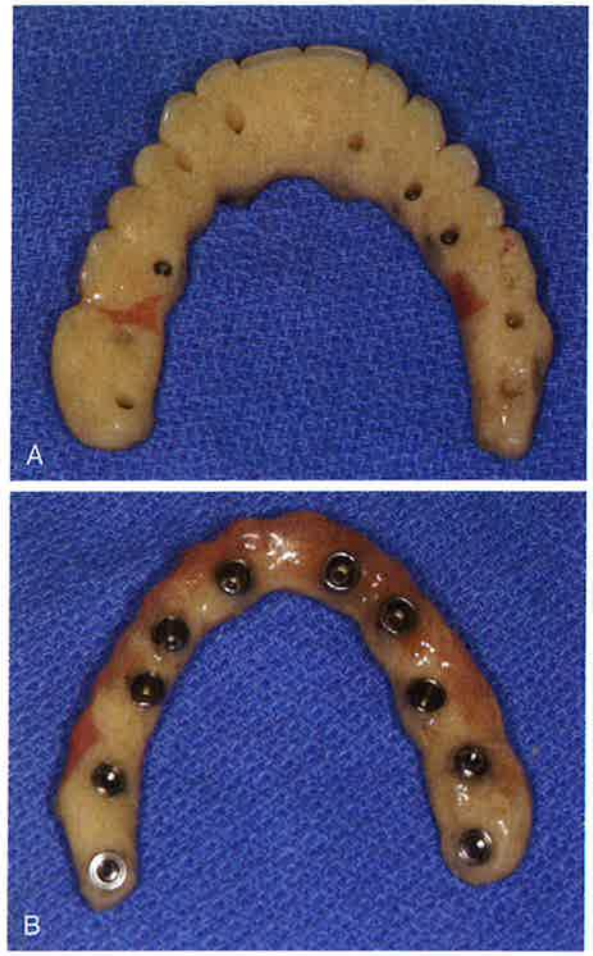


Figure 19-1. An all-acrylic conversion prosthesis containing stainless steel screw housings: underside **(A)** and palatal **(B)** views.

Teeth In A Day

In 2005 Balshi et al. published a landmark prospective study of 55 consecutive cases examining maxillary immediate full-arch functional loading following their highly specific Teeth In A Day protocol.[13] The study, which spanned a period between December 1999 and February 2004, examined 552 immediately loaded implants, with an average of 10 implants per maxilla. In each patient, the Teeth In A Day protocol dictated specific sequenced treatment procedures that were closely adhered to throughout this study. Of particular importance was the attachment of all implants immediately into a full-arch, second molar to second molar screw-retained all-acrylic fixed prosthesis, rigidly splinting all inserted implants to control occlusal loads during the initial 12-week healing period (Figure 19-1).

In this study the immediately loaded implants had a survival rate of 99.0% with a 100% prosthesis survival. According to the authors, such survival rates rival traditional two-staged implant protocols, suggesting that adherence to the strict Tooth In A Day protocol leads to a lasting state of osseointegration necessary for long-term stability of screw-retained prostheses. Supported by firm evidence-based data, the Teeth In A Day protocol in its entirety merits close examination.

Guiding Principles

Teeth In A Day is a combined surgical and prosthetic protocol designed to maximize long-term function and aesthetics of immediately loaded maxillary and mandibular implants and used most often in full-arch prosthetic reconstruction. From planning to execution, the surgical and prosthetic protocols are completely interdependent. Precise placement of individual implants is dictated from the beginning by advance knowledge of the intended prosthetic result. Likewise, the prosthetic protocol, from planning to interim restoration to the final prosthesis, serves to protect long-term implant survival as well as to maximize occlusal function and aesthetics. Continuous reevaluation, especially during the critical initial 12-week period, is formally mandated by the protocol. During this time, any necessary adjustments to the interim screw-retained acrylic-fixed prosthesis, either for functional or aesthetic

Figure 19-2. A, Preoperative panoramic radiograph demonstrates severe periodontal bone loss. **B,** Preoperative intraoral photograph shows severe collapse of the entire dentition and dramatic loss of vertical dimension. **C,** Preoperative full-face photograph.

reasons, are performed intraorally with the prosthesis remaining firmly in place. As in any successful implant-based reconstructive protocol, Teeth In A Day's positive long-term results are a function of initial detailed evaluation and planning, careful and precise surgical and prosthetic treatment, and meticulous patient follow-up.

Initial Evaluation

A comprehensive initial examination and evaluation is the critical first step in the Teeth In A Day protocol. Prior to clinical examination, panoramic and full-mouth periapical radiographs are obtained for each patient (Figure 19-2, *A*).

Following assessment of the patient's chief complaint and detailed review of the patient's medical and dental histories, a thorough oral clinical examination is undertaken. In addition to assessing for any present pathology, a meticulous occlusal analysis is performed, including assessment of current vertical dimension, temporomandibular joint function, tooth arrangement, including midline shifts, spacing between teeth, and planes of occlusion. Appropriate jaw records are obtained and recorded. A detailed aesthetic examination is then undertaken, including assessments of facial symmetry from frontal and profile views, smile analysis, including lip anatomy as well as smile line level, tooth coloration and gingival tone and shade, and facial skin color and tone. Intraoral and full-face digital photographs are then taken from every angle for immediate review with the patient and for later study (Figure 19-2, *B* and *C*).

Initial impressions are taken for study casts and, if deemed appropriate, a cone beam computed tomography (CBCT) scan is obtained for detailed anatomical study of the maxilla and mandible, emphasizing vital structures such as location of the inferior alveolar nerve, maxillary sinuses, and degree of available bone for implant placement.

Once comprehensive data are obtained and studied, detailed findings are thoroughly discussed with the patient, including viable alternatives to care. Details of the Teeth In A Day protocol, including potential risks and benefits, are reviewed with the patient. Once the decision is made to move forward with the Teeth in A Day treatment, working casts are prepared to begin fabrication of the acrylic provisional conversion prosthesis that will rigidly splint all implants immediately following fixture insertion.

Initial Preparation of Screw-Retained All-Acrylic Conversion Prosthesis

As noted in Balshi's 2005 prospective study of 55 consecutive cases following the Teeth In A Day protocol, attachment of all implants immediately into a full-arch, second molar to second molar acrylic screw-retained prosthesis is critical to the short- and long-term success of the procedure.[13] Therefore, prior to implant surgery, custom-made immediate dentures

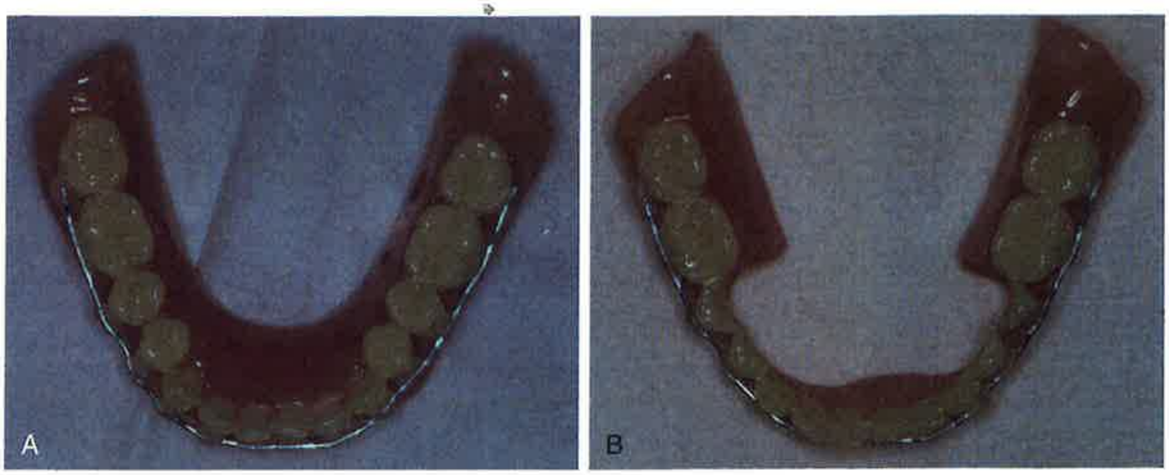


Figure 19-3. **A,** Mandibular immediate denture with labial wire reinforcement. **B,** The anterior lingual portion of the immediate denture is relieved in preparation for "pickup" impression of implant-supported prosthetic components and conversion to screw-retained fixed prosthesis.

made from prior impressions and jaw records are fabricated. In Figure 19-3, the mandibular denture is wire-reinforced on the buccal aspect and modified lingually to allow later connection following implant placement of prosthetic cylinders during the final stages of construction of the interim screw-retained prosthesis.

Surgical Protocol

Teeth In A Day is an open flap procedure, performed under direct vision. Patients sometimes require multiple tooth extractions followed by thorough debridement of chronically inflamed tissue, carefully performed alveoloplasties, and immediate placement of implants. Aesthetic considerations often mandate alveolar height reduction during alveoloplasty, especially in the anterior maxilla. For example, a patient with a high smile line would require increased reduction in alveolar bone height to allow a pleasing smile without showing excessive gingiva in the final prosthetic restoration.

Strategic and well-planned placement of implants is critical to the long-term success of the final implant-supported prosthesis. Bilateral, well-spaced implants that balance the occlusal load are necessary in this immediately loaded protocol. In the mandible, advantage should be taken of the dense bone located between the right and left mental foramina. It is important to avoid long, unsupported cantilevers, and careful placement of posterior implants in both the mandible and maxilla is recommended in the Teeth In A Day protocol (Figure 19-4). In the maxilla, placement of pterygomaxillary implants is frequently necessary to avoid negative cantilevering effects (Figure 19-5).[14-19]

In recent years platelet-rich plasma (PRP) has been added to the Teeth In A Day protocol to help accelerate osseointegration at the bone-implant interface. Multiple growth factors, including platelet-derived growth factor (PDGF), transforming growth factor beta-1 and beta-2 (TGF-β_1 and TGF-β_2), and insulin-like growth factor I (IGF-I) are found in the alpha granules of platelets. PRP, with its abundance of autologous growth factor proteins, amplifies and accelerates wound healing, including bone regeneration.[20] In the Teeth In A Day protocol, PRP as a fibrin gel is applied directly onto the implant surface prior to implant placement into the prepared osteotomy site.

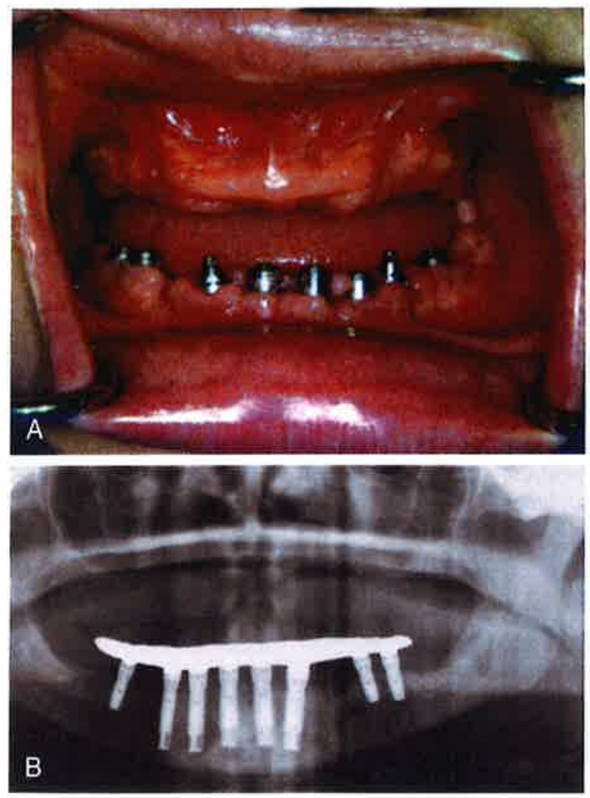


Figure 19-4. **A,** Bilateral placement of implants, avoiding lengthy cantilevers. **B,** Panoramic radiograph demonstrating anterior and bilateral posterior implant positioning.

Completing the Conversion Prosthesis

Following implant placement, abutments are positioned and tightened using a calibrated electronic torque-control device. The mucoperiosteal flaps are approximated lightly against the abutments. Long prosthetic guide pins are then placed to connect modified steel impression copings to the abutments (Figure 19-6, *A*). Next, a rubber dam is carefully positioned over each impression coping, after which acrylic resin is syringed around each of the prosthetic cylinders (Figure 19-6, *B*).

Figure 19-5. Pterygomaxillary implant placement is frequently necessary in the maxilla to avoid lengthy cantilevers.

The internal surface of the previously modified denture is then lined with additional resin material, followed by careful placement of the prosthesis into the desired intraoral position (Figure 19-6, *C*). The patient refrains from movement for approximately 4 minutes while the teeth are held in the planned occlusal relationship. During this interval, the rubber dam protects the underlying soft tissue and bone from the heat released as the acrylic polymerizes. Additionally, the rubber dam prevents any undercuts between abutments from being engaged by the hardened acrylic. The prosthesis, with the attached prosthetic cylinders, is then structurally enhanced, refined, and polished (Figure 19-6, *D*).

Following radiographic confirmation of proper implant positions, the finished interim prosthesis is connected to the abutments using small titanium prosthetic screws. Occlusal relations are then evaluated and adjusted as needed.

Interim Prosthesis: Its Critical Role in Teeth In A Day

The interim provisional prosthesis in many respects is the most critical element in ensuring long-term success in the Teeth In

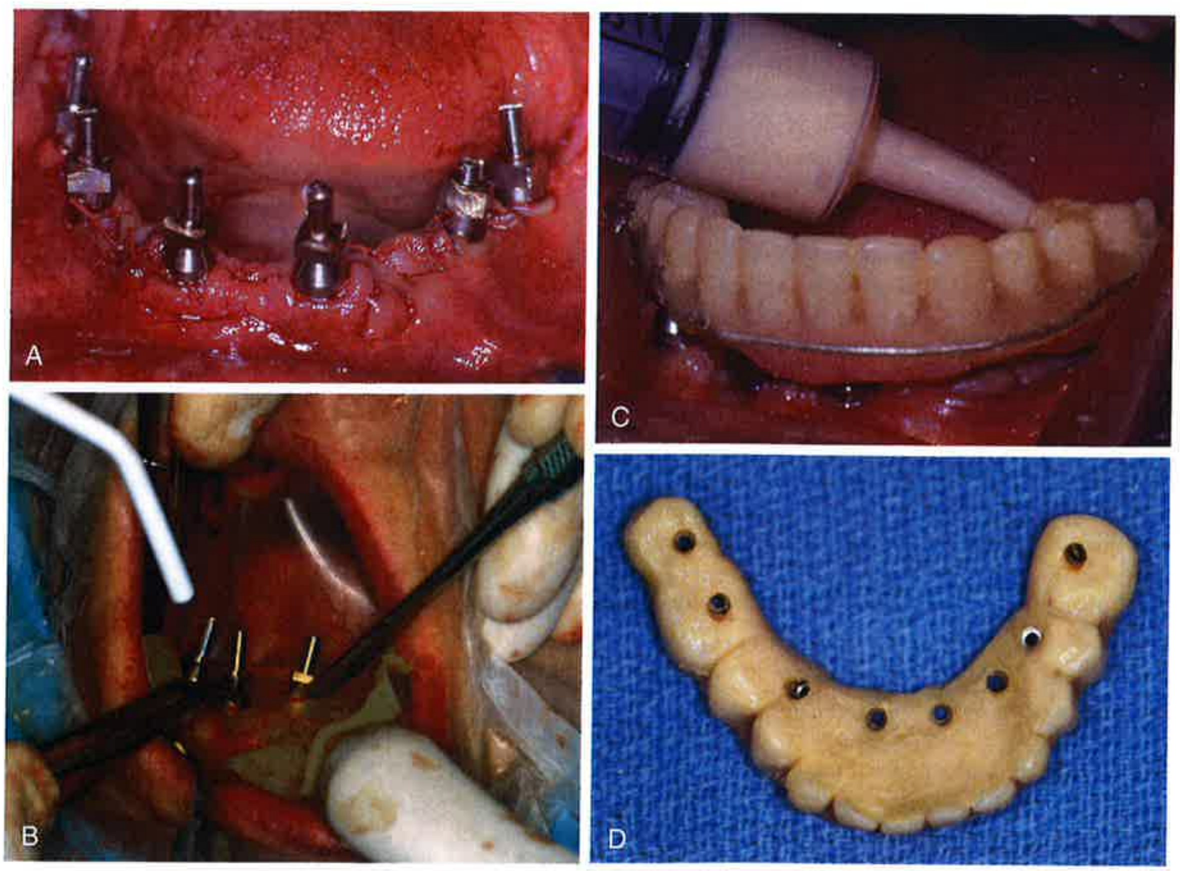


Figure 19-6. A, Prosthetic guide pins are placed to connect modified steel impression copings to the abutments. **B,** A rubber dam is carefully positioned over each impression coping. **C,** The internal surface of the modified denture is lined with acrylic resin and placed into the desired intraoral position. **D,** An example of a refined and polished fixed interim prosthesis.

A Day protocol, and as such merits further examination. In its pivotal role within the protocol, the interim prosthesis serves many functions.

As noted earlier, in 2003 Balshi et al. published 5-year results of their Teeth In A Day Protocol.[7] Central to their findings was the importance of undisturbed splinting of immediately loaded implants with an all-acrylic conversion prosthesis during the initial 3-month healing period following implant placement to prevent unwanted implant micromotion at the bone-to-implant interface. Rigidly splinting the implants, while at the same time distributing occlusal loads bilaterally, allows undisturbed bone-to-implant regeneration to occur during the initial stages of osseointegration.

In addition to its critical role during early healing, the interim provisional prosthesis serves as a crucial and evolving guide toward the final permanent implant-supported prosthesis. Through close patient follow-up, the interim prosthesis is evaluated and modified as needed until it becomes the prototype for the final permanent restoration. With some patients, a second provisional prosthesis may be constructed.

The importance of perfecting the provisional prosthesis by addressing all functional and aesthetic issues cannot be overstated. Factors such as proper vertical dimension, accurate horizontal occlusal plane parallel to the interpupillary line, correct tooth midline, adequate lip support, appropriate size, shape, and color of all anterior teeth, and proper tooth and gingival display upon smiling must all be corrected, verified, and built into the provisional prosthesis. Only then will the provisional prosthesis serve as an accurate prototype and guide for the permanent restoration.

Although the provisional prosthesis immediately rigidly splints the implants during the initial 3-month healing period, adherence to a soft diet is critically important to avoid unwanted occlusal force overload from interfering with successful osseointegration. Therefore, strict compliance with a soft diet during this period must be understood by and agreed to by the patient. To further protect against negative occlusal overload from parafunctionally generated forces, an acrylic night guard is fabricated and worn by the patient throughout the provisional prosthesis stage of treatment.

At the end of the initial 3-month healing period, with the interim prosthesis perfected and with a satisfied and symptom-free patient, final impressions and necessary laboratory work can proceed toward completion of a permanent, highly functional and aesthetic implant-supported restoration (Figures 19-7 and 19-8).

Figure 19-7. **A,** Preoperative view at initial evaluation. **B,** Postoperative view following Teeth In A Day treatment with placement of a mandibular provisional implant-supported restoration and maxillary complete denture.

Figure 19-8. **A,** At initial evaluation patient presented with severe tooth erosion secondary to longstanding bulimia. **B,** Final implant-supported permanent restorations following treatment with Teeth In A Day protocol.

Teeth In An Hour

In patients who require tooth removal secondary to trauma, gross decay, severe periodontal bone loss, or endodontic failure the Teeth In A Day protocol offers significant advantages over more traditional, two-stage implant procedures. The ability to immediately place implants and load them with a highly functional and aesthetic prosthetic restoration while at the same time ensuring exceedingly high success rates is valuable to both patient and clinician. Teeth In A Day has indeed produced a paradigm shift in how implant therapy is planned and executed. Is it possible, however, given the advancements in computer-aided design (CAD) and computer-assisted manufacture (CAM) to build on the significant achievements seen in Teeth In A Day to create more minimally invasive, time-saving procedures that still yield highly functional and aesthetic implant supported restorations? The answer came in 2004 with FDA clearance for the unique Teeth In An Hour protocol.

Unlike conventional treatment plans that are model based, Teeth In An Hour is a computer-based protocol that allows precise three-dimensional (3-D) virtual placement of specifically chosen implants to be translated into surgically guided implant placement without the need for soft tissue flap elevation. Using CAD/CAM software prior to surgery allows for the production of a computer-generated surgical template from which either an interim prosthesis or a permanent robotically milled titanium frame is constructed (Nobel Biocare Procera Technology, Yorba Linda, CA), thereby immediately loading all implants following implant placement.[21] This accurate, minimally invasive, time-saving protocol is beneficial to the patient and clinician and, as such, merits further examination.

A Close Examination of the Protocol

Teeth In An Hour begins with the same thorough initial clinical evaluation and radiographic work-up as in Teeth In A Day, including complete intraoral and extraoral photographic documentation (Figure 19-9).

Unlike Teeth In A Day, Teeth In An Hour is indicated for edentulous areas only, and most often for completely edentulous jaws, especially the maxilla. In the example illustrated in Figure 19-9, the Teeth In A Day protocol was first completed in the mandible. During the 3 months following the mandibular Teeth In A Day procedure, a newly constructed maxillary complete denture was worn by the patient. A maxillary implant-supported fixed prosthesis was then constructed and placed according to the Teeth In An Hour protocol.

The Teeth In An Hour protocol requires an initial highly functional and aesthetic denture with correct centric and vertical positions and tooth arrangement that can act as an exact model for the final computer-generated fixed prosthesis. The final prosthesis in this protocol is a virtual clone of the original denture but in a fixed prosthesis configuration.[13] Therefore, unless the patient presents with a denture that is completely adequate as a model for the final fixed prosthesis, procedures necessary for constructing a new denture must be undertaken. This newly constructed denture must be perfected in every way, both functionally and aesthetically, and must be completely satisfying to the patient because it represents what the final implant-supported restoration will look like.

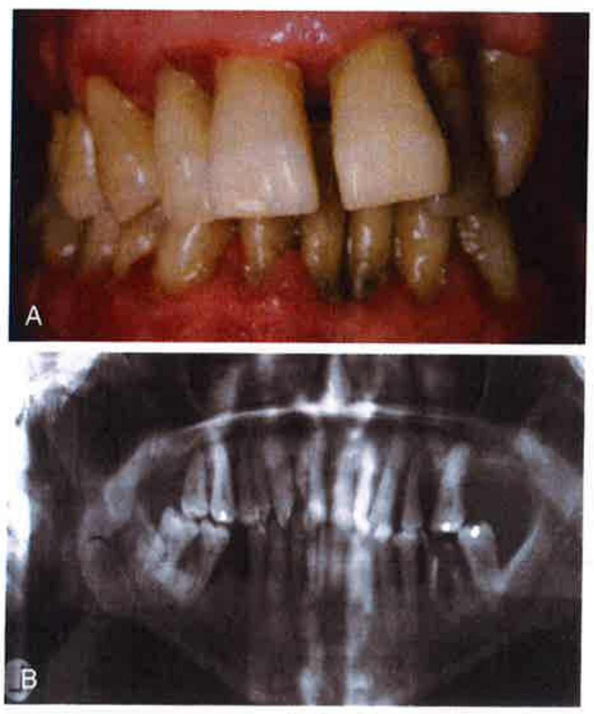


Figure 19-9. A, Clinical photograph demonstrating severe bone loss secondary to advanced periodontal disease. **B,** Preoperative panoramic radiographic demonstrating advanced bone loss in both maxillary and mandibular jaws.

The first step in Teeth In An Hour is construction of a radiographic guide for the CT scanning procedure. This can be accomplished by creating a duplicate transparent denture and impregnating it with multiple radiopaque markers for CT scanning (Figure 19-10, *A*). Approximately 6 to 12 sites at different levels from the occlusal plane, each approximately 1.5 mm in diameter, are filled with radiopaque gutta percha. It is also possible to position these radiopaque markers in the patient's actual denture.

Two CT scans, one with the patient wearing the radiographic guide and one with the radiographic guide alone, are obtained (Figure 19-10, *B* and *C*). During the first CT scan the patient occludes into a centric occlusion index to stabilize the radiographic guide during scanning. In the second scan, the radiographic guide is positioned in the same relative plane as during the first patient scan. The subsequent images are then digitally merged using Procera software, producing sophisticated 3-D images capable of detailed virtual placement of implants and abutments in proper relation to existing bone, overlying soft tissue, and the projected final fixed restoration.

Once the virtual implants and abutments have been placed, a highly detailed and accurate surgical template is computer generated. It will allow precise flapless implant placement into the sites previously selected on the computer (Figure 19-10, *D* and *E*).[22] The physical surgical template is made of rapid prototyping stereolithic laser cured resin with stainless steel sleeves for guiding drills. Note that horizontal anchor sleeves are included that will serve to guide horizontally positioned pins to firmly secure the surgical template into position prior to implant placement.

In addition to the surgical guide, the Teeth In An Hour protocol generates a detailed operating map used during surgery to precisely identify each implant fixture and abutment at each predetermined site (Figure 19-10, *F*).

On the day of surgery, 20 mL of the patient's blood is obtained to coat each implant surface with platelet-rich plasma in an attempt to accelerate healing at the bone-to-implant interface. With the surgical template anchored firmly in place, small cores of overlying soft tissue are removed at each intended implant site using a spade-like counterbore drill placed through the guide sleeves. Appropriate twist drills are then inserted into the guide sleeves and implant osteotomies are created. Using the computer-generated operating map, specific Nobel Biocare implants are inserted into position using appropriate guide sleeves. As noted in Figure 19-11, the Teeth In An Hour

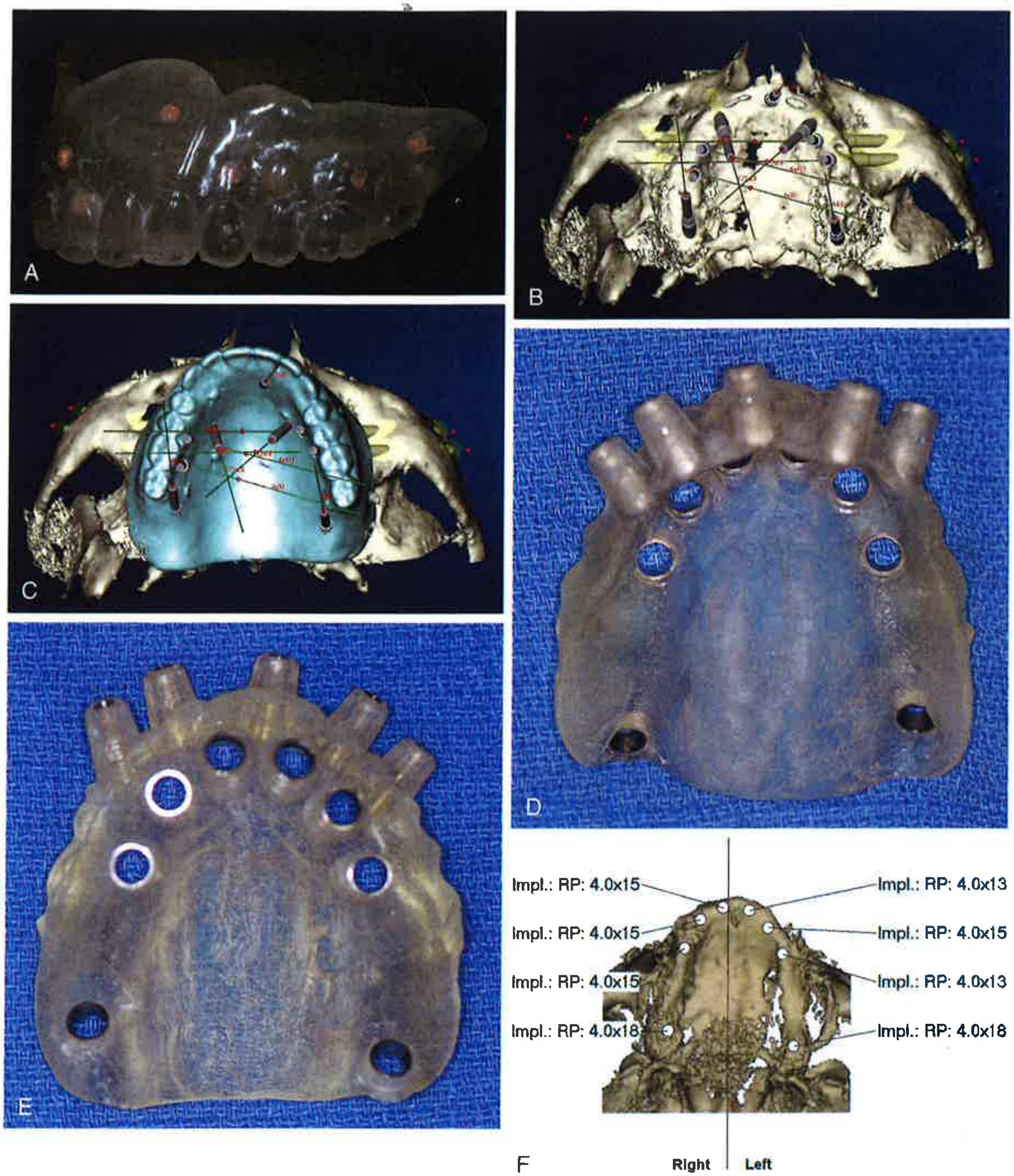


Figure 19-10. **A,** Radiographic guide with multiple gutta percha markers for CT scanning. **B,** NobelGuide Procera software 3-D reconstruction of maxilla with virtual implant placement. **C,** NobelGuide Procera software 3-D reconstruction of maxilla with virtual maxillary prosthesis overlay and associated implants. **D,** Computer-generated surgical template used during Teeth In An Hour surgery (intaglio view). **E,** Computer-generated surgical template used during Teeth In An Hour surgery (occlusal view). **F,** Computer-generated surgical map precisely identifying each implant and its intended location.

protocol also allows safe and predictable placement of pterygomaxillary implants when distal support and avoidance of lengthy cantilevers are needed.

Once all implants have been securely placed, the surgical template is removed, exposing the soft tissue openings at each implant location. The screw-retained abutments, which were predetermined in the computer plan, are positioned into the appropriate cylinders of the computer-generated interim or final definitive fixed prosthesis (Figure 19-12). The screw-retained fixed restoration with its attached abutments is then accurately seated on each implant and the screws are tightened. Any necessary occlusal adjustments are then made and all screw-access holes appropriately sealed (Figures 19-13 and 19-14).

No Bone Solution: Treating the Atrophied Posterior Maxilla Without Grafting

This chapter concludes with a brief examination of one of the most difficult therapeutic challenges in implant dentistry, the atrophied posterior maxilla. Over time, increasing enlargement of the maxillary sinus and subsinus alveolar bone loss often lead to insufficient bony volume necessary for placement of endosseous implants in the posterior edentulous maxilla (Figure 19-15).

Current therapy is often directed toward regenerating lost bone (i.e., sinus lift procedures with autogenous block or particulate grafts, allografts, alloplasts, xenografts, or combinations thereof). Frequently, multiple regenerative procedures are required. Such procedures, however, present with a number of limitations. Interim prostheses often cannot be worn over grafted sites while bone healing is occurring. In addition, depending on the size of the residual alveolar ridge, implant placement frequently must be delayed until bone regeneration has occurred. Given the inherent difficulties in regenerative treatments of the posterior maxilla, there are alternative approaches to care that can produce predictably reliable results while at the same time dramatically shortening treatment times.

In response to the same question, Brånemark in 1984 treated a grossly resorbed maxilla with his then newly designed zygoma implant without the need for additional bone grafting. The zygomatic buttress, with its relatively large bone volume, increased bone density, and potential for bicortical stabilization makes an ideal location for bilateral posterior implant placement in severely resorbed maxillas. In 2004, Brånemark et al. reported 1 year follow-up results for 76 patients treated with 145 zygoma implants.[23] The overall survival rate for the zygoma implants was 97.9%, with only a small number of minor complications. Again in 2004, Brånemark et al. reported 5- to 10-year follow-up results of 28 consecutively treated patients with severely resorbed edentulous maxillas. Of the 52 zygoma implants, all but 3 survived and were reported to be in good function, for a net survival rate of 94%.[24]

In 2006 Aparicio et al. published 6-month to 5-year results of 131 zygomatic implants placed in conjunction with regular anterior fixtures.[25] Within the reported follow-up period, 2 of 304 regular implants and none of the zygomatic implants failed. In this study patients benefited from full cross-arch implant-supported prostheses.

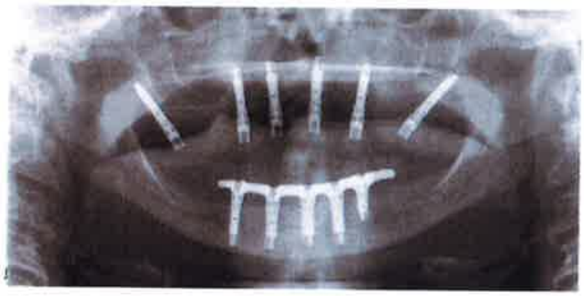


Figure 19-11. Postoperative panoramic radiograph of maxillary provisional prosthesis and mandibular definitive prosthesis placed following Teeth In An Hour protocol.

Figure 19-12. Teeth In An Hour computer-generated screw-retained prosthesis.

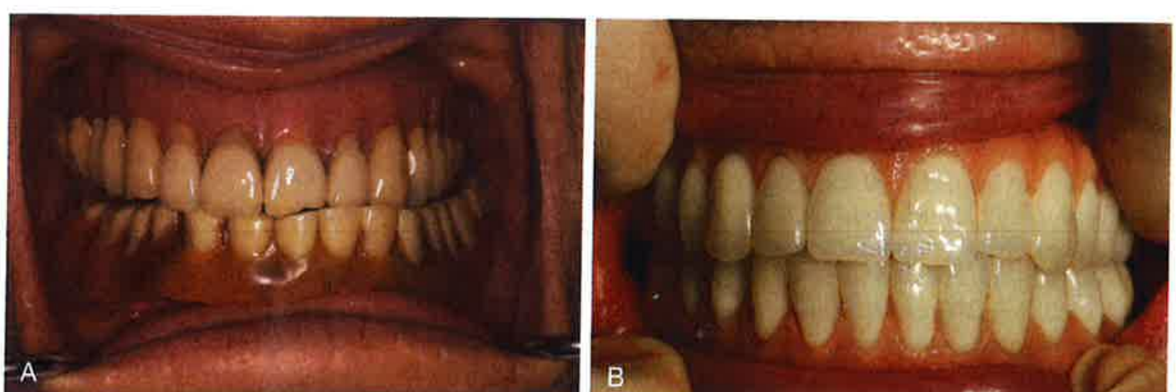


Figure 19-13. **A,** Clinical photograph demonstrating ill-fitting, worn, removable dentures. **B,** Clinical photograph showing screw-retained implant-supported restorations following treatment with Teeth In An Hour protocol.

Figure 19-14. A, Clinical photograph demonstrating severe bone loss and bite collapse secondary to advanced periodontal disease. **B,** Teeth In An Hour computer-generated screw-retained maxillary and mandibular prostheses.

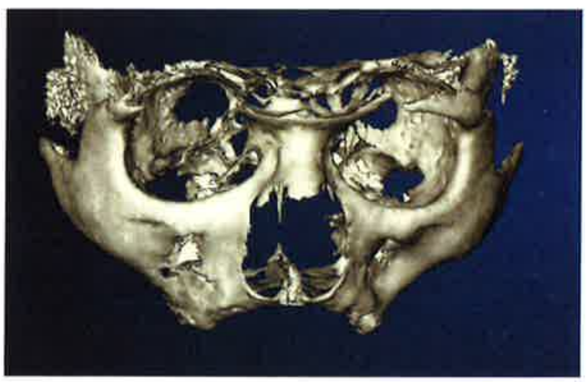


Figure 19-15. CT-generated 3-D image demonstrating severe maxillary alveolar bone loss.

Penarrocha et al. in 2007 reported the results of zygomatic implants placed between January 2000 and January 2005.[26] In this study, a total of 89 conventional and 40 zygomatic implants were placed. With a mean follow-up period of 29 months, 2 of the conventional and none of the zygomatic implants failed. According to the authors, zygomatic implants, when used in conjunction with premaxillary implants, can serve as viable alternatives to posterior maxillary bone grafting.

In 2006 Chow et al. reported the results of immediate occlusal loading of zygomatic implants with full-arch implant-supported interim prostheses.[27] In the timeframe of this study, all of the zygomatic implants were stable with no signs of failure. According to the authors, "immediate occlusal loading of the zygomatic implants has a very good potential for success, as much as immediate occlusal loading of normal dental implants."

In 2006 Bedrossian et al. reported the results of 14 consecutively treated patients with immediately loaded zygomatic implants.[28] Inclusion criteria mandated between 1 and 3 mm of posterior maxillary subsinus bone height, indicative of severe residual bone atrophy. Traditional premaxillary implants were placed bilaterally in canine and central incisor regions. Zygomatic implants, ranging from 35-52.5 mm were placed into right and left second and first premolar regions, respectively. In each patient, all 6 implants were rigidly splinted and placed into immediate function with an all-acrylic implant-supported provisional restoration. At a minimum of 1 year follow-up, none of the traditional or zygomatic implants exhibited any signs of failure either clinically or radiographically. According to the authors, "A possible explanation for the favorable outcome is the high initial stability of the zygomatic implants and the splinted cross-arch support of the 4 well-anchored standard premaxillary implants."[28]

In a soon to be published study, Balshi et al. examined the results of 110 consecutively placed zygomatic implants in 56 patients from May 2000 through October 2006. Of the 110 zygomatic implants, 5 machine-surfaced implants failed, 4 within the first 3-6 months and 1 within 9-12 months of insertion, yielding a 95.5% cumulative survival rate with follow-up data no less than 1 year and upwards of 5 years. To date no reports of failure occurred with any titanium oxide (TiUnite) surface implant. All implants in this study were immediately loaded following the Teeth In A Day protocol. According to the authors, the "zygoma implants used in this immediate loading protocol have proven in this study to have a higher clinical survival than implants in grafted maxillas."[29]

Finally, in a review of the prosthetic restoration of the edentulous maxilla with zygomatic implants, Ferrara and Stella advocated the use of zygoma implants in the atrophied edentulous maxilla for the following reasons: (1) The success rate of osseointegration for the zygoma implant is typically 96%. (2) Surgical interventions are decreased. (3) No bone harvesting or bone grafting procedure is necessary. (4) Overall operating and office time for the surgery is decreased. (5) The zygoma implant surgery can be accomplished in an office setting. (6) The comparative cost of zygoma implant placement versus grafting procedures is a savings for the patient.[30]

Combining Teeth In A Day and Teeth In An Hour Protocols to Treat the Atrophied Maxilla: A Case Report

In 2007, Balshi et al. reported a unique approach to the treatment of the totally edentulous, severely atrophic maxilla.[31] The patient was a 67-year-old retired surgeon with severe maxillary bone loss and a history of failed implant therapy (Figure 19-16, *A* and *B*).

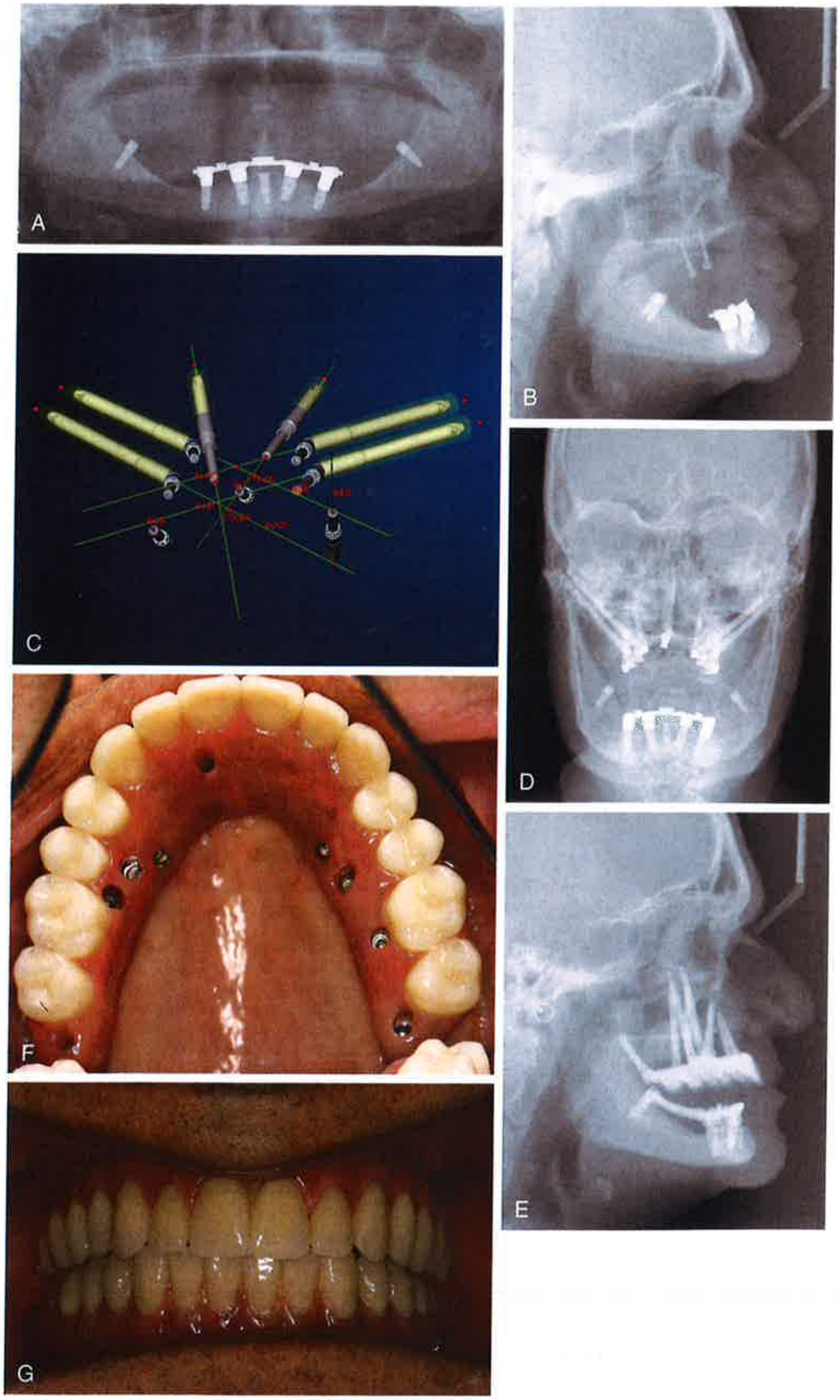


Figure 19-16. **A,** Preoperative panoramic radiograph demonstrating severe maxillary bone atrophy. **B,** Preoperative lateral cephalometric radiograph showing extreme maxillary bone loss. **C,** NobelGuide Procera software from prior CT scans shows planned implant positions only, including four zygomatic fixtures. **D,** Postoperative cephalometric radiographs demonstrating traditional and zygomatic placed implant fixtures. **E,** Occlusal view of maxillary definitive fixed screw-retained titanium and ceramic prosthesis. **F** and **G,** Final maxillary and mandibular implant-supported prostheses following the No Bone Solution protocol with no bone grafting required.

The proposed treatment plan, following the author's No Bone Solution protocol, was as follows:

1. Remove the nonintegrated mini-implants in the maxillary left first and second molar area.
2. Fabricate a new maxillary denture incorporating radiographic markers to be used in conjunction with a CBCT scan according to the Teeth In An Hour protocol (Figure 19-16, *C*).
3. Perform Teeth In An Hour guided surgery for placement of five traditional Brånemark implants and freehand placement of four zygomatic implants to support an all-acrylic screw-retained interim prosthesis (Figure 19-16, *D* and *E*).
4. Following 12 weeks of healing and successful osseointegration of all inserted implants, place a definitive screw-retained prosthesis. The prosthesis was a Procera milled titanium framework, which supported individual zirconium crowns (Figure 19-16, *F* and *G*).

Placing bilateral zygomatic implants allowed comprehensive dental rehabilitation of this grossly atrophied maxilla without resorting to bilateral sinus augmentation surgeries with prolonged healing times prior to implant placement and final restoration. Adhering to the details of both Teeth In A Day and Teeth In An Hour protocols, the No Bone Solution allowed immediate rigid full-arch loading of all implants, affording this patient excellent postoperative aesthetics and function.

REFERENCES

1. Brånemark PI, Zarb GA, Albrektsson T: Tissue-integrated prostheses osseointegration in clinical dentistry, Chicago, 1985, Quintessence.
2. Albrektsson T, Hansson H, Kasemo B, et al: The interface of inorganic implants in vivo: titanium implants in bone, Annal of Biomedi Engineering 11:1-27, 1983.
3. Schnitman PA, Wohrle PS, Rubenstein JE: Immediate fixed prostheses supported by two-stage threaded implants: methodology and results, J Oral Implantol 16(2):96-105, 1990.
4. Schnitman PA, Wohrle PS, Rubenstein Je, et al: Ten-year results for Brånemark implants immediately loaded with fixed prostheses at implant placement, Int J Oral Maxillofac Implants 12(4):495-503, 1997.
5. Balshi TJ, Wolfinger GJ: Immediate loading of Brånemark implants in edentulous mandibles, Implant Dent 6:83-88, 1997.
6. Balshi TJ: The Biotes conversion prosthesis: a provisional fixed prosthesis supported by osseointegrated titanium fixtures for restoration of the edentulous jaw, Quintessence Int 16(10):667-677, 1985.
7. Wolfinger GJ, Balshi TJ, Rangert B: Immediate functional loading of Brånemark System implants in edentulous mandibles: clinical report of the results of developmental and simplified protocols, Int J Oral Maxillofac Implants 18:250-257, 2003.
8. Rocci A, Martignoni M, Gottlow J: Immediate loading of Brånemark System TiUnite and machined-surface implants in the posterior mandible: a randomized open-ended clinical trial, Clin Implant Dent Relat Res 5(Suppl 1):57-63, 2003.
9. Glauser R, Ruhstaller P, Windisch S, et al: Immediate occlusal loading of Brånemark System TiUnite implants placed predominantly in soft bone: 4-year results of a prospective study, Clin Implant Dent Relat Res 7(Suppl 1):52-59, 2005.
10. Banden BL, Pedretti G, Dellacasa P, et al: Early function of splinted implants in maxillas and posterior mandibles, using Brånemark System TiUnite implants: an 18-month prospective multicenter study, Clin Implant Dent Relat Res 6(3):121-129, 2004.
11. Balshi SF, Allen FD, Wolfinger GJ, Balshi TJ: A resonance frequency analysis assessment of maxillary and mandibular immediately loaded implants, Int J Oral Maxillofac Implants 20:584-594, 2005.
12. Meredith N, Alleyne D, Cawley P: Quantitative determination of the stability of the implant-tissue interface using resonance frequency analysis, Clin Oral Implants Res 7:261-267, 1996.
13. Balshi SF, Wolfinger GJ, Balshi TJ: A prospective study of immediate functional loading, following the Teeth in a Day Protocol: A Case Series of 55 Edentulous Maxillas, Clin Implant Dent Relat Res 7(1):24-31, 2005.
14. Tulsane FJ: Implant treatment of missing posterior dentition. In Albrektsson T, Zarb GA, editors: The Brånemark osseointegrated implant, Chicago, 1989, Quintessence.
15. Balshi TJ, Hernandez R, Lee H: Use of pterygomaxillary tuberosity fixtures in the partially edentulous patient: A preliminary report, Int J Oral Maxillofac Implants 10:89-98, 1995.
16. Balshi TJ, Wolfinger GJ, Balshi SF: Analysis of 356 pterygomaxillary implants in edentulous arches for fixed prostheses anchorage, Int J Oral Maxillofac Implants 14:398-406, 1999.
17. Balshi SF, Wolfinger GJ, Balshi TJ: Analysis of 164 titanium oxide-surface implants in completely edentulous arches for fixed prosthesis anchorage using the pterygmaxillary region, Int J Oral Maxillofac Implants 20:946-952, 2005.
18. Balshi TJ, Wolfinger GJ: Historical, Current, and Future Perspectives. In Periodontology 2000, Vol. 33, Oxford UK, 2003, Blackwell Munsgaard, pp 67-81.
19. Balshi SF, Wolfinger GJ, Balshi TJ: Analysis of 164 titanium oxide-surface implants in completely edentulous arches for fixed prosthesis anchorage using the pterygomaxillary region, Inter J Oral & Maxillofac Implants 20(6):946-952, 2005.
20. Lynch SL, Genco RJ, Marx RE: Tissue engineering applications in maxillofacial surgery and periodontics, ed 1, Chicago, 1999, Quintessence.
21. Balshi SF, Wolfinger GJ, Balshi TJ: Surgical Planning and Prosthesis Construction Using Computer Technology and Medical Imaging for Immediate Loading of Implants in the Pterygomaxillary Region, Int J Periodont Resto Dent 26:239-247, 2006.
22. Balshi TJ, Garver DG: Surgical guidestents for placement of implants, Journal of Oral & Maxillofac Surg 45(5):463-465, 1985.
23. Hirsch JM, Ohrnell LO, Henry PJ, et al: A clinical evaluation of the zygoma fixture: one year of follow-up at 16 clinics, J Oral Maxillofac Surg 62(9 Suppl 2):22-29, 2004.
24. Brånemark PI, Grondahl K, Ohrnell LO, et al: Zygoma fixture in the management of advanced atrophy of the maxilla: technique and long-term results, Scand J Plast Reconstr Surg Hand Surg 38(2):70-85, 2004.
25. Aparicio C, Ouazzani W, Garcia R, et al: A prospective clinical study on titanium implants in the zygomatic arch for prosthetic rehabilitation of the atrophic edentulous maxilla with a follow-up of 6 months to 5 years, Clin Implant Dent Relat Res 8(3):112-122, 2006.
26. Penarrocha M, Garcia B, Marti E, Boronat A: Rehabilitation of severely atrophic maxillae with fixed implant-supported prostheses using zygomatic implants placed using the sinus slot technique: clinical report on a series of 21 patients, Int J Oral Maxillofac Implants 22(4):645-650, 2007.
27. Chow J, Hui E, Lee P, Li W: Zygomatic implants-protocol for immediate occlusal loading: a preliminary report, J Oral Maxillofac Surg 64:804-811, 2006.
28. Bedrossian E, Rangert B, Stumpel L, Indresano T: Immediate function wit the zygomatic implant: a graftless solution for the patient with mild to advanced atrophy of the maxilla, Int J Oral Maxillofac Implants 21:937-942, 2006.
29. Balshi SF, Wolfinger GJ, Balshi TJ: A Prospective Analysis of 110 Zygomatic Implants in a Single-Stage Immediate Loading Protocol, Submitted for Publication.
30. Ferrara ED, Stella JP: Restoration of the Edentulous Maxilla: The Case for the Zygomatic Implants, J Oral Maxillofac Surg 64:1418-1422, 2004.
31. Balshi TJ, Wolfinger GJ: Against all odds: a "no bone solution", Prosthodontic Insights 20(2):1-5, 2007.