

Immediate Fixed Restoration of the Edentulous Maxilla After Implant Placement

Lyndon Cooper, DDS, PhD,* Ingeborg J. De Kok, DDS, MS,†
Glenn J. Reside, DMD, MS,‡ Preeda Pungpapong, DDS, MS,§
and Fernando Rojas-Vizcaya, DDS, MS||

Immediate loading of the edentulous maxilla is possible when sufficient bone is available to provide primary stability of implants located in positions congruent with an ideal prosthesis. Treatment planning, implant placement with immediate provisionalization, and final prosthodontic rehabilitation are best integrated by a process that uses the immediate provisional prosthesis as a surgical and restorative guide. Designating the planned tooth position is a prerequisite step to the identification of possible implant positions. The cervical contours of the planned prosthesis are critical determinants of this relationship. Defining the planned tooth/residual alveolar bone relationship aids in selecting both the possible type of prosthesis and implant locations. When the treatment plan is transferred directly from the tomographic template to the surgical template to the conversion prosthesis used for immediate loading, the surgical and prosthodontic management of this procedure is well defined.

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The edentulous maxilla presents several confounding variables to the surgical and prosthodontic team responsible for dental rehabilitation using endosseous dental implants. These factors may be categorized as 1) anatomic variables, 2) functional variables, and 3) psychological/psychosocial variables.¹ Each category is significant and they often converge and create significant clinical challenges. When the clinical decision to follow an immediate loading protocol is made, all of these factors must be carefully considered and details of therapy may require modification. This article will review the basis for immediate loading procedures for the edentulous maxilla and illustrate how

the diagnostic interaction between restorative and surgical phases of therapy control the variables to achieve both short-term and long-term success.

The anatomic variables that most dramatically affect the prognosis of any endosseous implant-supported prosthesis are bone quality and bone quantity. Lekholm and Zarb² introduced a classification system that is today widely accepted and used in planning. Nearly a decade ago, the success of maxillary implants was considered in the context of bone quality and quantity and several reports indicated that maxillary implants were at risk in type IV bone.³ High success in low-density bone was reported by Bahat⁴ and attributed to the use of many implants, proper occlusal schemes, and functional protection. Limited bone quantity is also an important consideration; implants less than 10 mm in length are at greater risk of failure.⁵

A main observation gathered from experience with immediate loading of endosseous implants in the maxilla is that there is rarely any potential to classify the entire maxilla as 1 type of bone density or bone quantity. The precise osseous morphology is often site specific and requires careful classification of individual implant sites (Fig 1). While immediate loading of the edentulous maxilla is possible, the opportunity to avoid loading of particular implants included in the treatment plan should be taken whenever local osseous conditions preclude attaining primary stability with sufficient dimension implants.

Received from the School of Dentistry, University of North Carolina, Chapel Hill, NC.

*Director, Graduate Prosthodontics, Department of Prosthodontics.

†Assistant Professor, Department of Prosthodontics.

‡Clinical Associate Professor, Department of Oral and Maxillofacial Surgery.

§Graduate Student, Department of Prosthodontics.

||Graduate Student, Department of Prosthodontics.

Address correspondence and reprint requests to Dr Cooper: Department of Prosthodontics, University of North Carolina, 114 Dental Research Center, CB 7455, Chapel Hill, NC 27599; e-mail: Lyndon_Cooper@dentistry.unc.edu

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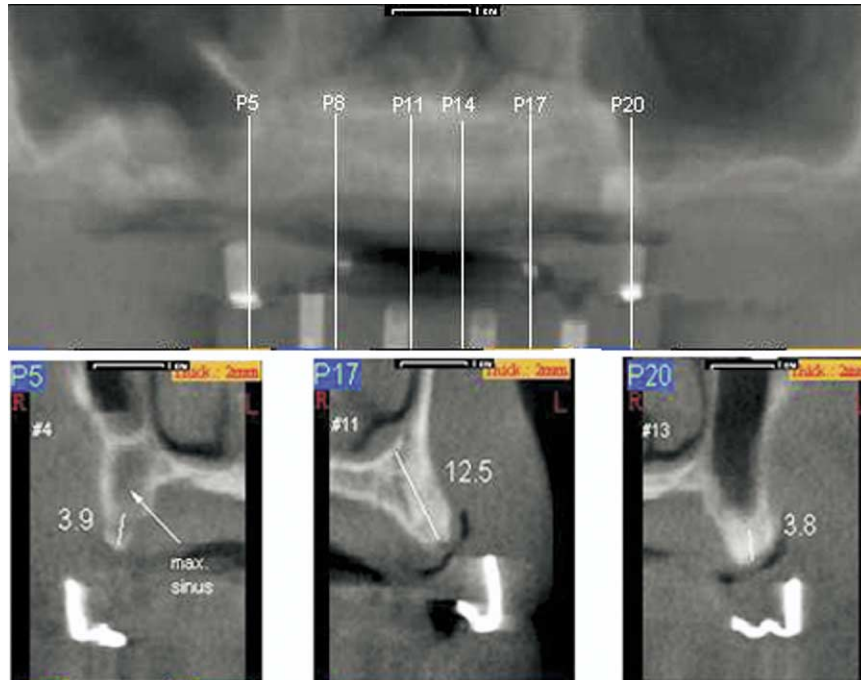


FIGURE 1. Tomographic analysis of the edentulous maxilla. There is regional and site to site variability in the bone density and bone quantity of the maxilla. Site specific diagnosis is required for immediate loading strategies. The image is of greater value when the designated positions of the teeth can be simultaneously identified. This example shows greater than 5 mm distance from the alveolar ridge to the cervical contours of the planned prosthesis and indicates that an implant-supported fixed denture will be needed to replace the missing alveolar ridge. The tomographic analysis also shows the obvious need for bone grafting before implant replacement.

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A second major anatomic constraint affecting the decision to provide immediate loading of the edentulous maxilla is the extent of maxillary alveolar resorption (Fig 2). Should sufficient bone volume exist for implant placement, but the extent of alveolar resorption negatively affect lip support, phonetics, hygiene, and intraoral comfort, then alveolar reconstruction by bone grafting procedures or the use of an overdenture prosthesis must be considered.⁶

Placement of lead foil strips (from radiographic film packets) onto the buccal, incisal/occlusal, and lingual surface along the axial midline of the tooth identifying the planned implant placement provides a clear representation of the cervical location, axial orientation, and distance of the planned tooth from existing bone (Fig 1). The tomographic images then allow for careful planning of the implant and selection of the most probable abutment solutions. It is then possible and useful to measure the distance from the planned implant/abutment interface to the tomographic outline of the planned tooth position. This indicates the selection of abutment height, restorative platform diameter, and angulation.

Immediate loading of the edentulous maxilla involves fixed prostheses. To date, there is no evidence that immediate loading of a maxillary overdenture prosthesis can be achieved with reproducible success (Table 1).

Caution is advocated in this particular scenario because, in the absence of loading, the lowest reported implant survival data is associated with conventional loading of maxillary overdenture prostheses.⁷ Beyond the challenges of attaining osseointegration, the challenge of restoring the edentulous maxilla is frequently related to esthetic demand and the associated facial support and gingival visibility, as well as the phonetic aspects of the prosthesis.⁸ Such considerations can exclude an immediate loading scenario.

The psychological and psychosocial impact of edentulism can be severe for some individuals.⁹ Some individuals are clearly intolerant of any removable prosthesis. The maladaptive denture patient is often best served by dental implant treatment. Interim phases of therapy can be extremely frustrating to such patients, and the potential immediate loading of an implant-supported maxillary prosthesis offers many advantages to the patient and clinical team.

One of the most controversial issues confronting clinicians and one of the most significant phases of immediate loading of the edentulous jaw is the provisional phase of treatment.¹⁰ The technical approaches vary from the use of prefabricated fixed partial dentures to complete denture conversion using either direct or indirect methods for screw-retained or cement-retained prostheses. The provisional



FIGURE 2. The impact of alveolar resorption on tooth/residual ridge relationships. *A*, The teeth are present in the correct phonetic and esthetic orientation, but the prosthesis is not properly related to the resorbed alveolar ridge. When a discrepancy of greater than 3 to 4 mm exists in the buccolingual or superior/inferior dimension, additional bone grafting or an overdenture prosthesis should be considered. *B*, Resolution of the ridge/tooth discrepancy by prosthetic intervention should be performed at the time of immediate loading; however, additional resorption of the alveolus may require additional modification 8 to 12 weeks following healing.

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restoration invokes the immediate loading forces and control of the loading environment is established using the provisional restorations. Soft tissue healing also occurs under the influence of the provisional restoration.¹¹ The quality and form of the provisional restoration markedly influence the ultimate shape of the soft tissues and contribute to the inflammatory healing environment during the interim period of immediate loading. The provisional restoration should be of high quality and proper form; delivery of the immediate prosthesis aids in establishing patient expectations and acceptance of therapy. This aspect of treatment can resolve many of the anatomic, functional, and psychological/psychosocial aspects of treatment.

The development of an immediate loading strategy for the edentulous maxilla can be facilitated by a process which fully integrates the immediate loading phase of therapy by use of a well-designed provisional prosthesis. The provisional prosthesis is integrated into the diagnostic, surgical, and restor-

ative phases through a process that begins with designation of eventual tooth position and continues through the process of defining prosthesis/alveolar bone relationships that guide implant position decisions. The process of developing the provisional prosthesis should permit the preoperative selection of abutments and prosthesis design and culminate in the seamless transition from a provisional to a final prosthesis design.

Designate Tooth Positions

The process of planning for the immediate loading of the edentulous maxilla begins with proper tooth placement. The first step is to define the coincident dental and facial midline and to identify the plane of occlusion that is associated with an appropriate vertical dimension of occlusion (Fig 3A). These procedures can be achieved by conventional denture fabrication techniques using stabilized record bases and occlusal rims. They are best refined using the diagnostic tooth arrangement (Fig 3B).

Some general guidelines help the clinician in arrangement of the teeth. When pre-extraction records are available, full advantage should be taken to attain useful tooth measurements to guide further treatment. The incisal edges of maxillary anterior teeth are, on average, 20 to 22 mm inferior to the buccal vestibule and the incisal edges of mandibular anterior teeth are, on average, 18 to 20 mm superior to the buccal vestibule (Fig 3C). This should be coincident with acceptable anterior tooth display and modifications of several millimeters can be made to enhance the esthetic result. Anterior tooth display, when measured in populations of varying ages, should range from 0 to 3 mm for older to middle-aged men or 2 to 6 mm for older to middle-aged women.¹² Buccolingual placement of the maxillary anterior teeth must be carefully planned to support both esthetics and phonetics; improper implant placement preventing ideal tooth placement will result in esthetic, phonetic, and functional problems. A guide for maxillary central incisor placement was suggested to be 10 mm anterior to the center of the incisal papilla and serves as a good starting point for tooth positioning. However, as suggested decades ago by Pound,^{13,14} phonetic and integrated esthetic principles guide anterior tooth position (Fig 3D). A key aspect in determining buccolingual position of the maxillary central incisor is the location of the incisal edge during phonation; its incisal edge should gently contact the dry/wet line of the lower lip when making “v” sounds and should be slightly anterior of this line when making “f” sounds. Indiscriminant phonation requires movement of the anterior tooth position in either the buccolingual or superior/inferior position. These steps in denture

Table 1. REPORTED OUTCOMES FOR IMMEDIATE LOADING OF THE EDENTULOUS MAXILLA

Study	Treatment	Outcome	Conclusion
Jaffin et al, 2004 ¹⁸	34 patients, 6-8 ITI implants (236 implants), minimum of 8 mm, loaded after 48-72 hours postsurgery	93% survival rate	Immediate loading in the complete edentulous maxilla is a viable treatment alternative.
Gallucci et al, 2004 ¹⁰	8 patients, 6-10 ITI implants (78 implants, 44 maxilla, 34 mandible) in 1 or 2 edentulous arches, immediately loaded with screw-retained provisional prosthesis	97.4% survival rate	The immediate loading of implants in edentulous arches with screw-retained provisional restorations does not appear to jeopardize the achievement of osseointegration.
Fortin et al, 2002 ¹⁹	45 patients, 245 NobelBiocare implants, Marius implant bridge	after 5 years, survival rate of 97%	The Marius bridge is an effective and predictable fixed implant-supported prosthesis for the patient with a fully edentulous maxilla.
Bergkvist et al, 2004 ²⁰	25 patients, 5-7 ITI implants (146 implants), 1-2 years	survival rate of 96.6%	ITI TPS solid-screw implant in combination with fixed prostheses has successful survival rates and were found to be a viable treatment alternative in the edentulous maxilla.
Hallman, 2001 ²¹	40 patients (31 totally edentulous) 8-12 mm 3.3 ITI implants (182 implants)	survival rate of 99.4%	The results of this study indicate that treatment with fewer, shorter, and narrower implants than for the standard procedure may be possible if using TPS planning as a good alternative to bone grafting.
Horiuchi et al, 2000 ²²	5 patients, 8 Brånemark System implants with at least a minimum length of 10 mm (52 implants)	survival rate of 96.5%	The results suggest that immediate loading of Brånemark System implants at the time of placement in edentulous patients can be a valuable adjunct to therapy and as predictable as delayed loading in maxillary arches.
Misch and Degidi, 2003 ²³	2 patients, 8-10 Biohorizons implants (18 implants)	survival and success rate of 100%	In the current report no implant failure occurred, and crestal bone loss values were similar to or less than values reported with the conditional 2-stage approach.
Rocci et al, 2003 ²⁴	46 patients, 96 Brånemark System	cumulative survival rate 91%	The study confirmed the feasibility of an immediate-loading treatment protocol in the maxilla, which included flapless surgery, implants, and abutments placed in predetermined positions, and prefabricated provisional restorations.
Olsson et al, 2003 ²⁵	10 patients, 61 TiUnite implants	93.6% survival rate	The results from this limited study on 10 cases indicate that early loading protocols can be applied for cross-arch dental bridges supported by 6 to 8 implants in the maxilla.

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construction or verification of current denture tooth position are necessary to guide the next step in planning for implant placement for the immediate maxillary implant prosthesis (Fig 3E).

Once the position of the incisal edges has been defined and the midline and plane of occlusion have been verified, then the refined position of all maxillary teeth may be designated according to standard

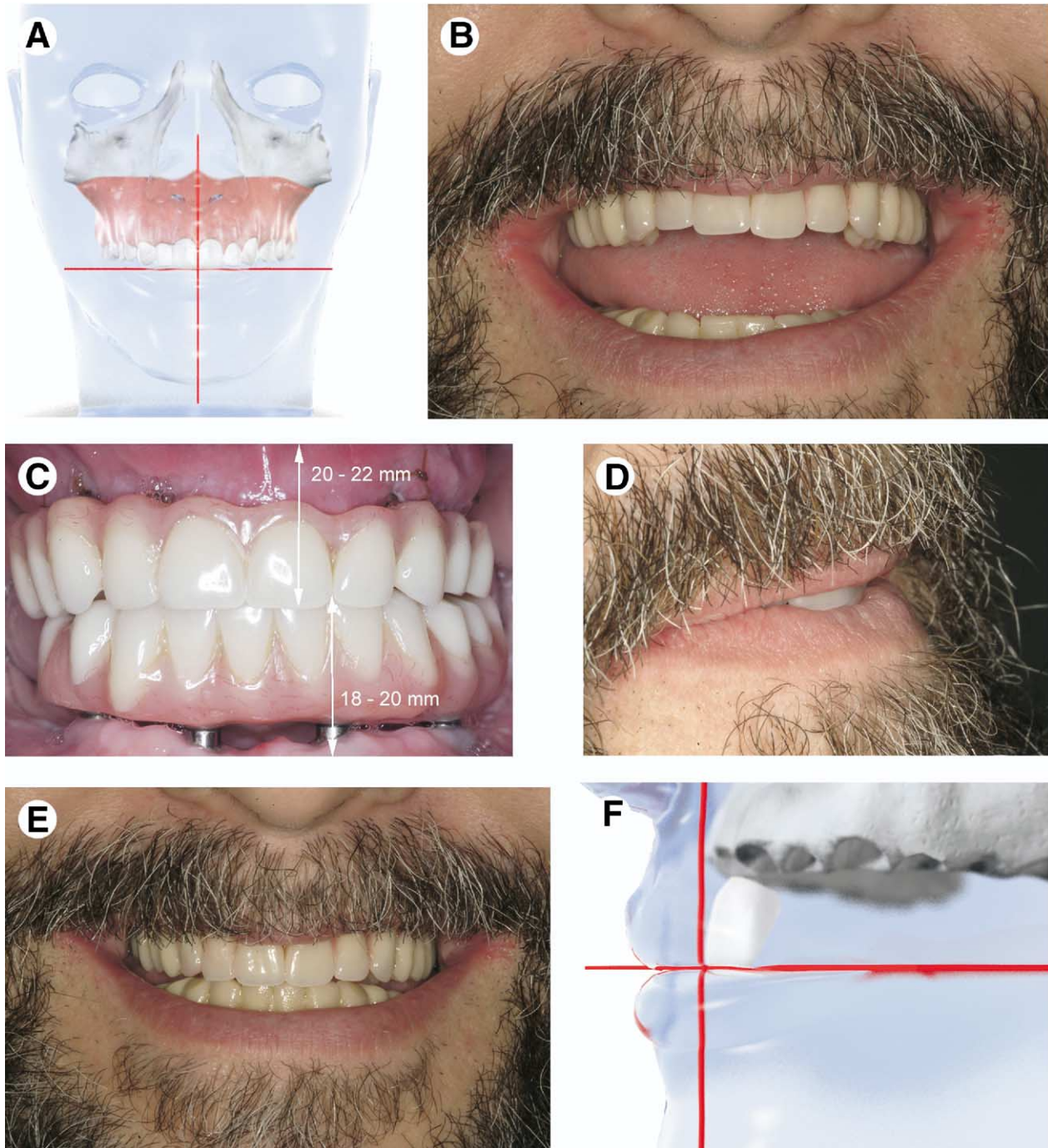


FIGURE 3. Designating tooth position is a first step in treatment planning for the immediate loading of the edentulous maxilla. *A*, The midline and plane of occlusion must be determined and used as cornerstones of planning for esthetic and functional tooth position. *B*, Tooth arrangement procedures are best performed in the clinical environment; note the tooth arrangement has been intentionally varied on the left and right sides to aid in selecting the proper arrangement. *C*, Some anthropomorphic averages are useful in the initial placement of prosthetic teeth for the edentulous patient. The distance from the vestibule to the incisal edge is approximately 20 to 22 mm and 18 to 20 mm or the maxilla and mandible, respectively. This position is a starting point for additional refinement. *D*, The phonetic evaluation of the trial denture tooth set-up is critical to the process of refining anterior tooth placement. This process aids in defining limits that should not be disturbed by incorrect implant placement. *E*, This process culminates in the mutual acceptance by the clinical team and patient of tooth position, esthetics, and function. The tooth arrangement will be used to develop the tomographic template (Fig 1), surgical template, and conversion prosthesis for immediate loading.

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rules of denture esthetics and occlusion. When the teeth have been properly set, the cervical contours of the prosthetic dentition can then be visualized. This is the key step in planning for any implant supported maxillary prosthesis (Fig 3F).

The cervical contours of the prosthetic dentition define the geometric limits of implant placement in the underlying bone and mucosa. In most simple terms, an implant can be placed beneath the cervical contour of the prosthesis with modest buccolingual or mesiodistal angular freedom. The use of angled abutment components provides a restorative solution whenever the implant is wholly located within the cervical contour of the designated prosthetic tooth. Problems of implant placement occur when the implant is not placed within the cervical contour (in embrasures or far buccal or lingual to the planned cervical contours). Therefore, the culmination of prosthetic planning for implant placement is the identification of the cervical contours of the prosthetic teeth in their proper esthetic and phonetic location.

Define the Relationship of Tooth Position and Alveolar Bone

The relationship of the planned cervical contours of the prosthetic teeth to the existing alveolus and underlying bone can be clinically illustrated and is a valuable process for the restorative and surgical team. Two very simple methods are available; one is to duplicate the denture and remove the buccal flanges by carefully trimming to the cervical contours of the prosthetic teeth (Fig 4A,B).

Placement of a properly designed surgical template displaying cervical contours of prosthetic teeth onto a diagnostic cast can reveal the distance from the desired clinical crown margin to the alveolar ridge (Fig 4C). Again, large distances are indicative of fixed denture solutions that provide prosthetic gingival and alveolar ridge form. Ridge lap contours suggest the possibility of alveolectomy to achieve esthetics. When prosthetic tooth lengths far exceed average tooth dimension (eg, maxillary central incisors >12.5 to 13 mm), fixed partial denture solutions may be unesthetic and/or result in large embrasures that create discomfort, food impaction, and phonetic difficulties. In these cases, a fixed denture solution providing prosthetic alveolar reconstruction and elimination of large embrasures may be warranted. Alternatively, an overdenture solution using conventional loading may be necessary.

The second approach is to make a thermoplastic index from a cast representing the diagnostically waxed maxillary dentition (Fig 4D). This index is well adapted to the palate and can be transferred with accuracy and stability to the edentulous maxilla to

display the position of the planned teeth and permit visualization of the surgery (Fig 4E). This template is very useful in analyzing the preparation of the osteotomy in all 3 dimensions (Fig 4F).

The first approach is most useful if a conversion prosthesis is used for immediate provisionalization and if a screw-retained, implant-supported, fixed denture is envisioned as the final prosthesis. The second approach is more commonly applied if fixed partial dentures are envisioned for both the immediate provisional and the final prosthesis. Because the principles of tooth placement and implant positioning are similar for both prosthodontic approaches, tomographic templates and resulting images as illustrated above (Fig 1) are readily integrated into the process of developing the provisional restoration or transitional denture.

Determine Implant Position

When the clinical team has defined the esthetic and phonetic potential by a waxed denture or diagnostic denture try-in procedure, and the relationship of the planned prosthetic tooth position is defined (by tomographic analysis) with respect to the underlying bone to support implant placement, the surgical plan may be finalized. Likely or potential implant positions are next determined by consideration of the available bone (contour and density), function, and surgical approach.

Current suggestions for the immediate loading of the edentulous maxilla include the placement of 6 to 14 endosseous dental implants (Table 1). Experience using 6 to 8 endosseous implants suggests that, when rough surface implants are used, good osseointegration occurs under loaded conditions (Fig 5). The number of implants used is guided by: 1) the extent of the planned prosthesis, 2) the quality of available bone, 3) the estimated function during the loading period, and 4) potential financial considerations.

Presurgical estimation of the number, dimension, and location of dental implants is then used to convert the tomographic template to a surgical template (Fig 6A). Identifying the buccal cervical contours of the prosthetic tooth position in the template is a very important aspect of surgical template design. This landmark is a guide in implant position selection and serves as a boundary for implant placement.

The tomographic template can be converted to the surgical template by removal of the lead foil strips, creating access holes for surgical drills (Fig 6B) and sterilization/disinfection. When a clear material is provided to the surgeon, better visualization is afforded. The attributes of a useful surgical template include features that a) make it useful to the surgeon during surgery and b) provide valuable transfer of informa-

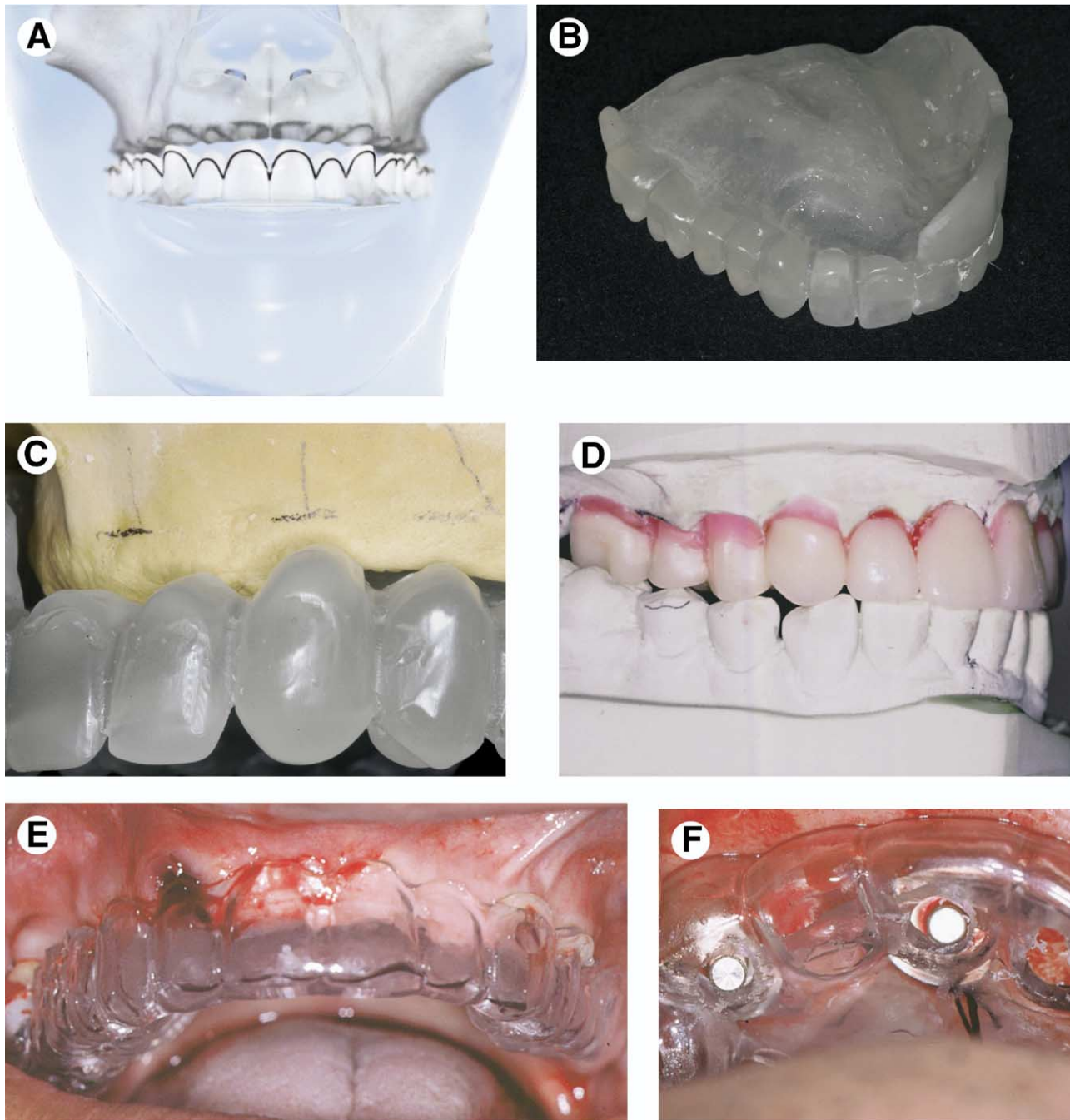


FIGURE 4. The cervical contours of the planned prosthetic teeth have a key role in the translation of planned tooth position to the clinical environment. *A*, The diagnostic tooth arrangement establishes the esthetic, phonetic, and masticatory roles of the teeth; proper tooth arrangement defines the cervical contours of the planned prosthesis. *B*, Because every implant must reside beneath the cervical contour of a designated tooth, these contours guide implant placement. When the immediate loading prosthesis will be created via a conversion prosthesis, a duplicate denture is made and modified by carefully trimming the buccal flange to the cervical contours of the teeth. *C*, When placed onto the diagnostic cast, the likely relationship of the prosthesis and residual ridge is revealed and forecasts any potential problems. *D*, Alternatively, an immediate loading prosthesis will be created from a diagnostic waxing of cement-retained fixed partial dentures (in this case by placement of denture teeth onto the edentulous ridge). *E*, From a cast of the diagnostic waxing, a thermoplastic index is made to transfer the location of the cervical contours and occluding surfaces of the planned prosthesis to the mouth. Stability is gained from maintaining full palatal coverage and accuracy is assured by carefully trimming to the cervical contours of the diagnostically waxed prosthesis as well as use of a clear template material. *F*, The position of the implants should be verified in 3 dimensions. Here the mesiodistal and buccolingual position of 2 implants are shown to be located in the designated position for a cement-retained prosthesis; the important third dimension is verified by examination of the relationship of the implant to the cervical margin of the template when viewed from the facial aspect.

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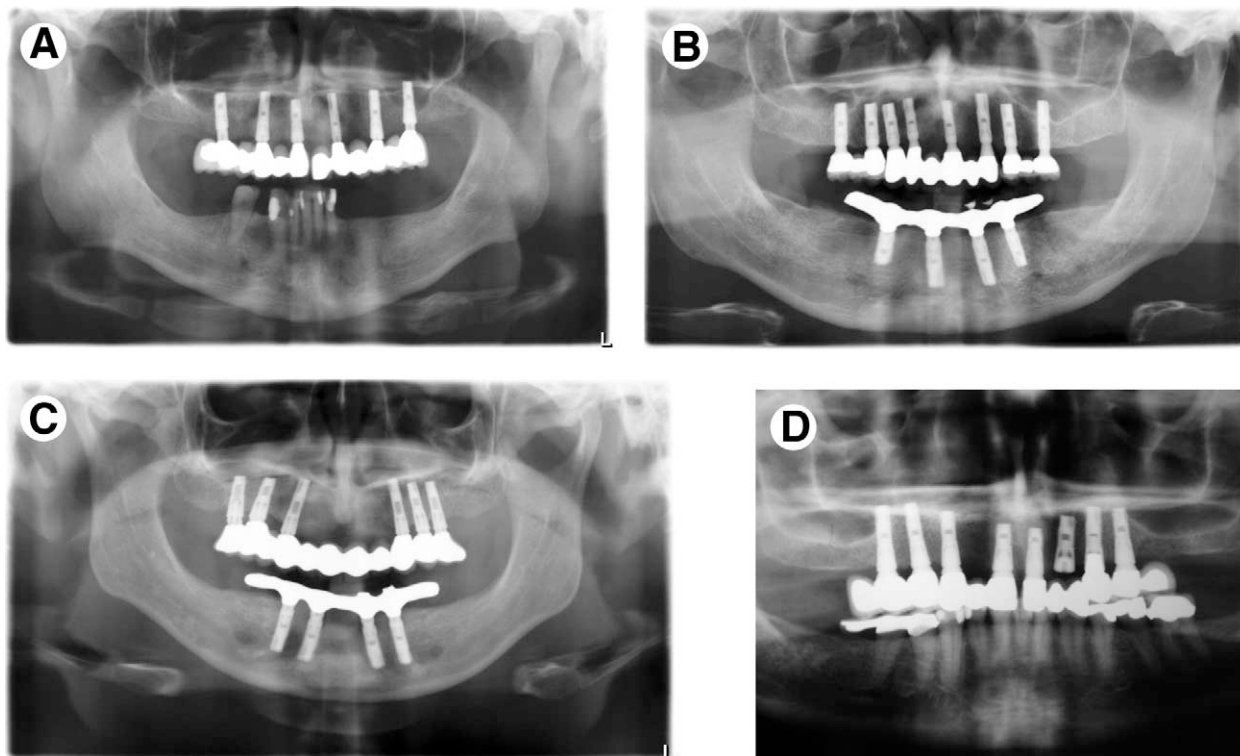


FIGURE 5. Immediate loading of the edentulous maxilla is efficiently performed using 6 to 8 implants distributed equally across the midline. Panoramic radiographic examination of selected implant position for: *A*, Immediate loading of the edentulous maxilla using 6 implants placed into the central incisor, canine, and first molar position (6-month follow-up). The posterior left implant was placed in bone lateral to the maxillary sinus, while the right implant was placed into the sinus using an osteotome preparation technique. *B*, Immediate loading of the edentulous maxilla using 8 implants versus 4 immediate loaded implants in the mandible (3-year follow-up). The left distal implant required an osteotome sinus lift to permit use of an 11-mm fixture. The right central incisor position was of insufficient bone quantity and the implant was alternatively placed in the right lateral incisor position. *C*, Immediate loading of the maxilla for treatment of ectodermal dysplasia (3-year follow-up). The anterior maxilla was atrophic and implants could not be placed. Three implants were placed bilaterally in the bicuspid and molar position and restored with cross-arch splinted porcelain fused to metal, screw-retained fixed denture. Concern for the anterior cantilever effect during the loading period promoted the use of the longest implants possible. *D*, Immediate loading of the edentulous maxilla was planned for placement in the central incisor, canine, and premolar positions bilaterally (2 year follow-up). The planned use of distal cantilevers is supported by the documented behavior of conical seal design abutments. Note that incorrect mesial placement of the left canine implant into the embrasure resulted in the intentional covering of the implant to allow an esthetic fixed partial denture to be created. Note that incorrect angular placement of the adjacent left bicuspid implant resulted in the creation of a custom gold abutment for proper placement of the crown margin despite shallow implant placement.

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tion from the diagnostic cast and tomographic images to the surgical environment. Generally, a surgical template must 1) be stable (very important during maxillary surgery) and accurately related to the maxillary alveolar ridges and palate, 2) be rigid, 3) give physical access and visibility to the surgical site, and 4) guide implant placement in 3 dimensions. This last point is assured by display of the cervical contour of the planned prosthetic tooth to guide buccolingual, mesiodistal, and incisopal placement.

Surgical Implant Placement

After verifying that the surgical template is stable and firmly seated, its first use is for marking the mucosa overlying the future implant site. This can be completed with an indelible marker or a round guide drill. These marks guide the mucosal incision, and

following elevation, the bone may be secondarily marked to guide the osteotomy. Next the surgeon should evaluate the vertical space between the alveolus and the cervical margins displayed by the template. Insufficient dimensions can be modified by judicious alveolar bone removal that does not compromise eventual implant placement. Implants should be placed 2 mm lingual to the buccal extent of the cervical contour, should never extend mesial or distal to encroach on mesial or distal embrasure spaces, and should not be placed lingual to the cingulum or lingual cusp of the desired tooth. The implant must be a minimum of 2 to 3 mm apical to the cervical tooth contour to permit biologically prudent abutment placement. The next sequential steps in preparing the osteotomy are performed using the template as a general guide. The template does not

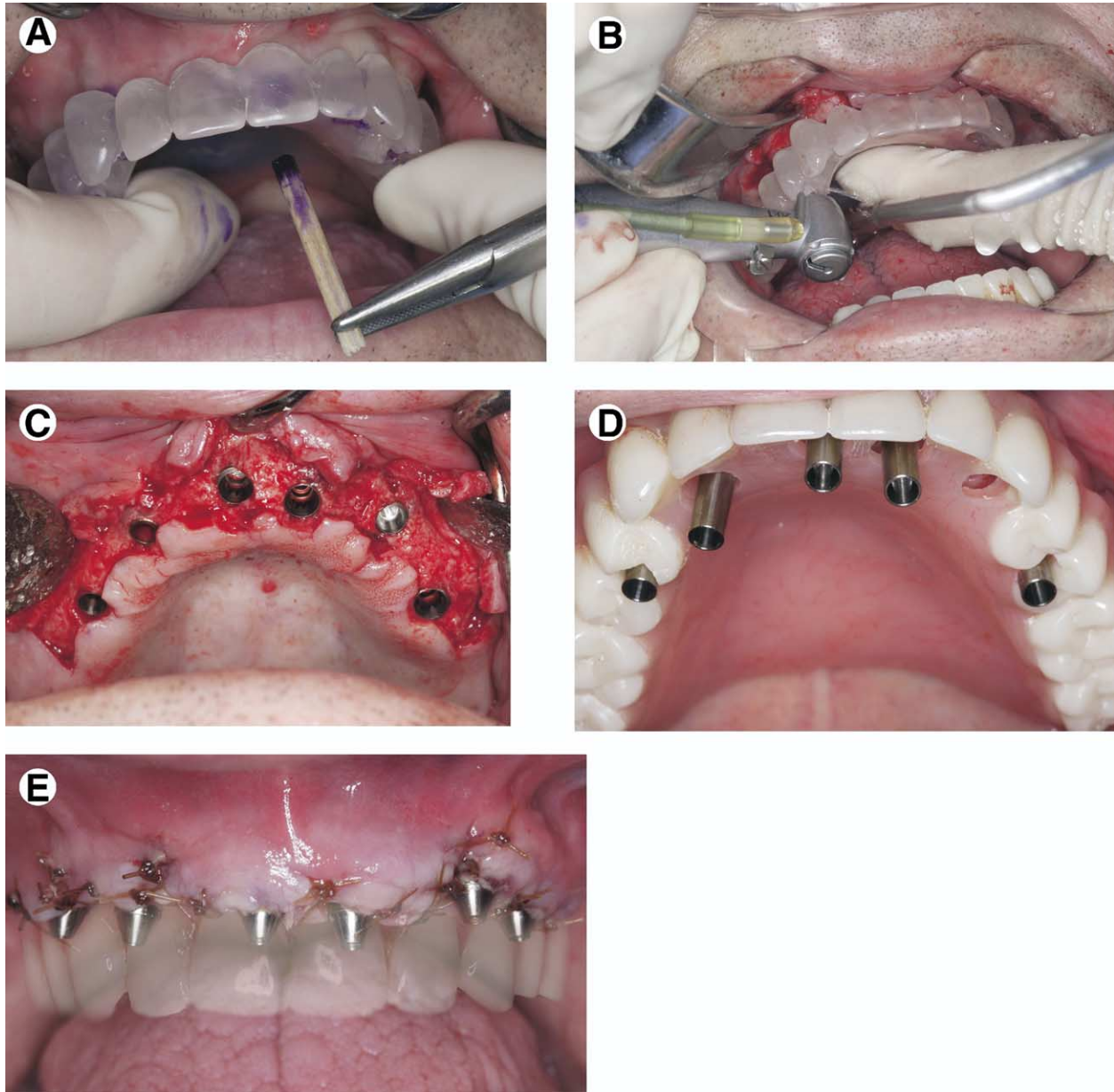


FIGURE 6. Immediate loading using a screw-retained conversion prosthesis derived from a new transitional denture. *A*, The new transitional denture is duplicated to create the surgical template (see Fig 4B, the template contains drill access holes that permit marking of the osteotomy sites with an indelible marker.) *B*, Drilling through the stabilized template is well visualized through a transparent template and from the buccal aspect. *C*, The intraoperative position of the implants suggests the buccal and mesial placement of the right central incisor implant. Note the absence of a palatal flap that facilitated the stability of the surgical template. *D*, Placement of the titanium temporary cylinders through access holes created in the transitional denture. The mesial displacement of the right central incisor implant is not clearly visible. The proper relationship of the prosthesis to the implant/abutment/temporary cylinder is verified by full seating of the transitional denture palate and proper occlusion of the denture teeth. *E*, Superimposed images reveal the mesial displacement of the right central incisor implant and the planned relationship of the cervical contours of the planned teeth to the residual alveolar ridges. **(Figure 6 continued on next page.)**

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fully restrict implant drill movement; instead it establishes boundaries for the osteotomy. An ideal situation is when the restoring dentist is present to aid in 3-dimensional guiding of implant placement. Access in posterior sites defined by the template may be limited because of restricted interocclusal dimension. In these cases, access holes may be converted to

buccal slots or, alternatively, anterior implant orientation can be marked with guide pins to help visualize proper posterior implant angulation. It is important that the template is brought to the mouth to guide the step-wise process of creating an osteotomy for ideal implant placement. Because the goal of this procedure is immediate loading of the implants, it is imper-

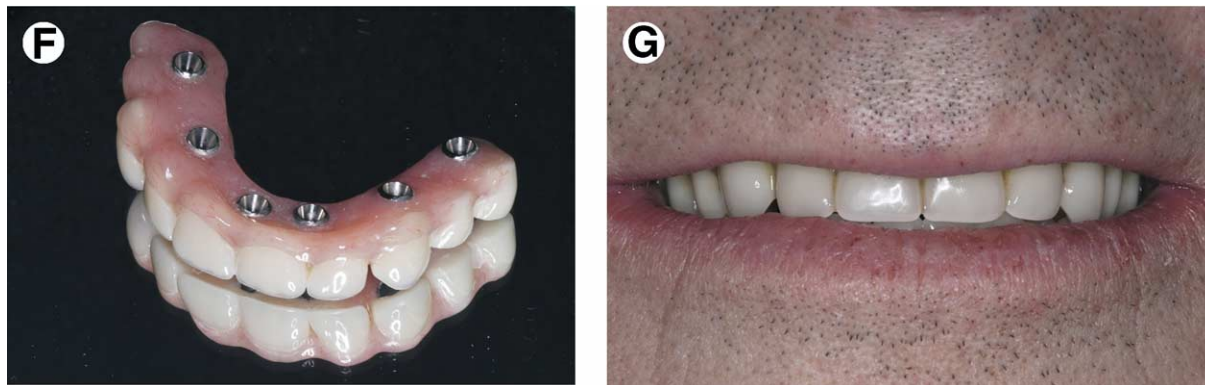


FIGURE 6 (cont'd). *F*, The conversion prosthesis contains 6 titanium temporary cylinders that sit passively on the abutments. The flanges are removed and all surfaces of the denture are highly polished. *G*, Facial image reveals the position of the teeth 3 weeks following the immediate loading procedure; the established midline and plane of occlusion were maintained despite the malposition of the central incisor implant.

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ative that primary stability be attained. The modification of drilling procedures and the use of osteotomes are 2 ways to ensure good primary stability. The implant should exhibit no axial mobility and fully resist rotational movement when challenged with firm finger pressure.

Provisional Restoration at the Time of Implant Placement

When the implants are placed in accordance with the designated plan, available abutments should compensate for implant position and angular discrepancies and correct the prosthesis path of draw in an anticipated manner. Either screw-retained or cement-retained prostheses may be placed and it is recommended that the decision be based on the final prosthesis design; this should be decided upon before commencing surgery. Reduced effort and cost are realized when final abutments can be chosen and used at the time of implant surgery. When screw-retained designs are chosen, either a conversion prosthesis may be fabricated from an existing or new complete denture or a fixed partial denture may be developed by pick-up of the screw-retained metal cylinders. When cement-retained designs are used, an interim, fixed partial denture is best adapted to abutments by a reline procedure. These 2 different approaches are illustrated here.

Immediate Loading of the Edentulous Maxilla Using a Screw-Retained Conversion Prosthesis

When implants are placed using a surgical template derived from a new complete denture, the location of implants may have been selected using a tomographic template derived from the new com-

plete denture (Fig 6A). This integrated approach is strongly advocated because it assures proper orientation of abutments with the conversion prosthesis. Placement of abutments into the implants such that the prosthesis finishing line approximates the designated cervical contour of the restoration is the first step in development of the conversion prosthesis. The abutments should always permit a minimum of 2 mm of peri-implant mucosa to exist between the implant/abutment interface and the abutment/crown margin. This is required for biologic width formation. The abutment/crown finishing line should be placed approximately 1 mm beneath the soft tissue margin.

After abutment placement into the implants, temporary titanium cylinders are placed through the prosthesis and onto the abutments (Fig 6B). Several important preparatory steps are required to make the conversion denture process proceed smoothly. First, as the denture sits on the alveolar ridge and palate in its proper occlusal relationship with the opposing dentition, the midline and plane of occlusion should be verified by comparison with the diagnostically waxed cast or diagnostic denture. Any corrections required should be made at this moment. Minor movements of the template may lead to malpositioning of the implant or lead to displacement of the prosthesis (Fig 6C). It is essential to assure that the relationship of the prosthesis to the existing alveolar tissues and the opposing dentition are not disturbed by interference of the abutments with the denture. If such interference occurs, then the temporary cylinders should be trimmed for occlusal clearance and the denture access holes should be expanded to prevent displacement of the prosthesis by the temporary cylinders (Fig 6D). Note that when divergent implants are involved, it is best to place the temporary cylinders through access holes because it is not possible to

place the denture over the divergent temporary cylinders unless a great deal of the denture is removed.

The fidelity of the temporary cylinder interface with the abutment should be verified by visual inspection and lightly tightening the bridge screw. Rubber dam material should be placed beneath the temporary cylinders such that it covers and protects the suture line. In addition, the temporary cylinder should be filled with a quick-setting vinyl polysiloxane material to prevent hard acrylic resin from entering and blocking screw access. It is absolutely essential that the tissue-bearing surface of the denture is fully contacting the primary denture bearing areas and the occluding surface of the prosthetic teeth remain intact because these relationships established on the final mounted casts are the only clinical landmarks that guide prosthesis position relative to the implants and abutments (Fig 6E).

When this final check is complete, the acrylic denture may be placed into its proper position and then connected to the temporary cylinders. Using a monoject syringe, denture repair resin should be placed into the relieved denture access holes in close approximation to the temporary cylinders that are fully seated onto the abutments. When the denture repair resin has polymerized, the vinyl poly siloxane material is removed from the temporary cylinders and the bridge screws are removed. Next the denture is gently lifted from the abutments. Two common reasons for resistance from displacement of the denture are the incorporation of a suture into the polymerized resin (resolved by cutting the suture free) and the binding of the polymerized resin against divergent abutments (below the abutment/implant interface). Clinical care should be taken to release the denture from the abutments without displacing the implants.

The conversion prosthesis now contains the temporary cylinders. Before proceeding, the integrity of the temporary cylinder bond with the conversion prosthesis should be examined. If the temporary cylinder moves, additional resin should be placed around the cylinder, the conversion prosthesis reseated onto all abutments using light finger pressure to tighten all bridge screws, and the temporary cylinder polymerized in its proper orientation. In all cases, it is important to place the untrimmed conversion prosthesis onto all abutments to visually verify accuracy of fit. There should be no visual discrepancies at the abutment/temporary cylinder interfaces at this time. Working at the abutment/temporary cylinder interface offers the distinct advantage of visualization in a relatively bloodless field when compared with procedures that require manipulation at the implant/abutment interface before final suturing of the surgical site.

Completion of the conversion prosthesis requires removal of all flanges and palatal denture base material (Fig 6F). If the final result will be a prosthesis free of tissue contact, then the conversion prosthesis should resemble this plan. If, on the other hand, the prosthesis is to contact tissue or include ovate pontic designs, then this is the appropriate time to fully develop this architecture by addition of acrylic resin. In any event, the trimmed and refined conversion prosthesis should be free of voids and excess acrylic monomer, highly polished (pumice and buffing compound), cleaned, and disinfected. It is recommended that the polished prosthesis be cleaned using soap and a toothbrush to remove loose debris or by placing it in an ultrasonic cleaner for 5 minutes, followed by disinfection by placement into chlorhexidine gluconate (0.12%) mouth rinse for 5 minutes just before insertion.

The insertion of the screw-retained conversion prosthesis is rapidly achieved by placement of all bridge screws with finger tight pressure (Fig 6G). The screw access holes are also rapidly filled using a vinyl poly siloxane material and a syringe tip followed rapidly by rubbing the area with a gloved finger coated with lubricant to provide a smooth and non-irritating surface. This plug of material can be removed instantly at the 8- to 10-week period to gain immediate access to the bridge screws. Thereafter, conventional steps in the process of creating a final implant-supported, fixed denture are performed using the tooth position designated by the original denture tooth arrangement as a guide for the final prosthesis.

The final step in delivery for immediate loading of the edentulous maxilla is to verify that there exist bilateral, broadly distributed, and symmetrical interocclusal contacts in centric relation following delivery of the prosthesis. Careful evaluation using dental articulating paper and mylar shim stock is advocated for checking that all mandibular buccal cusps are contacting the maxillary prosthesis equally. Moreover, excursive contacts should be well distributed among the teeth contacting on the working side, and the cusp height/cusp angles should be designed as low as feasible during this healing period.

Immediate Loading of the Edentulous Maxilla Using a Cement-Retained, Fixed Partial Denture

When implants are placed using a surgical template derived from a diagnostic waxing of a fixed partial denture, the planning of implant placement is also guided by using a tomographic template also derived from this waxing. The surgical template can be duplicated in tooth-colored resin or serve a dual role as the template and the basis for the prosthesis (Fig 7A-E). The designated cervical contour of the interim, fixed prosthesis is

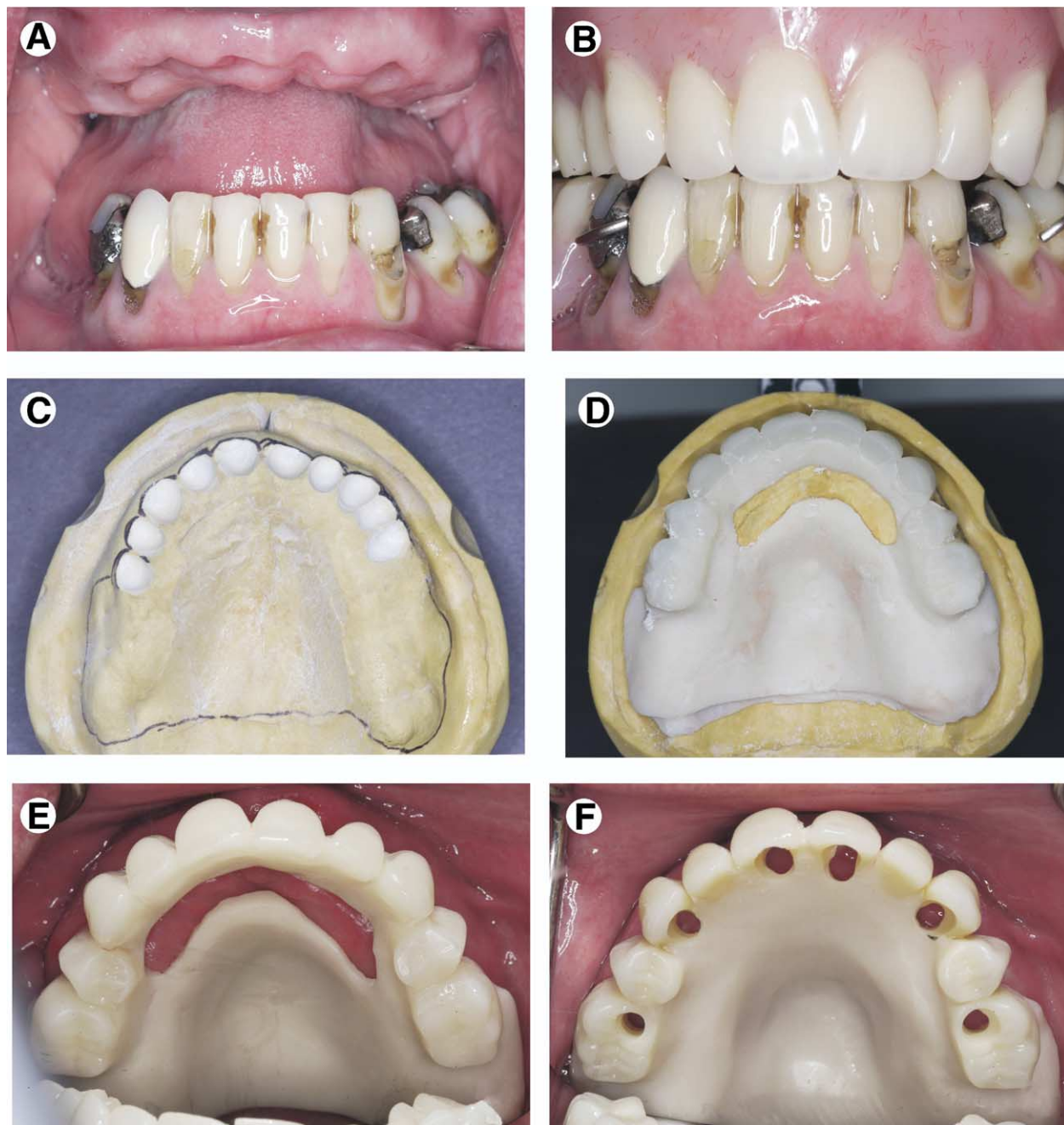


FIGURE 7. Immediate loading using a cement-retained provisional prosthesis developed by use of a stabilized acrylic, fixed partial denture technique. *A*, Preoperative condition of the edentulous maxilla 3 months after tooth extraction. *B*, The transitional denture defines the position of the planned fixed prosthesis. *C*, Using a duplicate denture (Fig 4), the cervical contours of the planned prosthesis are transferred to the working cast. *D*, The stabilized acrylic, fixed partial denture is created in tooth-colored acrylic by duplicating the denture using a silicone index. *E*, A second duplicated denture is also made and used as the surgical template by creating drill access holes and trimming the buccal flanges to the designated cervical contours. *F*, Flapless implant placement is guided in 3 dimensions by the surgical template. **(Figure 7 continued on next page.)**

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especially important for a cement-retained prosthesis because the implant/abutment finishing line should be placed approximately 1 mm beneath the soft tissue margin when tooth-like soft tissue contours are desired.

After abutment placement into the implants, the interim prosthesis must draw over the abutments

without any interference. Appropriate relief must be created to assure that the tissue bearing surface of the interim prosthesis and the occluding surface of the interim fixed partial denture remain intact to guide prosthesis position (Fig 7F,G). If divergent implant placement does not permit interim prosthesis place-

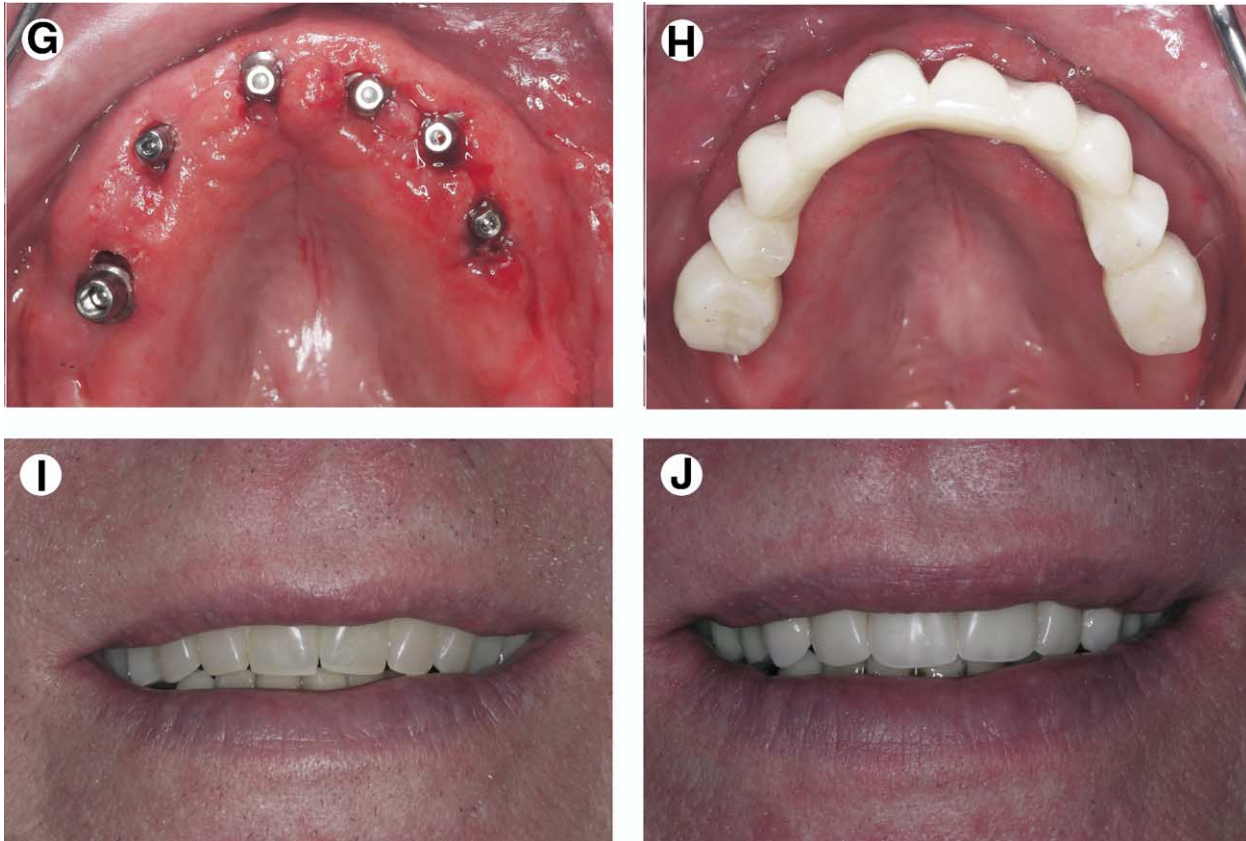


FIGURE 7 (cont'd). G, Following implant placement, the stabilized acrylic, fixed partial denture is relieved internally to fit over the abutments and is orientated by the palatal tissue contact and the occlusal contacts. H, The relined acrylic, fixed partial denture is trimmed, highly polished, and cemented onto the abutments. Comparison of the planned tooth position displayed by the transitional denture (I) and the cemented, fixed partial denture for immediate loading (J) demonstrates the control of the midline, plane of occlusion, and esthetic tooth form.

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ment or interferes with path of draw, then alternative angled abutments should be placed or minor adjustment of the abutment can be made at this time. Unlike the screw-retained prosthesis that permits from 40° to 90° divergence, cement-retained abutments frequently allow only 10° to 30° divergence of implants.

After the path of draw is clearly defined, the mandatory steps in preparing for the intraoral relining or indexing of the provisional prosthesis are the same as those described above for the conversion prosthesis. The acrylic, fixed denture template may then be placed over the abutments and relined with acrylic resin. As the resin polymerizes, the acrylic, fixed denture should be lifted and replaced to avoid locking polymerized resin into undercuts. When fully polymerized, the acrylic, fixed denture is trimmed of over-extended materials and placed onto the abutments to assess goodness of fit. The margins can be highly refined by their extraoral adaptation to abutment analogs. Proper transition contours and tooth morphology should be accurately carved and refined before careful polishing. The interim prosthesis should be cleaned and disinfected as previously described.

The cementation of the interim, fixed partial denture prosthesis must be performed carefully. Any resultant prosthesis mobility is a considerable risk to implant stability and osseointegration. Therefore, while different cements may be used, we have used permanent cement (Ketac-Cem Maxicap or Duralon; 3M ESPE, Seefeld, Germany) to assure lasting cementation during the immediate loading and provisionalization period of 8 to 12 weeks (Fig 7H). This choice better assures that the prosthesis will remain intact without possible patient attempt to recement it in a nonideal position. Often, the prosthesis can be removed using hemostats and direct occlusal force. Any residual cement may cause inflammation and compromise bone and soft tissue healing.¹⁵ All efforts must be made to limit cement extrusion beyond the abutment/restoration margin and, in particular, into the peri-implant mucosal tissues. Avoiding unwarranted deep implant placement helps in this effort. While all attempts are made to remove excess cement at the immediate loading visit, evaluation of the patient for retained extruded cement is a primary goal of the 1-week recall visit. The final step before completion

of the immediate loading procedure is to adjust and verify that the occlusion offers bilateral and symmetrical contacts in centric relation and is free of single-tooth excursive contacts. When complete, the immediate loading procedure should provide a prosthesis that duplicates the designated tooth arrangement illustrated by the diagnostic waxing or accepted interim denture (Fig 7I,J).

Previous reports state that the adaptation of laboratory-prepared provisional restorations is necessary to accommodate radical change between the pre- and post-implant surgery situation.¹⁰ Experience developed over 4 years of providing this therapy has shown that the provisional restoration design serves a greater purpose of integrating the diagnostic, surgical, and immediate provisionalization phases of treatment. The designation of tooth position and identification of the cervical contours of prosthetic teeth provide the guidelines for ideal implant positioning. When defining the relationship of the planned tooth position with available alveolar bone is achieved using the same diagnostic tool, then synergy in surgical and restorative planning is achieved and is evident when abutment selection occurs before implant placement. Progression to surgery using the same diagnostic tool that designates the cervical contours of the restoration assures accuracy of implant placement in 3 dimensions. Finally, when this diagnostic tool serves as the template or foundation for the interim prosthesis or conversion prosthesis, fully integrated therapy is achieved for immediate loading of the edentulous maxilla. This process can be achieved in the analog state using articulated casts, diagnostic dentures, and interim prostheses. This approach is highly adaptable and reinforces the initial steps of defining tooth position. Alternative methods using computer-aided design also appear ready for clinical translation.^{16,17} Despite computer-aided design, the initial diagnostic steps of tooth position and esthetic evaluation require clinical intervention and denture construction.

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