Full-Arch Implant Surgical and Restorative Considerations: Utilizing a Full Template Guidance Technique

Category: Implants Created: Sunday, 01 September 2019 00:00 Written by Drs. Scott D. Ganz and Isaac Tawil Print

INTRODUCTION

Full-arch dental implant reconstruction requires proper diagnosis and treatment planning to assess the existing patient anatomy, any pathologies, occlusion, soft-tissue volume, lip support, and aesthetics, and gain understanding of the desired outcome.[1] A decision tree can be established based upon sound prosthodontics and surgical protocols to maximize success when a full-arch, implant-supported reconstruction is contemplated. Technological innovations can only enhance the diagnostic, treatment planning, communication, surgical, and restorative aspects for each patient. Three-dimensional imaging modalities afforded by current cone beam computed tomography (CBCT) provides the foundation for all that follows[2,3] (Figure 1). The native DICOM (Digital Imaging and Communications in Medicine) data, once imported into an interactive treatment planning software application, allows for careful inspection of the existing anatomical presentation to identify potential implant receptor sites that will aid in realistic implant placement simulations and avoid potential complications (R2Gate Software [MegaGen]) (Figure 2).[4] Regardless of the eventual surgical protocol, the authors believe that the diagnostic phase must be based on a complete and thorough review of the CBCT scan data.[5]

Figure 1. Three-dimensional imaging modalities afforded by current cone beam computed tomography (CBCT) are essential for proper diagnosis and treatment planning.

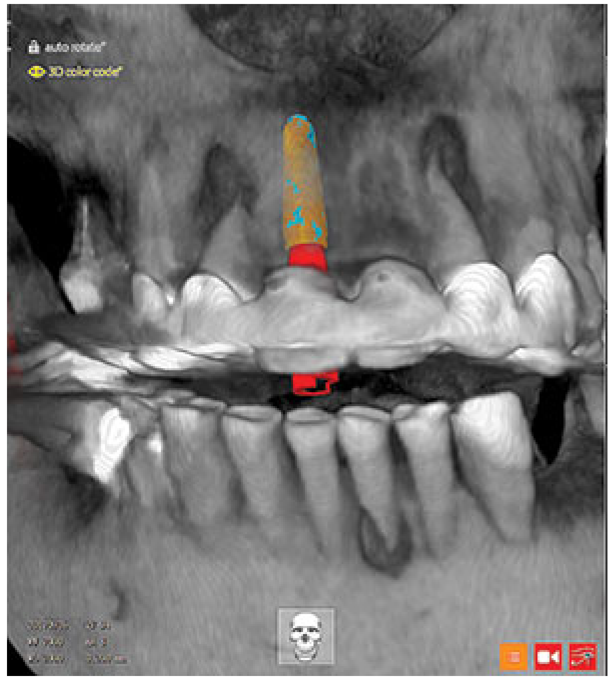

Figure 2. Interactive treatment planning software, such as the R2Gate Software (MegaGen), helps clinicians identify potential implant receptor sites to aid in realistic implant placement simulations.

Figure 3. A failing maxillary and mandibular dentition exhibited mobile teeth, a poor bite, mal-aligned teeth, and bone loss.

CASE REPORT

A failing maxillary and mandibular dentition exhibited mobile teeth, a poor bite, mal-aligned teeth, and bone loss (Figure 3). The CBCT data were analyzed to determine the most appropriate treatment alternatives based upon bone quality, bone density, and an appreciation of the patient's desires. Utilizing advanced software applications (Blue Sky Plan [Blue Sky Bio]), the diagnostic information for implant planning can be fully appreciated in all of the necessary views, including cross-sectional, coronal, sagittal and axial, and in 3-D reconstructed surface models. Implant receptor sites can be identified, and virtual implants can be positioned with each of the previously mentioned views, as no single view can provide all of the necessary information to achieve success (Figure 4a). Placing an implant into a cross-sectional slice is only the beginning of the process of helping to visualize the thickness and opacity of the buccal and palatal cortical plates and the quality of the intermedullary bone to determine whether an implant can be placed that has an appropriate length and diameter to fit the remaining alveolus, based upon the "Triangle of Bone" protocol[6] (Figures 4b and 4c). Additionally, virtual implant simulation plays a significant role in managing the desired restorative outcomes based upon tooth position and the choice of screw or cement retention (Blue Sky Bio). In the authors' opinion, the most efficient manner to facilitate the process is to extend an “abutment projection” from the coronal aspect of the implant through the occlusal table, as visualized in yellow in Figures 4a and 4b. When a guided surgical approach is contemplated, the template can be designed to be tooth-borne, bone-borne, or mucosal-borne. When appropriate, it is important that the drill guide be stabilized to prevent any movement during surgery. One aspect that is often underestimated is the planning of fixation or anchor pins to help achieve the highest degree of surgical accuracy. Each potential anchor pin must be positioned to avoid adjacent vital structures and engage dense cortical bone, helping to gain bicortical stabilization when possible. This will often penetrate both buccal and lingual plates and avoid close proximity to implant receptor sites (Figure 5).

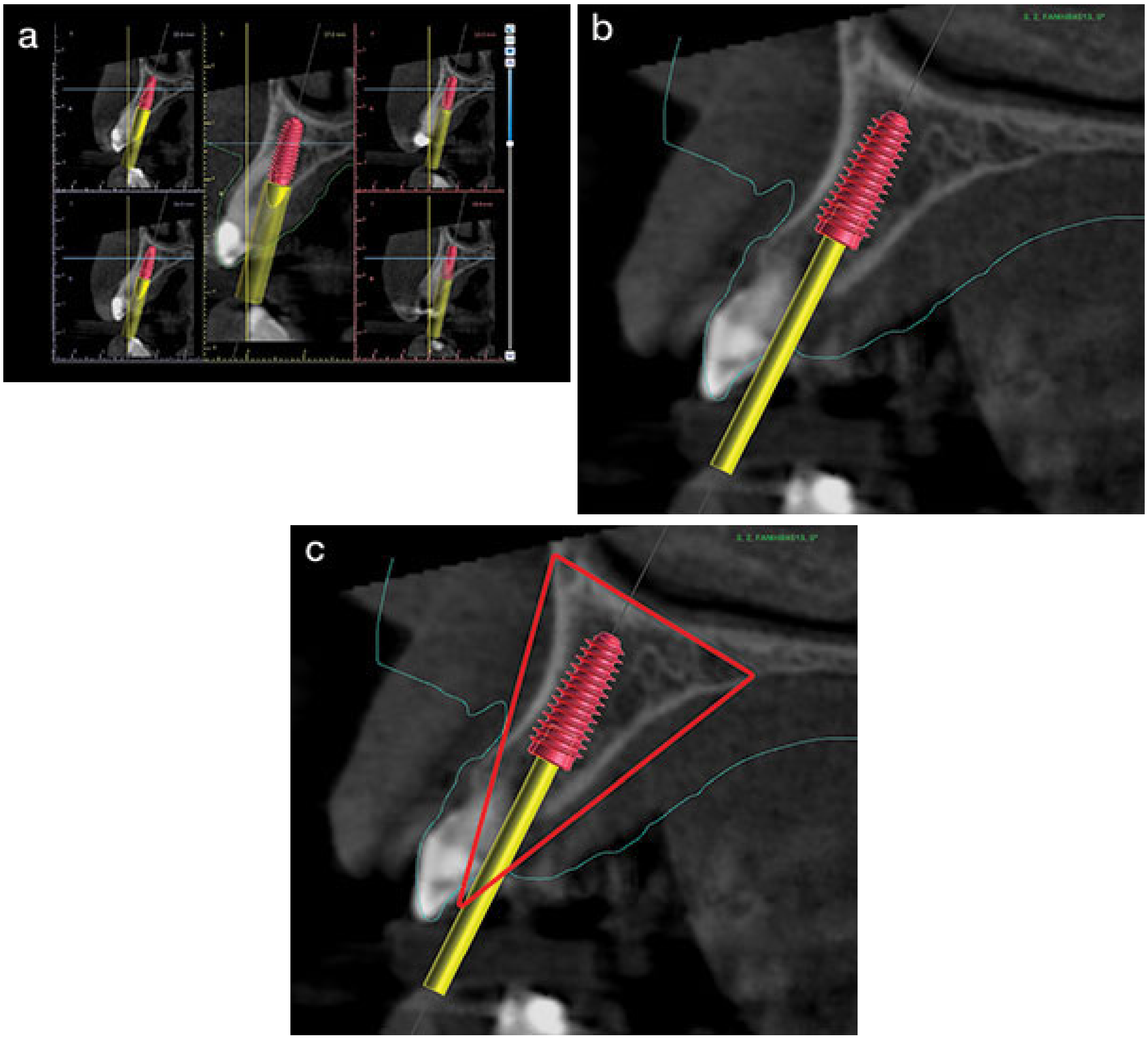

Figure 4. (a) Implant receptor sites were identified, and virtual implants were positioned in the cross-sectional slices. **(b)** The diagnostic process visualized the buccal and palatal cortical plates and the quality of the intermedullary bone. **(c)** An appropriate length and diameter implant was positioned within the remaining alveolus based upon the “Triangle of Bone” protocol.

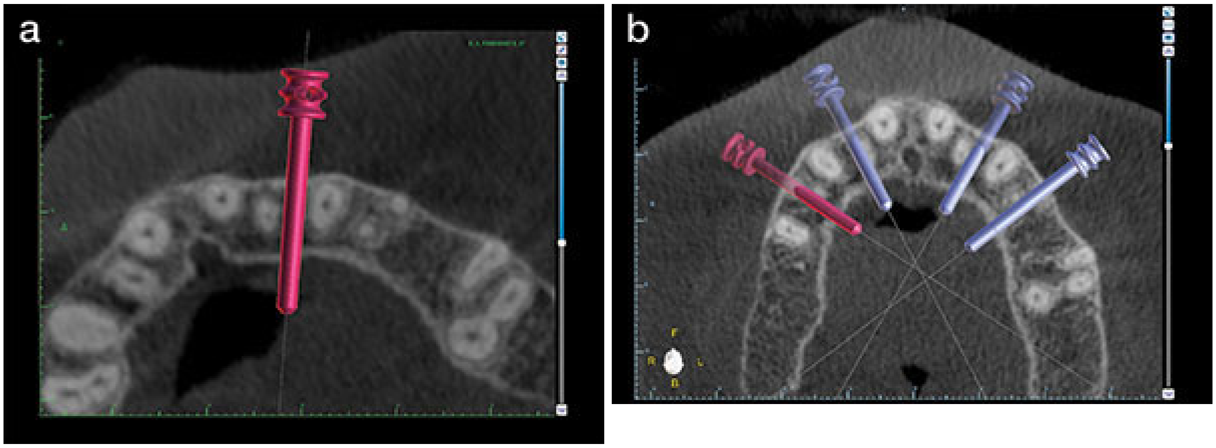

Figure 5. Anchor pins were carefully positioned to avoid adjacent vital structures and engage dense cortical bone, helping to gain bicortical stabilization when possible. They will often penetrate both buccal and lingual plates and avoid close proximity to implant receptor sites.

The diagnostic phase is greatly enhanced when the existing intraoral condition can be captured with either an analog or a digital method. In a traditional analog method, a physical impression records the teeth and soft tissue. A stone model can then be fabricated from the impression. To facilitate 3-D planning, the stone cast can then be digitized using a desktop scanner. Alternatively, the impression itself can be scanned, resulting in an STL (stereolithography) file that can be aligned to the opposing occlusion and then merged to the CBCT DICOM dataset (Figure 6). The fully digital method utilizes an intraoral scanner to directly digitize the oral condition.[7] Full-face, intraoral retracted views and smiles (not shown) are often required to complete case planning. Through the process of segmentation, a surface model can be reconstructed from the DICOM data based on bone density (Figure 7a). Often, this process is hindered by metal scatter artifact from existing ceramo-metal restorations, making it difficult to adequately define the anatomy. Therefore, it is recommended that there be a space between the upper and lower jaws when the CBCT scan is acquired. As good segmentation is often very time consuming, third-party companies, such as 3D Diagnostix, are available to manage this often-essential aspect of implant planning. Present software applications allow for extremely accurate merging of STL files and DICOM data (Figure 7b). To complete the planning process, a diagnostic wax-up or virtual tooth setup of the desired prosthetic outcome can be designed to achieve true, restoratively driven implant placement when applied to 3-D surface DICOM data[8] (Figure 8). The final plan often requires bone reduction to facilitate implant placement and the necessary restorative space for the prosthesis.[9]

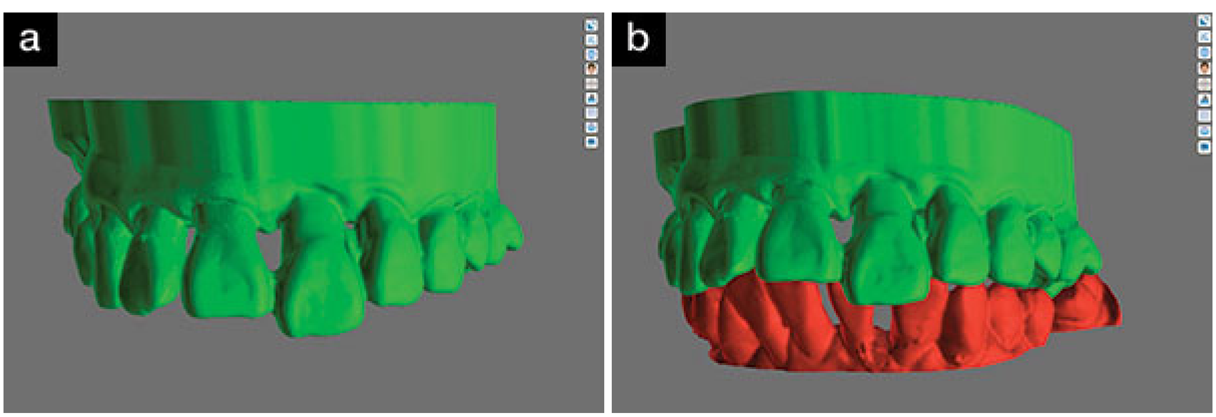

Figure 6. (a) The stone cast was digitized using a desktop scanner. **(b)** The resultant STL (stereolithography) file was aligned to the opposing occlusion and merged to the CBCT DICOM (Digital Imaging and Communications in Medicine) dataset.

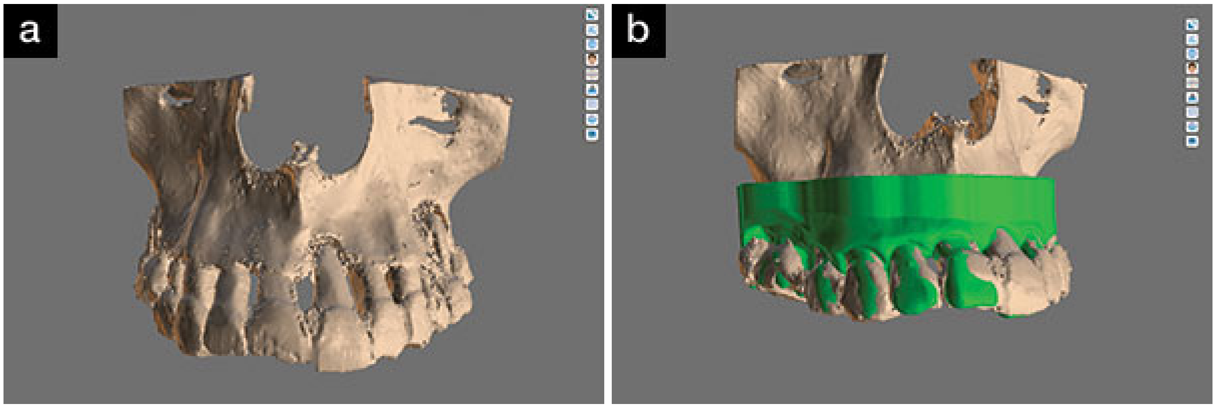

Figure 7. (a) Through the process of segmentation, a surface model was reconstructed from the DICOM data based on bone density. **(b)** Present software applications provided extremely accurate merging of the STL files of the pre-existing intraoral occlusion and the DICOM data.

An innovative approach to full-template guidance utilizes the existing dentition to position a metal "fixation base" (FB) to which everything else will be related (GuidedSmile CHROME [ROE Dental Laboratory]). Positioning the FB over the teeth is accomplished with a "pin guide" that orients the base in the proper position. A full-thickness, muco-periosteal flap reflects the tissue sufficiently within the vestibule to allow for positioning of the fixation pins (Figure 9). Prior to seating over the teeth, the FB is securely attached to the pin guide with a series of "Swiss locks" and delivered over the teeth (Figure 10a). This method allows for the metal frame to be correctly positioned. Proper fit of the pin guide over the teeth is essential and can be verified by visual inspection though the "windows" of the resin. In this case, 4 anchor pins were utilized to stabilize the metal guide (Figure 10b). As previously stated, it should be noted that planning for the location of receptor sites for the anchor pins is as important as planning for the position of the implants—ensuring that they are all located in good-quality bone, often taking advantage of both buccal and lingual/palatal cortical plates.

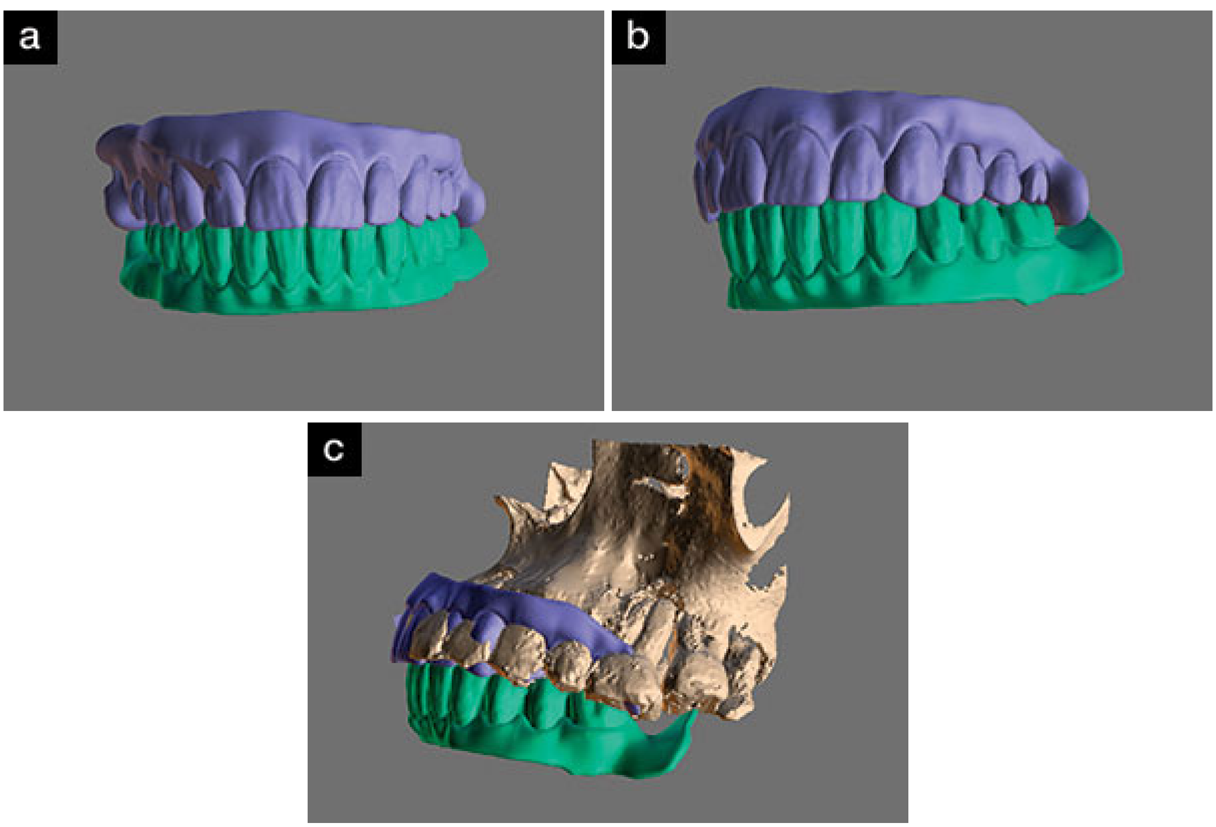

Figure 8. To complete the planning process, the diagnostic wax-up or virtual tooth setup of the desired prosthetic outcome was applied to the 3-D surface DICOM data in seeking to achieve true, restoratively driven implant placement.

Figure 9. A full-thickness, muco-periosteal flap reflects the tissue sufficiently within the vestibule to allow for fixation of the anchor pins to the underlying bone.

After the FB was secured to the bone, the pin guide was removed, leaving the maxillary teeth available for extraction (Figure 11a). The teeth were all carefully removed, leaving the remaining alveolus exposed (Figure 11b). It should be noted that the metal guide for this case example was designed to sit floating away from the bone. Planning for a full-arch restoration may require bone reduction to provide the restorative space required, which can be accomplished with rotary instrumentation, piezo ultrasonic surgery, or a reciprocating saw (Figure 12a). The amount of bone reduction needed was determined after a careful evaluation of potential implant sites in relation to the desired prosthetic outcome (Figure 12b). The outer aspect of the metal FB was used as a bone reduction guide as first defined by Ganz (2006).[9]

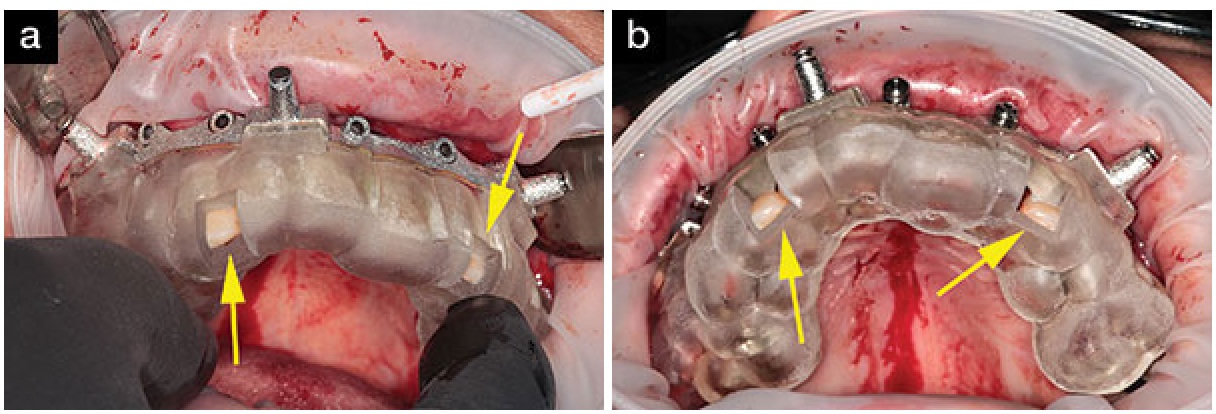

Figure 10. (a) Prior to seating over the teeth, the "fixation base" (FB) was securely attached to the pin guide with a series of "Swiss locks" and delivered over the teeth.
(b) Proper fit of the pin guide was verified by inspection though the "windows" of the resin. In this case, 4 anchor pins were utilized to stabilize the metal guide.

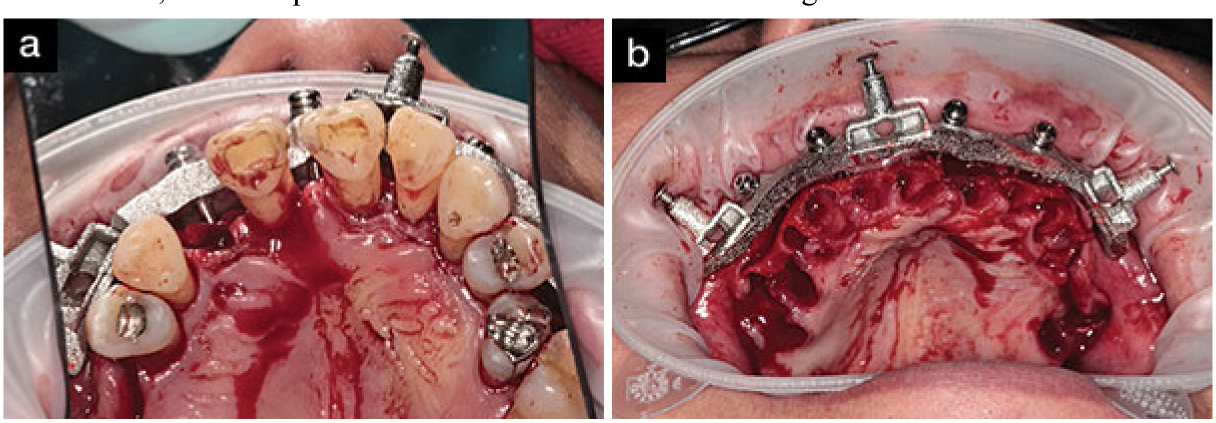

Figure 11. (a) After the FB was secured to the bone, the pin guide was removed, leaving the maxillary teeth available for extraction. **(b)** The teeth were all carefully removed, leaving the remaining alveolus exposed.

The "carrier guide" (CG) serves several purposes. The translucent resin plate is first utilized to check if adequate bone reduction has been accomplished. The CG will not fit passively into the Swiss locks if the bone has not been properly leveled. The compressed area of bone can often be visualized through the resin (Figure 12c).

Full-template guidance allows for the precise drilling of the implant osteotomies with or without the use of sleeves embedded within the surgical template or separate key inserts that match the drill diameters of the guided surgical kit that must be utilized. Innovative designs have allowed for the elimination of these separate components, simplifying the drilling protocol. The R2Gate Guided Surgery Kit consists of a sequential series of drills that match the diameter of either a resin surgical guide or a metal guide, as illustrated in this case example (Figure 13). The wide drill core or barrel will engage the entire vertical height of the guide cylinder to ensure drilling accuracy and depth control. Starting with a short drill and gradually using longer drills within the initial osteotomy helps to maintain proper trajectory until final implant diameter and depth are achieved. The osteotomy drill guide was seated onto the FB and secured by the Swiss locks (Figure 14a). Each osteotomy is carefully prepared with R2Gate Guided Surgery Kit sequential surgical drills at the recommended drilling speed (Figure 14b). Accurate guided surgery requires accurate drilling, followed by accurate placement of the implants. If the implants are placed freehand after using drill guides, they are referred to as "template-assisted" (Ganz-Rinaldi Classification 2015).[10] Inaccuracies can arise with freehand placement. Full-template guidance means the implant is delivered through the template after the osteotomies have been completed. In order to achieve full-template guidance, a manufacturer-specific implant carrier must be used to engage the inner walls of the template cylinders as specified by the planning software. Each implant was first attached to the implant carrier and delivered to the site at the appropriate rotational speed and torque (Figure 14c). To maximize implant stability within the maxillary bone, it was important to use an appropriate implant design. Six AnyRidge implants (integrated dental systems) were placed, first using the handpiece and then hand-torqued until final depth was achieved (Figure 14d). Each implant was tested for stability using resonance frequency analysis (Mega ISQ [integrated dental systems]) and found to be sufficient to receive an immediate restoration.

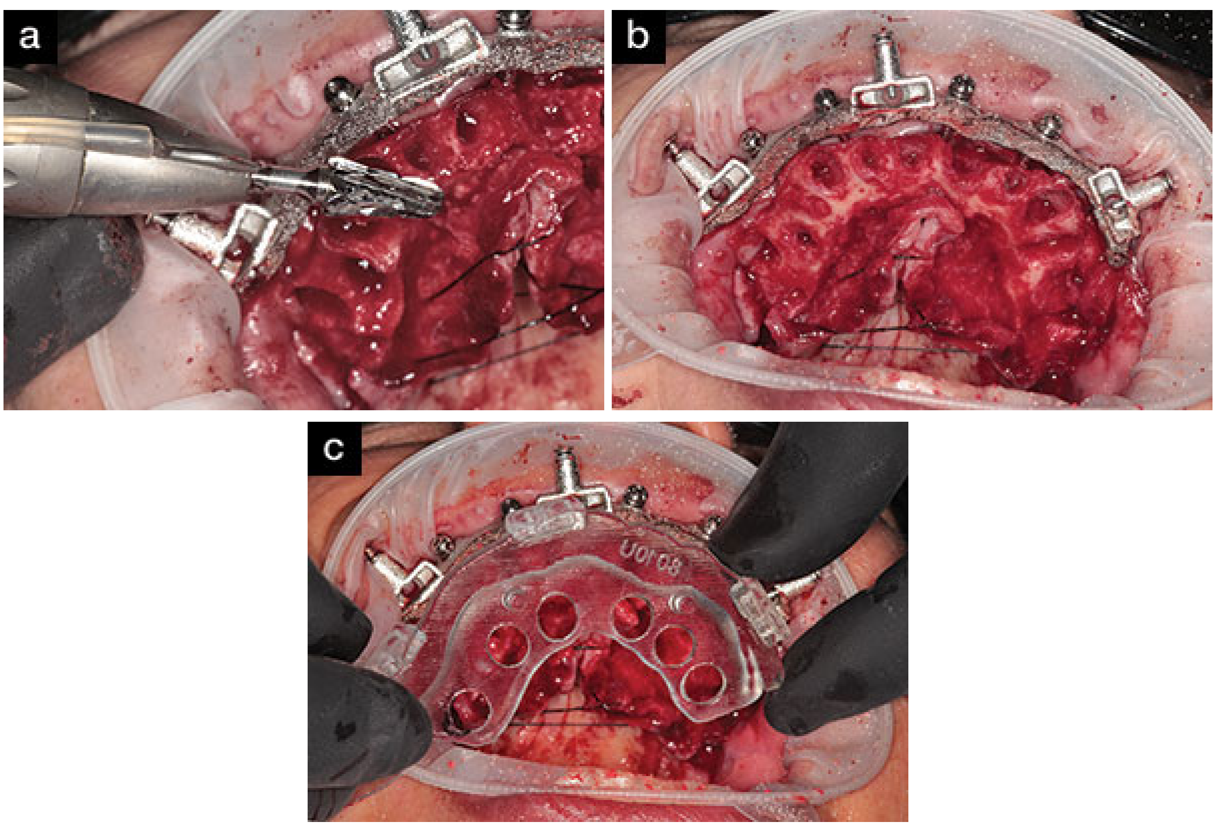

Figure 12. (a) Rotary instrumentation (round and serated tapered burs from Meisinger

USA) was used to manage bone reduction and was required to provide **(b)** adequate restorative space as determined after careful evaluation of potential implant sites in relation to the desired prosthetic outcome. **(c)** The "carrier guide" (CG) fit passively into the Swiss locks to verify that the bone had been properly leveled.

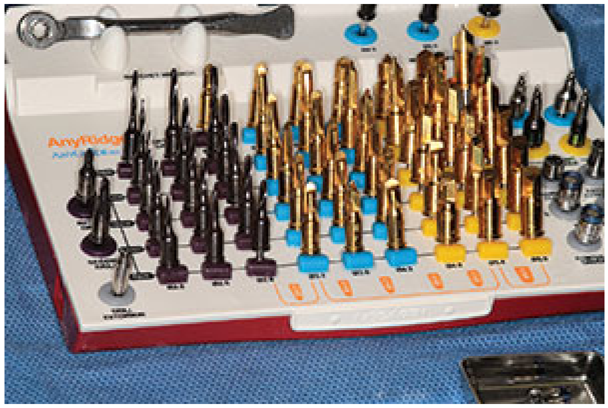

Figure 13. The R2Gate Guided Surgery Kit consists of a sequential series of drills to achieve full-template guidance in a keyless system.

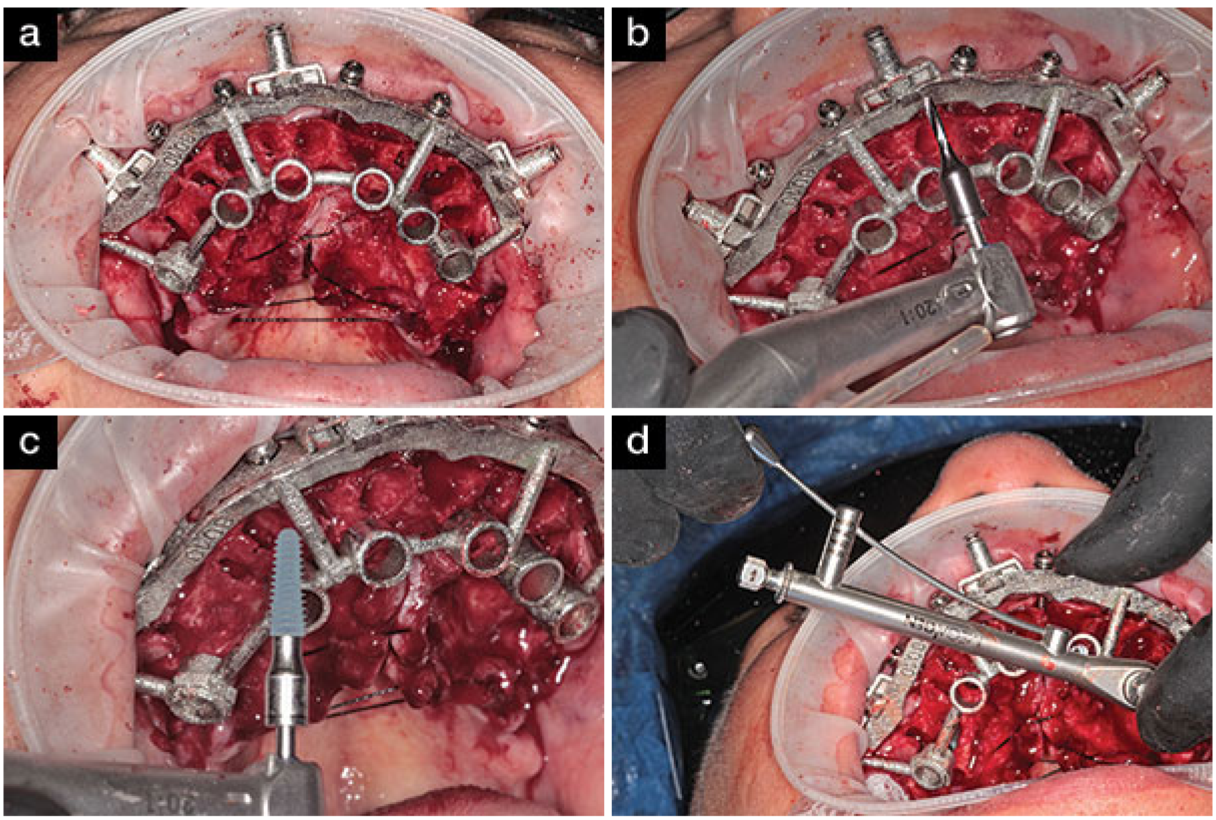

Figure 14. (a) The osteotomy drill guide was seated onto the FB secured by the Swiss locks. **(b)** Each osteotomy was carefully prepared with R2Gate sequential surgical drills with the wide core or barrel that engaged the entire vertical height of the guide cylinder to ensure drilling accuracy and depth control. **(c)** Each AnyRidge implant (integrated dental systems) was first attached to its matching implant carrier and then delivered to the site at the appropriate rotational speed and torque. **(d)** Six AnyRidge implants were placed by first using the handpiece and then hand-torquing them until final depth was achieved.

Prior to inserting screw-receiving abutments, the carrier guide was once again seated on the FB. Depending upon the manufacturer, multi-unit abutments (MUAs) are generally available in various tissue cuff heights and angles that are established during the planning phase. The second purpose of the CG is to help guide the placement of the MUAs through the predefined holes and onto each implant. The anterior implants received AnyRidge straight MUAs for the screw-retained prosthetic result, and the posterior-most implants received 30° MUAs. The final purpose of the CG is to orient the transitional prosthesis to the predetermined position of the implants by utilizing the "resin pillars" (Figure 15a, blue arrows). The right and left distal implants must be rotated so that the angled MUAs allow for the screw-access hole to fit within the envelope of the prosthesis by utilizing titanium sleeves and screws (Figure 15b). The titanium sleeves will then be incorporated into the transitional prosthesis with a dual-cure acrylic (Quick Up [VOCO]). Prior to inserting the acrylic, a small, oval-shaped piece of rubber dam is placed over each titanium sleeve to protect the underlying surgical site. An alternative method allows for the prosthesis to attach directly to the fixation guide (Figure 15c). Once the acrylic had reached a final set, the prosthesis was then removed and examined for any acrylic deficiencies or gaps. These gaps were all filled, and the prosthesis was polished. While the prosthesis was adjusted, any bony defects were filled with corticocancellous allograft (Maxxeus Dental Community Tissue Services), and the area was covered with layers of platelet-rich fibrin and sutured around the MUAs. The transitional prosthesis was delivered to the patient with minimal bite adjustments (Figure 16). The lower full-arch, implant-supported reconstruction was completed during the same visit (ROE Dental Laboratory).

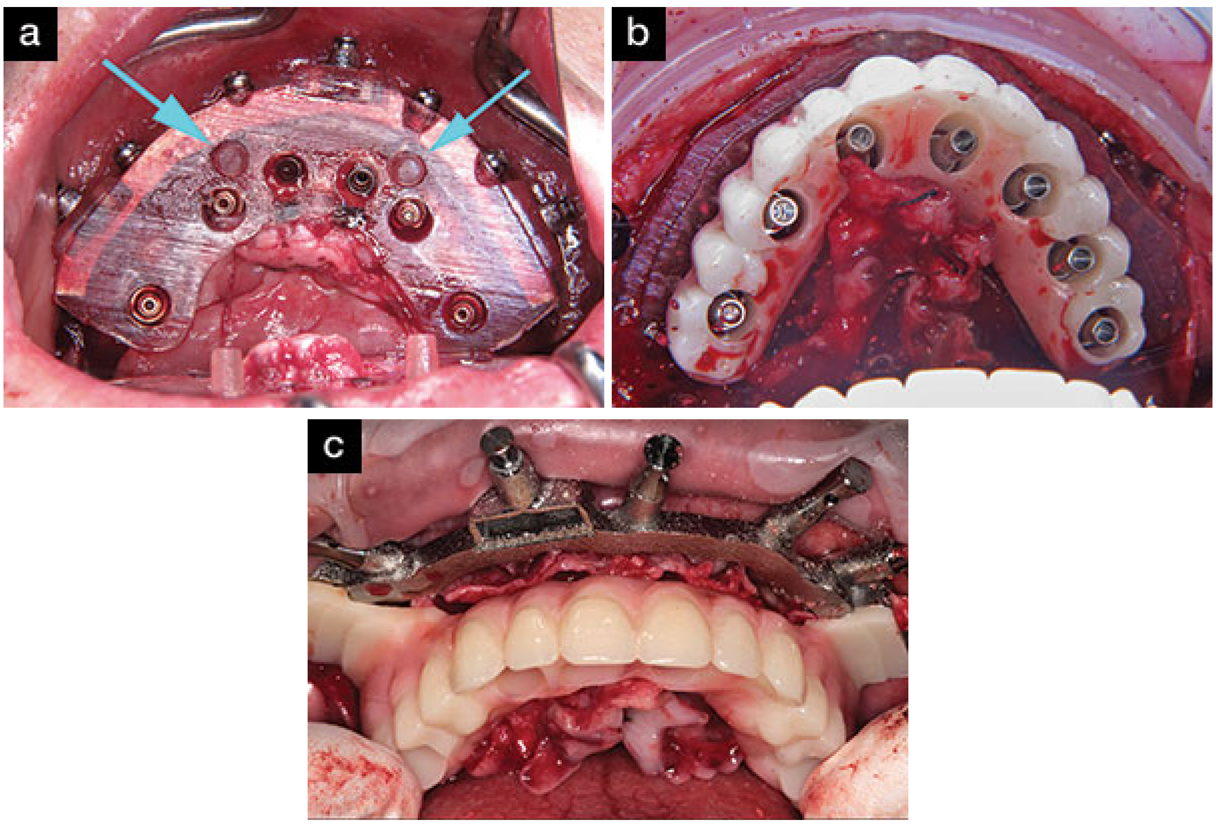

Figure 15. (a) The second purpose of the CG was to help guide the placement of the multi-unit abutments (MUAs) through the predefined holes and onto each implant. The final purpose of the CG is to orient the transitional prosthesis to the predetermined position of the implants by utilizing the "resin pillars" (blue arrows). **(b)** The right and left distal implants must be rotated so that the angled MUAs and attached titanium sleeves fit within the envelope of the prosthesis. **(c)** An alternative method, when space is limited, allows for the prosthesis to attach directly to the fixation guide.

Figure 16. The transitional upper and lower prostheses (completed at the same visit) were delivered to the patient with minimal bite adjustments (ROE Dental Laboratory).

CLOSING COMMENTS

The ability to incorporate 3-D imaging modalities, when combined with interactive treatment planning softwares has greatly enhanced the clinicians' ability to diagnose and treatment plan for single and multiple implants.[11,12] As technology has advanced, guided surgery protocols have improved, offering innovative alternatives for partially and fully edentulous patients. While CT-derived surgical templates have been available for almost 2 decades, the focus has been on the surgical aspect of implant placement. Interactive treatment planning software has provided clinicians with an appreciation of the bony anatomy to assess implant receptor sites and even more. The evolution of guided applications has included the development of the bone reduction guide, the sinus lift guide, and the harvest guide for guided bone grafting procedures. Software applications, such as R2Gate and Blue Sky Plan, allow for the planning of implants in relation to the desired prosthetic outcomes. However, the missing link has been the accurate orientation of the prosthesis at the time of surgery. The merging of CAD/CAM design with 3-D DICOM data enables restoratively driven implant planning at a very high level. Implants can be predictably placed with the prosthetic outcome in mind—critical for immediate loading of full-arch restorations.

The case example presented herein illustrates the use of a stackable system that provides a fixation base anchored to the bone to which a drill guide can be mounted for accurate osteotomies and a carrier guide can oriented to the transitional prosthesis. This greatly facilitates the processes of immediate placement and immediate restoration. Further research will be required to validate the methods and long-term outcomes of this full-template guidance solution for full-arch implant reconstruction.

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Disclosures: Dr. Ganz recieves honoraria for lectures from ROE Dental Labs, IDS, MegaGen, Meisinger USA, and Osstell. Dr. Tawil reports no disclosures.

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