Full-Arch Implant Surgical and Restorative Considerations: Innovative Digital Workflow Using a Verification Jig With Teeth

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If a patient presents with a failing dentition, there are several different treatment options available when a fixed-prosthetic result supported by dental implants is contemplated. This could include extraction and bone grafting, allowing the ridge to heal before implants are placed, or extractions and immediate implant placement with concurrent bone grafting to fill any voids in the remaining bony architecture. These 2 examples would usually leave the patient with a removable, complete denture during the healing phase prior to loading of the implants for either a fixed or removable restoration. A treatment alternative presented by Ganz and Tawil in *Dentistry Today* (September 2019) described the necessary steps to achieve restoratively driven surgical planning for full-arch implant reconstruction when implants were loaded the day of surgery with a prefabricated fixed, provisional restoration.

The immediate loading of dental implants offers many advantages over delayed treatment alternatives, including (1) the surgical phase generally being completed in one visit, (2) the ability to plan the pre-established occlusion in advance to achieve an immediate functional and aesthetic result, (3) reducing overall treatment time for the definitive restoration, and (4) a reduction in the number of patient visits. As technology continues to evolve, so do the variations in protocols that have been developed to enhance the process of delivering both preoperative and postoperative treatment. This article presents innovations that can improve the workflow in ways that are essential to improve efficiencies and achieve success with single and dual full-arch implant reconstructions.

Figure 1. The preoperative intraoral, retracted view illustrates missing, broken, fractured, and decayed teeth with plaque and calculus accumulation, revealing severe soft-tissue inflammation.

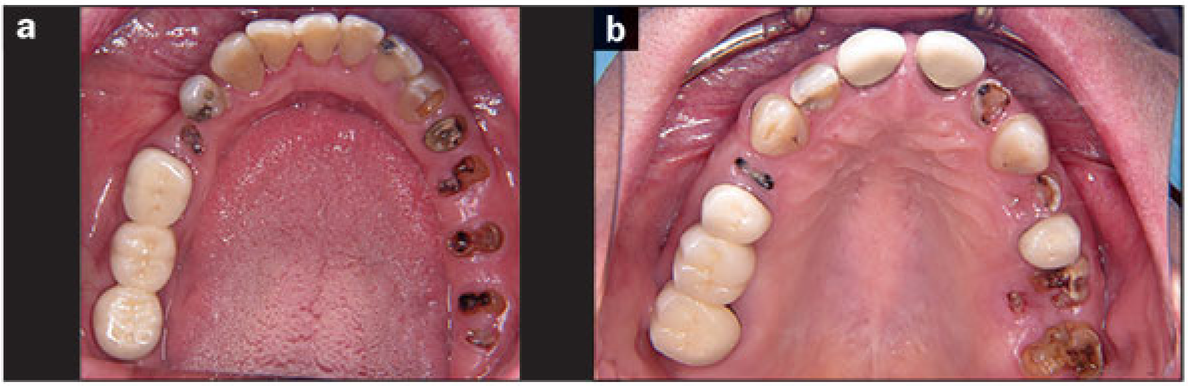


Figure 2. The patient complained of pain and difficulty chewing and exhibited a reduced vertical dimension of occlusion and hyper-erupted posterior teeth.

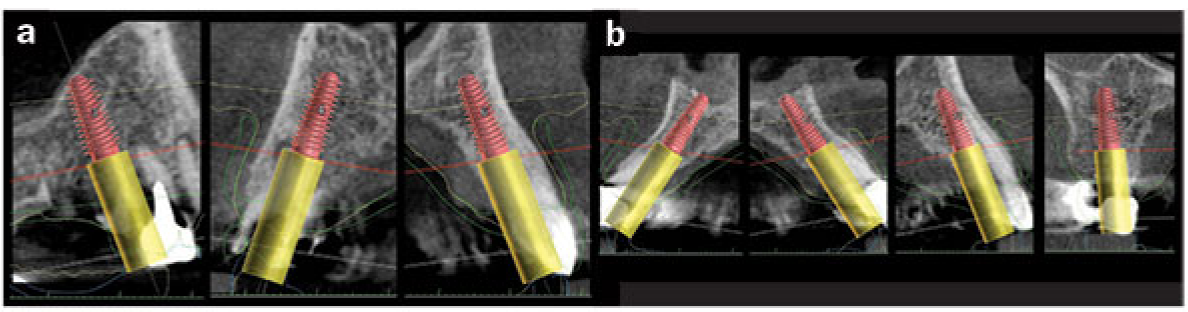


Figure 3. Cross-sectional images reveal the planned positions of each implant. Note the yellow "projections," which reveal the trajectory and position of the screw-access holes as they emerge through the tooth set-up outline (green). The red line represents the coronal portion of the implants and where the bone will be reduced.

Diagnostics and Surgery Phase

A 58-year-old male presented with a failing dentition. The pre-op, intraoral, retracted view illustrates missing, broken, fractured, and decayed teeth and plaque and calculus accumulation with severe soft-tissue inflammation (Figure 1). The patient complained of pain and difficulty chewing and exhibited a reduced vertical dimension of occlusion (VDO) and hyper-erupted posterior teeth (Figure 2). The pre-existing intraoral condition was recorded with impressions and stone casts that were then digitized with a desktop scanner. Additionally, an intraoral scan (3Shape) recorded the existing occlusion. The patient's anatomy was fully assessed with 3-D imaging technology and interactive treatment planning software. Cone-beam computed tomography (CBCT) (Carestream Dental) was essential in being able to visualize the periapical pathology exhibited by multiple teeth. Utilizing the digitized casts, the dental laboratory team completed a virtual tooth setup to establish the correct plane of occlusion, function, and aesthetics. The virtual occlusion was merged to the original teeth to assist in the diagnostic phase of selecting the appropriate implant receptor sites. The dimensions and volume of the alveolar bone, thickness and opacity of the cortical plates, and overall density were important in evaluating each implant receptor site necessary for initial stability. The positions of the 7 proposed implants were planned to achieve a screw-retained fixed restoration (Figure 3). It is important to note the yellow "projections," which reveal the trajectory and position of the screw-access holes as they emerge through the tooth set-up outline (green). The red line represents the coronal portion of the implants and where the bone will be reduced to create the necessary restorative space.

Figure 4. The necessary components included the tooth-borne Fixation Base with Pin Guide, anchor pins, bone reduction guide, osteotomy drill guide, Carrier Guide, transitional full-arch prosthesis, and various 3-D printed models for both maxillary and mandibular arches.

Figure 5. The Fixation Base was first secured to the Pin Guide and then seated on the maxillary teeth so that facial anchor holes could be drilled and anchor pins could be placed through the guide holes of the Fixation Base.

Figure 6. The Carrier Guide was used to accurately position the transitional prosthesis so that it could be secured to the implant sleeves with dual-cure acrylic (Stellar DC Acrylic [TAUB Products]).

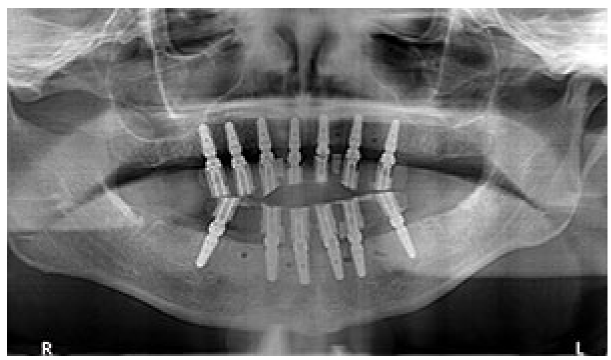


Figure 7. The postoperative panoramic radiograph shows an excellent surgical result for both arches after the placement of 13 implants.

Figure 8. The transitional maxillary and mandibular restorations were evaluated for

proper bite and occlusion.

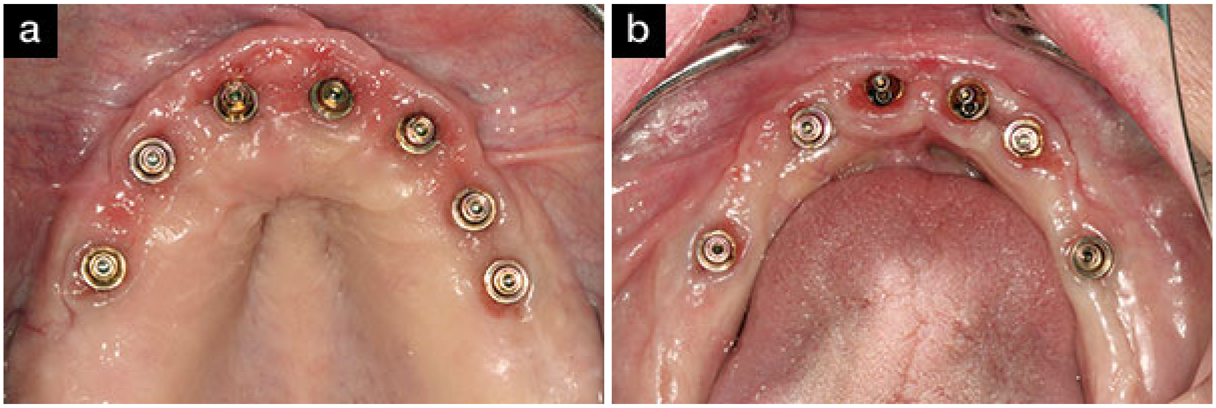


Figure 9. The prostheses were removed after an adequate healing time, and the soft-tissue maturation was evaluated relative to the multi-unit abutments.

Figure 10. The panoramic radiograph at 2 months reveals the transitional screw-retained prosthesis.

The surgical phase was planned to utilize the full-template guided surgical protocol as described in the first article (**Dentistry Today**, September 2019) and, therefore, only summarized here. On the day of surgery, the necessary components included the tooth-borne Fixation Base with Pin Guide, anchor pins, a bone reduction guide, an osteotomy drill guide, a Carrier Guide, a transitional full-arch prosthesis, and various 3-D printed models for both maxillary and mandibular arches (Figure 4) (Chrome GuidedSMILE [ROE Dental Laboratory]). The Fixation Base was first secured to the Pin Guide and then seated on the maxillary teeth. The facial anchor holes were drilled through the guide holes in the metal guide, and anchor pins were then placed trans-cortically through the buccal surface of the Fixation Base (Figure 5). The teeth were extracted, and the bone was leveled as per the surgical plan (red line on cross-sectionals). Based upon the software plan (BlueSky Plan), 7 implants were placed (AnyRidge [Mega'Gen]). Using resonance frequency analysis (RFA), implant stability quotients (ISQ [Osstell]) were recorded to determine sufficient stability for loading. Multi-units were placed on each implant based upon the tissue height and to redirect the screw-access hole correctly within the envelope of the restoration. Titanium sleeves were then attached to each implant, and the Carrier Guide was used to accurately position the transitional prosthesis so that it could be secured to the implant sleeves with dual-cure acrylic (Stellar DC Acrylic [TAUB Products]) (Figure 6). The process was repeated for the mandibular arch. The post-op panoramic radiograph reveals an excellent surgical result for both arches after the placement of 13 implants (Figure 7). The transitional maxillary and mandibular restorations were evaluated for proper bite and occlusion (Figure 8). After an adequate healing time, the prostheses were removed, and the maturation of the soft tissue was evaluated relative to the multi-unit abutments (Figure 9). The panoramic radiograph at 2 months revealed the transitional screw-retained prosthesis (Figure 10).

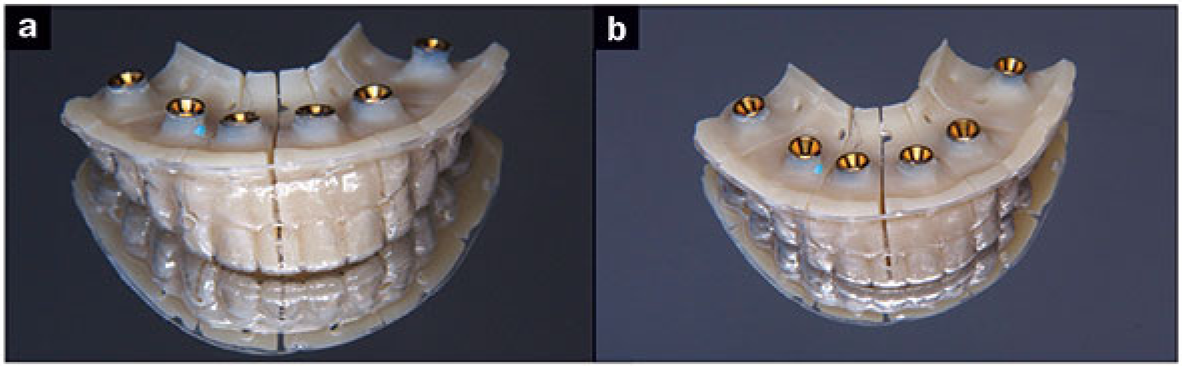


Figure 11. The upper and lower iJIGs (ROE Dental Laboratory) were sectioned and held together with a clear vacuum-formed overlay for seating and then intraoral luting.

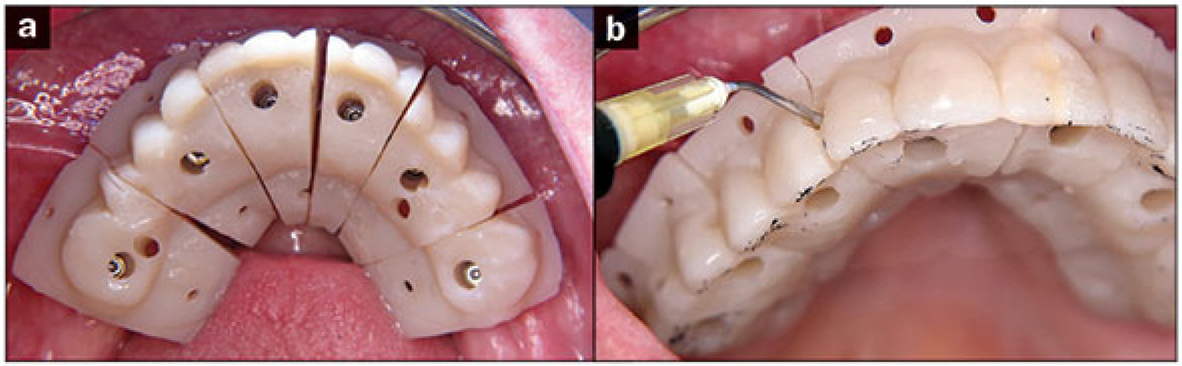


Figure 12. Each section of the iJIG was tightened onto the multi-unit abutments and luted together with either flowable composite, autopolymerizing, or dual-cure resin.

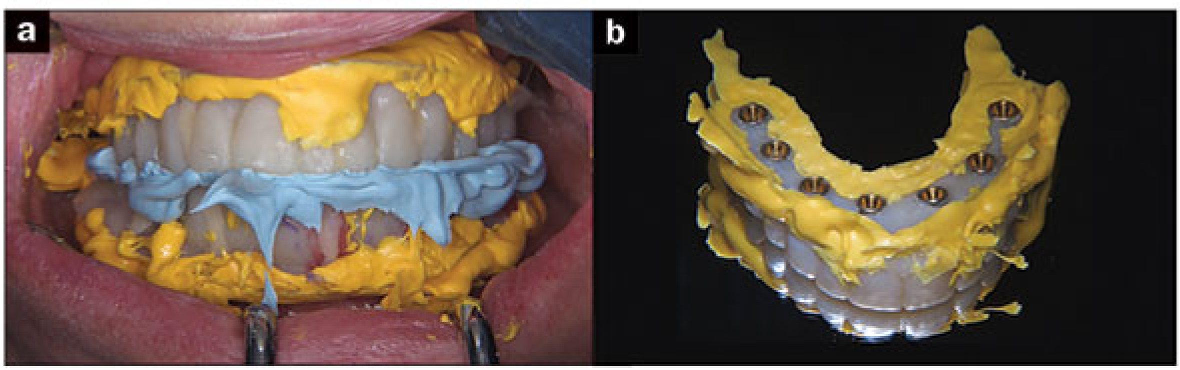


Figure 13. The iJIG prosthesis was reinserted, and a vinyl polysiloxane impression material was then injected via syringe to capture the tissue interface and bite relationship.

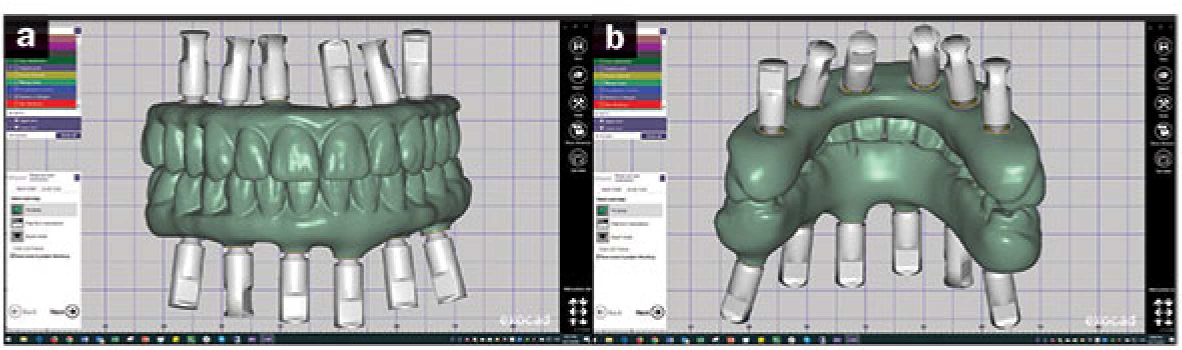


Figure 15. The digitally articulated maxillary and mandibular arches were designed based on the updated information in order to correct any occlusal adjustments, tissue gaps, aesthetic considerations, and/or functional changes.

Restorative Phase

The conventional restorative phase would usually commence with intraoral impressions to relate the implant positions to a master cast for the dental laboratory team to design and fabricate the definitive prosthesis. From the master cast, it would be required to complete a verification index of the implants and determine the VDO, centric relation, and bite registration using standardized prosthodontic protocols. However, current technology allows for the introduction of improved digital workflows that greatly aid the restorative phase. A combination of analog and digital solutions were developed over time with the introduction of the iJIG (ROE Dental Laboratory). The initial purpose of the iJIG was to help with the design and fabrication of a full-arch restoration using an existing full-arch transitional restoration on multi-unit abutments. Simply, the iJIG is a verification jig with teeth. The device allows the clinician to lute passive sections together in the mouth, equilibrate the occlusion, capture the bite, and pick up the intaglio soft tissue. This device provides all of the necessary records to fabricate a final or prototype restoration. It is also necessary to submit full-face and full-smile photos, especially if aesthetic changes are desired.

Figure 14. A stone model was then created from this impression to capture the location of the multi-unit abutments.

The first-generation iJIG involved removing the existing transitional prosthesis for digitization with either a 360° scan from an intraoral scanner or a desktop scanner. The prosthesis was then reseated to scan the opposing arch and to digitally record the bite relationship. The first generation was adequate in concept but very challenging for both the clinician and the dental laboratory technician trying to decipher the images of the cylinders and trajectory of the access holes to align the components. To overcome this difficulty, special iJIG analogs (ROE Dental Laboratory) were developed to accurately capture the position of the implants and prosthetic components. The third generation utilized CAD software to develop digital tooth setups with anatomical teeth that were used to compensate for the equilibrated and worn teeth as a result of function during the healing phase.

The Generation 4 iJIG is a prosthetic device that was designed based on the concept of "see your smile before surgery." With CHROME GuidedSMILE (ROE Dental Laboratory), most patients receive a nearly true-to-form smile simulation and subsequent virtual tooth setup based on standard triangulation language (STL) digital files that mimic the simulation. During the planning phase, the implants were positioned based upon the merging of intraoral scans or digitized stone cases in combination with the transitional prosthetic design exported as an STL file. Therefore, the original implant and tooth-planning phase rendered an ideal set-up STL file based on the simulated smile design and stored in the computer until the final restorative phase began. The new STL files of surgical/prosthetic/intraoral scans were merged with the original tooth setup. The new iJIG was then fabricated based upon the previously approved and actual transition prostheses worn during the healing phase. This replica was then used to register slight changes in implant position, soft tissue, occlusion, and aesthetics. The upper and lower iJIGs were sectioned and held together with a clear, vacuum-formed overlay for seating and then intraoral luting (Figure 11). Each section was tightened onto the multi-unit abutments and approximated to be luted together with either flowable composite or autopolymerizing or dual-cure resin (Figure 12). It was important that all sections were fully seated and passive. It is recommended that the fit of the prosthesis be verified with radiographs.

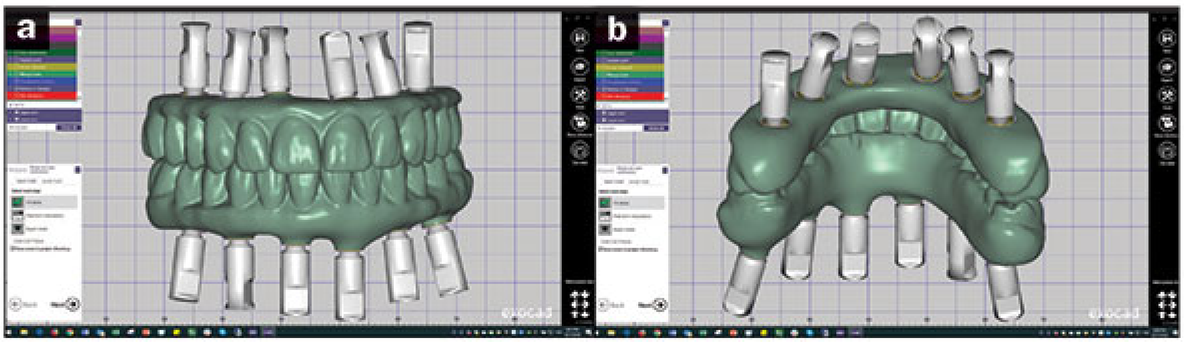


Figure 15. The digitally articulated maxillary and mandibular arches were designed based on the updated information in order to correct any occlusal adjustments, tissue gaps, aesthetic considerations, and/or functional changes.

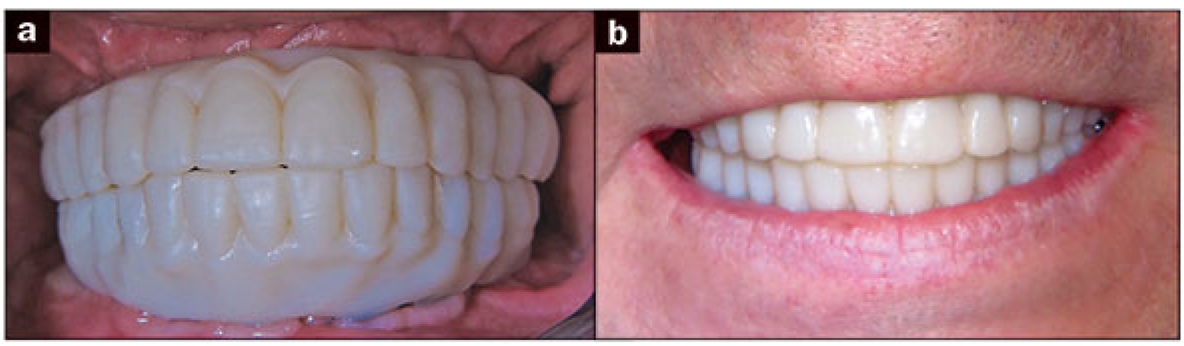


Figure 16. The 3-D-printed resin clinical prototypes were fabricated based upon the new virtual design and evaluated intraorally.

Figure 17. As previously described, the pre-op condition was captured in color with an IOS (3Shape).

After careful luting, the full-arch try-in prosthetic was removed, and tray adhesive was applied to the intaglio surface and circumferential margins. The prosthesis was reinserted, and a vinyl polysiloxane impression material (Aquasil [Dentsply Sirona Restorative]) was then injected via syringe to capture the tissue interface and bite relationship (Figure 13). The prostheses with impression material attached and the bite registration were then sent to the lab for processing. A stone model was then created from this impression to capture the location of the multi-unit abutments (Figure 14). Once the dental laboratory team received the new information, it was digitized and entered into the CAD/CAM software to complete the design (exocad DentalCAD software [exocad]). It is essential that the position of the implants be accurately represented with the appropriate analogs within the software library. The digitally articulated maxillary and mandibular arches can then be ideally designed based on the updated information to correct any occlusal adjustments, tissue gaps, aesthetic considerations, and/or functional changes (Figure 15). Based upon the new virtual design, resin-based, 3-D printed, clinical prototypes were fabricated and evaluated intraorally (Figure 16).

Recently, the fifth-generation iJIG introduced a more anatomical emergence design with the inclusion of an intraoral soft-tissue scan. As previously described, the pre-op condition was captured with an IOS (Figure 17). After the healing phase was completed, an IOS was utilized to record the position of the MUAs and the surrounding soft tissue for both the maxillary and mandibular arches (Figure 18). Utilizing the iJIG special scanning analogs attached to the implants, the entire prosthesis was then scanned and digitized extraorally and merged with the opposing arch and bite scans as previously described (Figure 19). The introduction of the soft tissue aids in the design of the prototype iJIG in establishing the material-to-ridge relationship of the final prosthetic tooth position, tissue contours, cantilevers, etc. The iJIG and resin-try-in phase provide the clinician with essential information to deliver a more accurate and predictable final restoration. The sixth generation requires the previously described seating procedures. The information was again introduced into the CAD/CAM software (3Shape) to complete the design of the final prosthesis, taking into consideration all changes in occlusion and aesthetics (Figure 20). The lateral views of the virtual design are illustrated in Figure 21. The final, screw-retained monolithic zirconia restorations were delivered for both arches. The screw-access holes were first covered with polytetrafluoroethylene (PTFE) tape, followed by a composite filling (Figure 22). The final prosthesis can be visualized in the retracted views, showing an acceptable functional and aesthetic result (Figure 23). The final prosthesis could be fabricated in zirconia, nano-bonded-to-titanium or nano-bonded-to-Trinia, which are both Crystal Ultra (Digital Dental) materials.

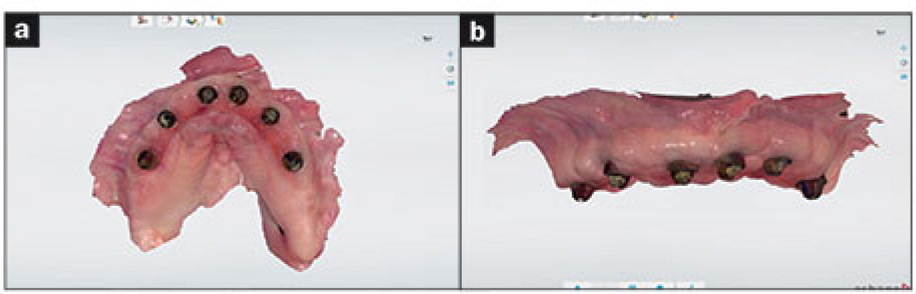


Figure 18. After the healing phase was completed, an IOS was utilized to record the position of the MUAs and the surrounding soft tissue for both the maxillary and mandibular arches.

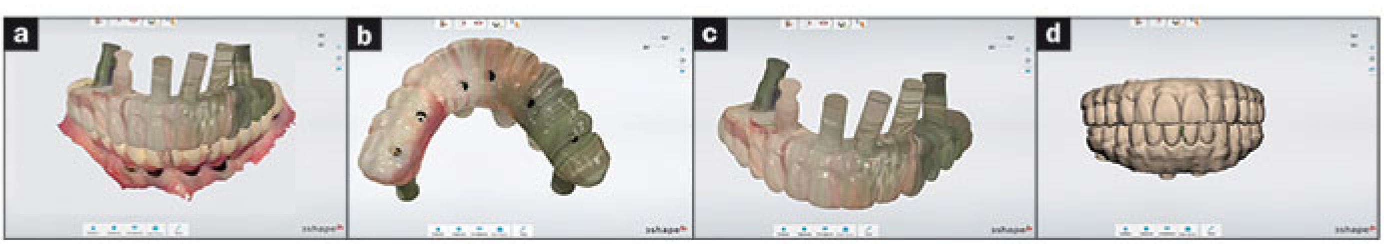
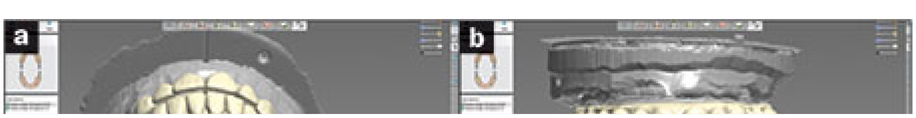


Figure 19. Utilizing special iJIG-scanning analogs attached to the implants, the entire prosthesis was then scanned and digitized extraorally and merged with the opposing arch and bite scans.



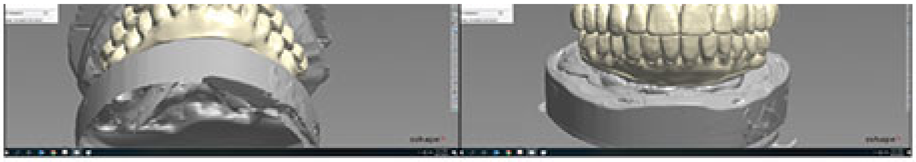


Figure 20. The CAD/CAM software (3Shape) was utilized to complete the design of the final prosthesis, taking into consideration all changes in occlusion and aesthetics.

Figure 21. The lateral views of the virtual CAD prosthesis designs.

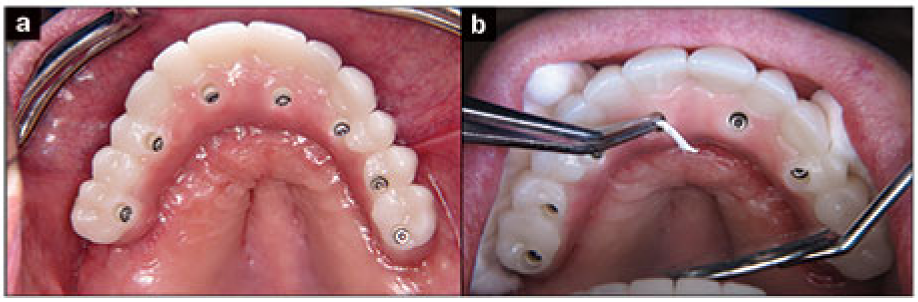


Figure 22. (a) The final screw-retained monolithic zirconia restoration in the maxilla was delivered for both arches. **(b)** The screw-access holes were obturated with polytetrafluoroethylene (PTFE) tape, followed by a composite filling.

Figure 23. The final upper and lower prostheses as seen in the retracted views, showing an acceptable functional and aesthetic result.

IN SUMMARY

With careful diagnosis and treatment planning, it is possible to predictably manage full-arch, immediate, implant-supported restorations. The first of our 2-part series described the 3-D assessment of patient anatomy to provide the blueprint for tooth extraction, bone reduction, and immediate implant placement with concomitant transitional restoration made possible with an innovative full-template, guided solution. The article further described a stackable guide system that provided a combination of a drill guide, a bone reduction guide, an implant insertion guide, and a link to the full-arch maxillary restoration.

This second installment of the 2-part series described the steps necessary to complete a simultaneous dual-full-arch prosthetic reconstruction after the confirmation of osseointegration and satisfactory soft-tissue maturation surrounding the multi-unit, screw-receiving abutments. Conventional analog prosthetic protocols have required intraoral impressions that capture the implant abutments within a stone master cast to be mounted on an articulator at the proper vertical and centric relation position. The dental laboratory technician was then tasked to create a wax-up with denture teeth to confirm the bite, lip support, phonetics, and aesthetics. From this analog protocol, a screw-retained, definitive restoration was completed. It was not until the digital workflow and advanced CAD/CAM software that allowed for digitization of the analog setup to create a virtual design and resultant STL files for fabrication of full-arch monolithic zirconia restorations. To enhance the digital workflow, the evolution of the time-saving device, the iJIG, was presented.

As previously described, the immediate loading of dental implants for full-arch reconstruction offers many advantages over delayed treatment alternatives, but it does require a prefabricated prosthesis at the time of surgery. For the purposes of this article series, the transitional restorations were all digitally designed and produced with a nearly true-to-form smile simulation for delivery via a stackable guide system at the time of surgery. The current iteration of the iJIG manages the small differences from the original transitional restoration to the desired final restoration with an accurate and time-saving innovation. The iJIG is compatible with most implant systems, such as integrated dental systems, Nobel Biocare, BioHorizons, NeoDent, Straumann, Hiossen, Thommen, and Keystone. Other systems, which include Zimmer Biomet, Implant Direct, CAMLOG, Dentsply Sirona Implants, MIS Implants Technologies, Paltop, and others, require specific OEM (original equipment manufacturer) MUA replicas to accurately scan the prosthesis. The iJIG can potentially reduce restorative time down to 3 visits.

The present case study required bone reduction to achieve the necessary restorative space for the completion of successful dual-full-arch FP-3 prostheses utilizing the Chrome GuidedSMILE concept with advanced digital workflows. The same full-template guided protocols have also been demonstrated in cases where preservation of the alveolar and interproximal bony architecture was desired, which resulted in an FP-1 prosthetic (pink-free) design, or when zygomatic implants were to be used to support a fixed restoration necessitated in a severely atrophied maxillary arch. More research and additional multi-center studies will help in understanding the long-term success of these innovative surgical and restorative protocols.

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Dr. Ganz received his specialty certificate in maxillofacial prosthetics/prosthodontics. He is a Fellow of the Academy of Osseointegration, Fellow of the International College of Dentists, a Diplomate of the International Congress of Oral Implantologists (ICOI), US Ambassador of the Digital Dental Society, and co-director of Advanced Implant Education (AIE). Dr. Ganz was recently honored for his lifelong contributions by the American Academy of Implant Dentistry and the Digital Dentistry Society. Dr Ganz is on the faculty of the Rutgers School of Dental Medicine and maintains a private practice in Fort Lee, NJ. He can be reached at drganz@drganz.com.

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