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DENTAL TECHNIQUE

Digital workflow for definitive immediately loaded complete-arch CAD-CAM implant-supported prosthesis in 3 appointments without using intraoral scanning

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ABSTRACT

This article presents a rapid technique for the accurate transfer of implant positions immediately after image-guided surgery to enable the immediate installation of a definitive complete-arch implant-supported prosthesis with an implant biological width of 3 mm within 3 appointments. A sleeveless copy of the implant surgical guide is magnetically connected to a reference guide to ensure the accurate capture of cylindrical titanium transfer abutments. In the laboratory, the sleeveless guide with the splinted transfer abutments attached is used to generate a definitive cast to be scanned with a desktop scanner. The resulting digital definitive cast is then combined with the original meshes of the prosthetically driven virtual treatment plan to enable a definitive computer-aided design and computer-aided manufactured prosthesis to be fabricated and installed with passive fit. (J Prosthet Dent 2022;■:■-■)

An immediately loaded complete-arch implant-supported fixed prosthesis is a treatment option for edentulous patients with adequate ridge bone volume.[1-3] However, conventional immediate loading approaches typically require challenging immediate impressions and relining of the interim prosthesis.[4]

Immediate loading has also been used with computer-aided design and computer-aided manufacturing (CAD-CAM) prostheses in patients receiving complete-arch image-guided implant surgery following a prosthetically driven surgical plan. For this purpose, an interim CAD-CAM resin prosthesis can be manufactured before the surgery and immediately installed by capturing the abutments with resin materials. However, to produce a subsequent definitive prosthesis, the final position of the implants placed is generally transferred into the CAD software program after the healing period.[5,6]

Several digital workflow methods have been described to provide CAD-CAM implant-supported prostheses.[7-16] Photogrammetry and intraoral scans (IOSs) are considered accurate for digital implant transfer.[7,8] However, the digital files resulting from such methods may not be easily merged with the original 3-dimensional (3D) meshes of a complete-arch prosthetically driven treatment plan. Furthermore, IOSs have been reported to be uncomfortable immediately after complete-arch implant surgery, and accuracy is challenging for large edentulous spans.[9]

The aim of this technique report was to introduce a digital workflow within 3 appointments to transfer the positioning of newly placed implants without using an IOS or photogrammetry in immediately loaded complete-arch implant definitive rehabilitations following image-guided alveolar ridge reduction.

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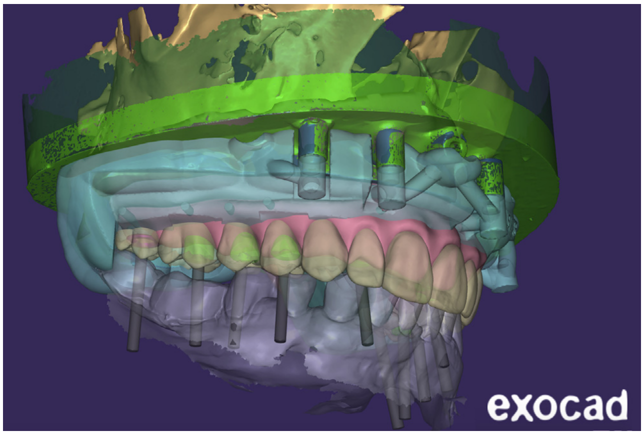

Figure 1. Virtual diagnostic wax patterns planned along with alveolar bone reduction and position of implants and abutments.


Figure 2. Alveolar bone reduction osteotomy with surgical guide in position.

TECHNIQUE

1. Make intraoral scans (TRIOS 3; 3Shape A/S) of the maxillary and mandibular arches, as well as the patient's occlusion. In addition, make facial scans (clOner; dOne 3D) of the natural smile, forced smile, and occlusal relationship with lip retractors (OptraGate; Ivoclar AG). Finally, make a cone beam computed tomography (CBCT) (OP 300; Instrumentarium) scan with the lip retractors in place.
2. Import all images, including standard tessellation language (STL) files from the IOSs, digital imaging and communication in medicine (DICOM) files from the CBCT, and facial scan object (OBJ) files into a CAD software program (NemoStudio; Nemotec SL) to perform virtual waxing. Select and import a tooth library for the maxillary arch. Design, shape, and position each tooth in the arch based on the smile analysis and occlusion. Then, perform prosthetically driven virtual implant placement, followed by the virtual surgical planning of alveolar ridge reduction taking into consideration the space needed for a fixed complete denture.[5] Then, perform a digital simulation of a 3-mm-long soft-tissue layer overlying the reduced alveolar ridge. Use the software program tools for fabricating a surgical guide to digitally design a bone-supported alveolar ridge reduction surgical guide and an implant-placement surgical guide. Both guides should be designed to be magnetically connected to each other.[5] Three-dimensionally print (Hunter; Flashforge) the resulting surgical guides from a light-polymerizing resin (priZma 3D Bio Guide; Makertech Labs). In addition, 3D-print 2 identical sleeveless copies of the implant surgical guide.
3. Export the maxillary digital wax pattern, the simulation of hard- and soft-tissue shapes resulting after alveolar ridge reduction, the implants and respective abutments, the surgical guides, and the shape of the magnetic internal attachments (BDS Magnetic Guide-TIMMES; Beyond Digital Solutions) as individual STL files to import them into another CAD software program (DentalCAD; exocad GmbH) along with all the files obtained in the previous step (Fig. 1).
4. During the second clinical appointment, extract the teeth atraumatically and elevate a flap to expose the buccal bone. Place the alveolar ridge reduction guide overlaying the soft tissue of the palate and the buccal bone of the ridge. Fix this guide to the bone with anchor pins (Kit Smart Guided; Kopp Implantes). Perform ridge osteotomy with a piezoelectric surgical device (Dent-Surg Pro; CVDentus) (Fig. 2). Next, use magnetic internal attachments to connect the implant placement surgical guide on top of the ridge reduction guide. Perform complete-arch implant placement (Grand Morse Ø4.0 mm × 13mm; Neodent) (Fig. 3).
5. Remove the implant placement guide leaving the bone reduction guide in place to screw the conical implant abutments (Mini-Abutments, GM Ø4.8 mm; Neodent) (Fig. 4). Screw cylindrical titanium transfer abutments (Temporary Titanium Cylinder; Neodent) onto the conical implant abutments. Then, connect the sleeveless copy of the implant surgical guide (transfer guide) to the bone-reduction guide by using the magnetic internal attachments. Capture the transfer abutments into the transfer guide with a fast-setting autopolymerizing red acrylic resin (Pattern Resin LS; GC America) (Fig. 5). Remove both guides from the

Figure 3. Implant placement guide magnetically connected to bone reduction guide.

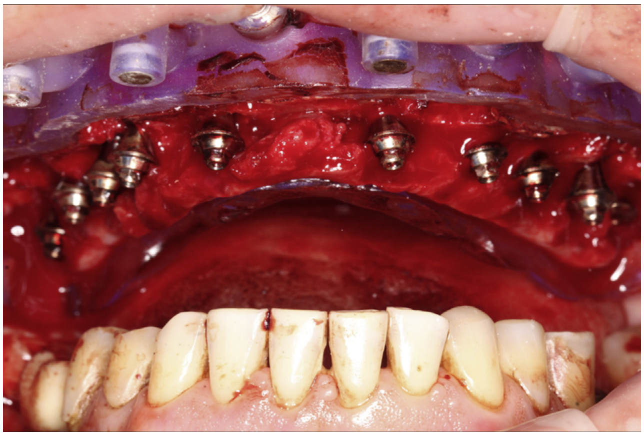

Figure 4. Implants placed with conical miniabutments.

patient's mouth and either place healing abutments onto the conical implant abutments or deliver an immediate interim prosthesis until the third clinical appointment.

6. In the laboratory, screw implant analogs to the transfer abutments that were splinted to the transfer guide. Then, splint all analogs with rigid metallic wires (Fio de Aço; Dental Speed) to the alveolar ridge reduction guide with the same fast-setting autopolymerizing red acrylic resin to ensure stability (Fig. 6). Next, connect the alveolar ridge reduction guide to the transfer guide.
7. Unscrew the transfer abutments from the analogs to remove the transfer guide. Place the alveolar ridge reduction guide with the splinted analogs on a dental cast base to embed the analogs in special plaster (Gesso Pedra Especial; Dental Cremer) (Fig. 7).
8. Screw implant scan bodies onto all analogs and scan them along with the alveolar ridge reduction guide with a desktop scanner (AutoScan-Ds-EX Pro; Shining 3D) (Fig. 8). Save the resulting scan as an STL file.
9. Import the resulting STL file to a new project in the CAD software program (DentalCAD) to superimpose the original project of the virtual treatment plan (Fig. 9). For this purpose, align the meshes of all STL files from both projects by matching the location of the implants planned and actually placed, as well as the location of the bone reduction guide, which is the same in both projects. Then, digitally design the complete-arch implant-supported fixed complete denture based on the initial digital waxing.
10. Save the STL file and mill with a polymethyl methacrylate (PMMA) disk (Trilux Multilayer; RuthiBras) of the selected shade with a 5-axis milling machine (Ceramill Motion 2; Amann Girrbach AG). After milling, use light-polymerizing resin (NT Premium; Coltène) to make the artificial gingiva and cement anodized metallic Ti-base cylinders (Metallic Cement Cylinder; Kopp Implantes) to the PMMA milled restoration.
11. Finally, in the third clinical visit, place the definitive screw-retained complete-arch implant-supported fixed prosthesis under immediate loading before adjusting the occlusal relationship for centric relation and excursive movements (Fig. 10).

Figure 5. Interim transfer abutments splinted to sleeveless transfer guide.

DISCUSSION

Several digital workflow methods have been described to provide an immediately loaded complete-arch implant-supported fixed prosthesis.[2,10,11] However, these methods describe either the delivery of an interim restoration or procedures with numerous and complex laboratory steps to make a definitive restoration. In contrast, the present digital workflow, in which a definitive complete-arch implant-supported fixed complete

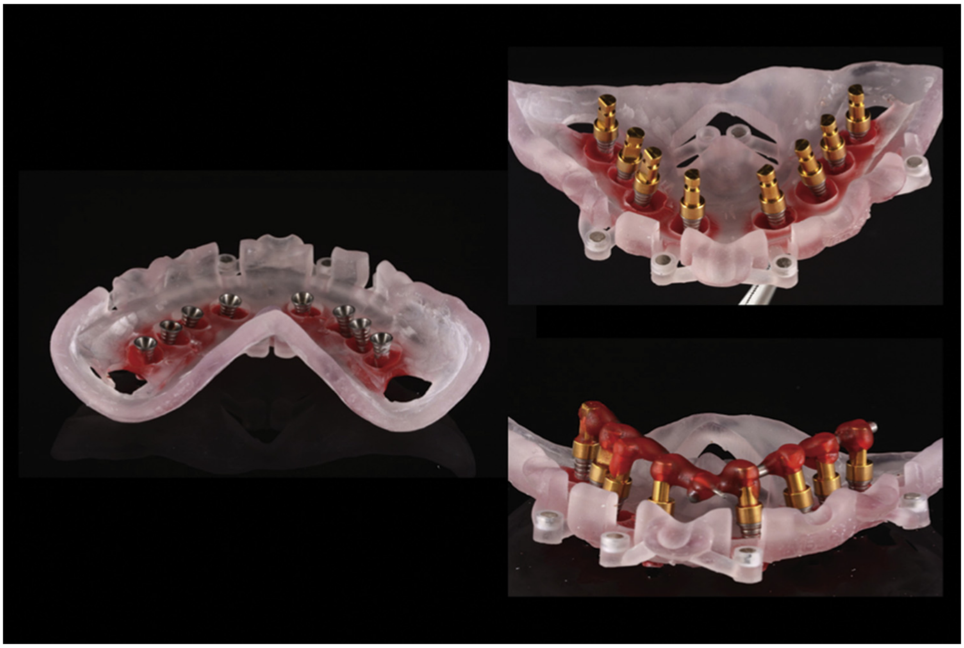

Figure 6. Implant analogs splinted to improve stability.

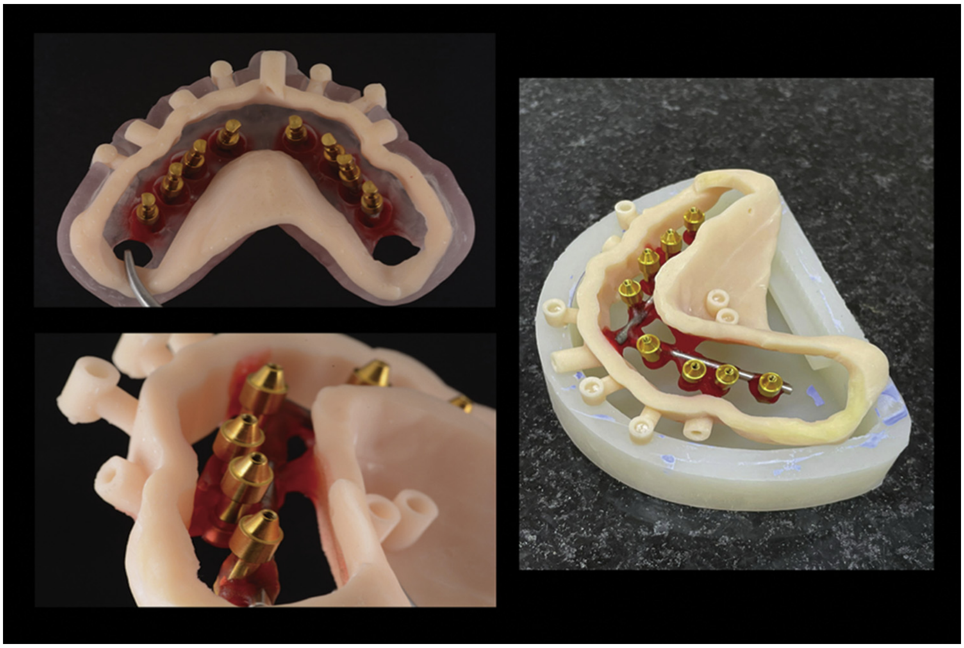

Figure 7. Dental base used to make special plaster cast containing splinted implant analogs.

denture is immediately loaded with passive fit, is straightforward and takes a total of 3 clinical appointments.

Passive fit is essential for definitive immediately loaded complete-arch implant-supported fixed prostheses.[12] Three-dimensional deviation of implant positions in relation to the respective virtual treatment plan prevents the immediate installation of a definitive prosthesis.[13] To overcome this issue, the present technique accurately transfers the implant positions to a physical cast that can be scanned extraorally with a desktop scanner, eliminating the need for intraoral scanning immediately after surgery.[14] This enables the correct alignment of the STL files of the alveolar ridge reduction guide obtained before and after implant placement, essential for a digital workflow involving virtual patients.[5,6] As a result, the present technique should ensure passive fit of complete-arch implant-supported

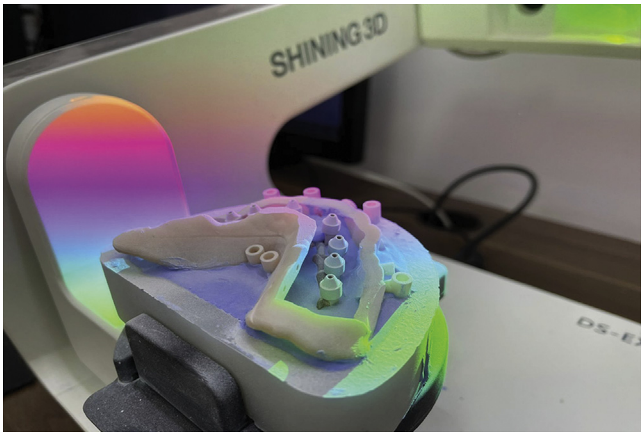

Figure 8. Desktop scanning of special plaster cast.

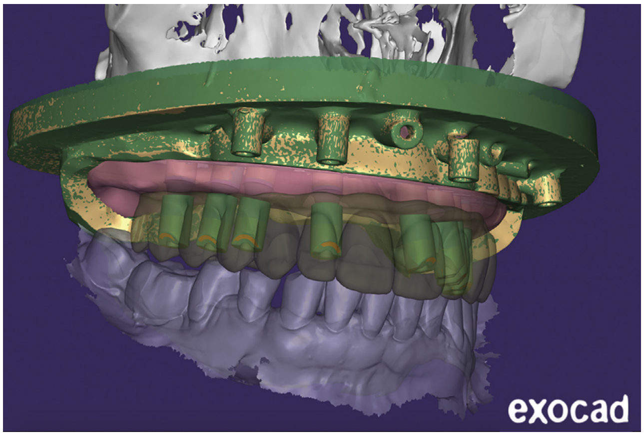

Figure 9. Superimposition of postoperative desktop scan of implant positions with initial project of prosthetically-driven virtual implant planning.

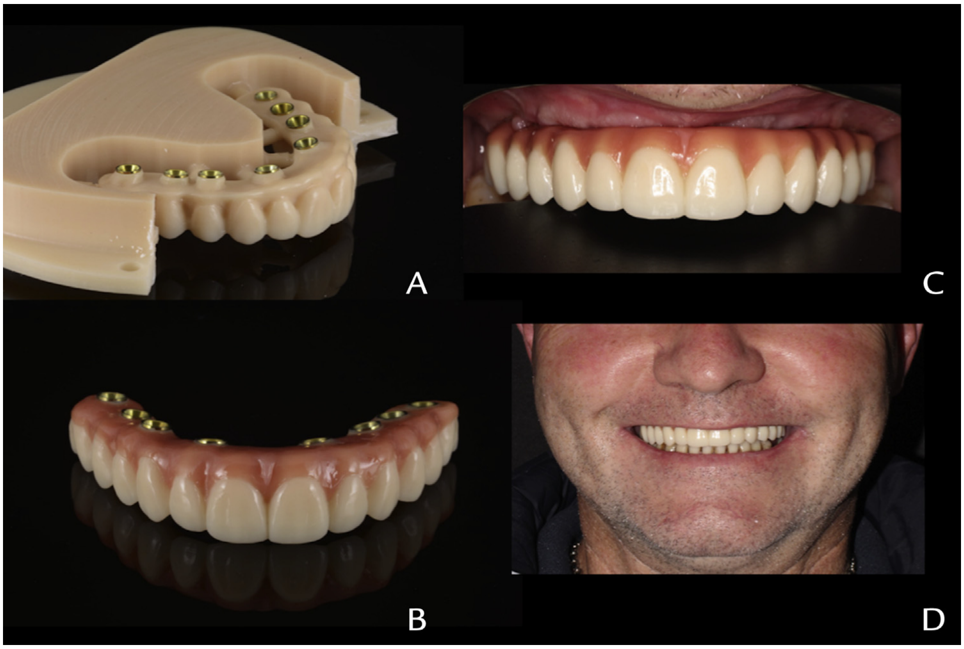

Figure 10. A, Milled CAD-CAM PMMA complete-arch implant restoration. B, Gingival light-polymerizing resin added. C, Intraoral view of maxillary PMMA complete-arch implant restoration. D, Smile view. CAD-CAM, computer-aided design and computer-aided manufacturing; PMMA, polymethyl methacrylate.

prostheses, even when more than 5 implants are placed.[15] In the present example, 10 implants were placed because increasing the number of implants for maxillary complete-arch immediate loading reduces implant failures and complications,[16] and the cortical bone at the alveolar crest was measured on a CBCT scan during surgical planning to be less than 1-mm thick, affecting implant insertion torque and primary stability.[17]

Alveolar marginal bone loss and subsequent remodeling of the overlying soft-tissue contour are a challenge for complete-arch implant-supported fixed prostheses. However, the marginal bone loss in complete-arch rehabilitations with immediate loading has been reported to be similar to conventionally loaded implants.[18-20] Severe bone loss after the delivery of a definitive complete-arch implant prosthesis should be prevented by ensuring a minimum peri-implant biological width of 3 to 4 mm.[21] For this reason, the digital simulation of the soft-tissue contour overlying the alveolar crest after bone reduction had a height of 3 mm. Similarly, the need for bone reduction should be determined during virtual treatment planning to enhance predictability and considering factors such as the height required for the fixed complete denture, the availability of bone width, and the desired final depth of each implant platform.[5]

Limitations of this technique include the need for a laboratory step to embed the implant analogs in special plaster to ensure that the positions secured by the transfer guide are adequately transferred to a dental cast. Furthermore, prospective and comparative studies are recommended to address differences in outcomes between the present technique and those currently used, that is, intraoral scans of scan bodies and photogrammetry.

SUMMARY

The present technique describes an alternative to definitive complete-arch rehabilitation with immediate loading in 3 appointments with a new method of transferring the actual position of the implants from the patient's mouth to the CAD software program by using a desktop scanner. The method should ensure passive fit of the immediately loaded definitive prosthesis, eliminating the need for an interim prosthesis during implant osseointegration. This technique can be considered a treatment option for patients receiving immediately loaded implant-supported CAD-CAM fixed complete dentures.

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