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Digital Duplication and 3D Printing for Implant Overdenture Fabrication

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Abstract

This technical report describes a workflow to fabricate an implant overdenture via digital duplication of an interim complete removable dental prosthesis and additive manufacturing (3D printing). An edentulous patient was provided with an interim maxillary denture after implant placement. After 4 months of healing, the existing interim denture was scanned, duplicated via 3D printing, and used to make the final impression, record the maxillomandibular interocclusal relationship, and transfer the esthetic information to the definitive implant overdenture. The framework of the implant overdenture was digitally designed and manufactured using a direct metal printing (DMP) system. This digital duplication workflow facilitated the implant overdenture fabrication with favorable clinical outcomes.

With the expectation for better masticatory efficiency, retention, and satisfaction,[1-3] some patients prefer to replace their complete removable dental prosthesis with implant overdenture. In such instances, the existing complete removable dental prosthesis may offer valuable diagnostic information during the fabrication of new implant overdenture. A clinically satisfactory complete removable dental prosthesis can be duplicated to preserve the diagnostic information on the desired esthetic outcomes, tooth size and arrangement, occlusal schemes, contour of the denture extension, and intaglio surface.[4,5] The duplicated denture can serve as a trial prosthesis or a custom tray to make a definitive impression and record maxillomandibular interocclusal relationship.[6]

A variety of techniques have been proposed to duplicate clinically satisfactory complete removable dental prosthesis.[7-9] Traditionally, denture duplication requires several steps, such as creating the mold with impression materials, pouring autopolymerizing resin into the mold, re-contouring, and polishing of duplicated prosthesis.[10] The development of digital technology facilitates this workflow.[11] The existing denture can be digitalized by either an optical scanner or cone beam computed tomography (CBCT).[8,12-14] The Data Imaging and Communications in Medicine (DICOM) file produced by CBCT imaging can be converted to a standard tessellation language (STL) file format,[12] and utilized in the computer-aided design and computer-aided manufacturing (CAD/CAM) process.[15] With many advantages and rapid development, additive manufacturing (3D printing) has gained its popularity in dentistry. Various materials include light-polymerizing resin, and even metal alloy can be 3D-printed to meet different clinical demands.[16]

This technical report describes a digital workflow to fabricate an implant overdenture by duplicating an existing complete removable dental prosthesis using a digital workflow and fabricating the definitive prosthesis using 3D printing.

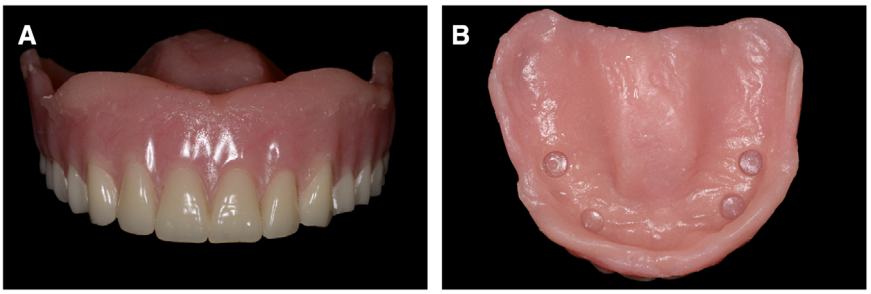

Figure 1 Maxillary interim denture after soft relining. (A), frontal view, (B), intaglio view.

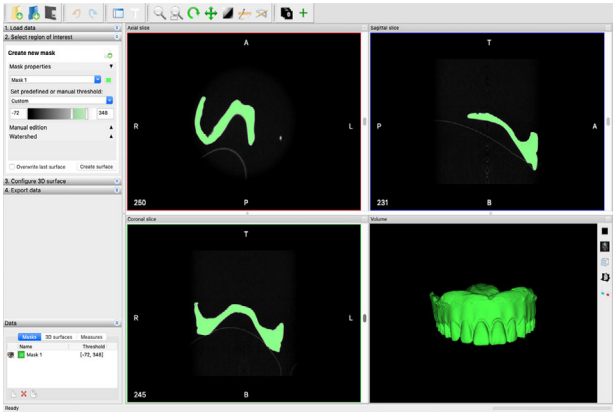

Figure 2 File conversion from DICOM to STL.

Figure 3 3D-printed duplicated denture.

Technique

An edentulous patient received 4 dental implants in the maxilla, and an interim complete removable dental prosthesis was inserted after the implant surgery. After 4-months of uneventful healing, the patient was scheduled for the fabrication of maxillary definitive implant overdenture. The patient was satisfied with the functional, esthetic, and phonetic outcomes of the interim complete removable dental prosthesis.

1. Reline the maxillary interim complete removable dental prosthesis using vinyl polysiloxane soft reliner (Silagum-Comfort; DMG Chemisch-Pharmazeutische) to obtain the desired intaglio surface adaptation (Fig 1).
2. Scan the interim denture using CBCT (3D Accuitomo-170; J. Morita Corp) with the fields of view (FOV) of 80 × 80 mm, and exposure protocol at 75 kV and 2.0 mA. Export the scanned volumetric dataset in the DICOM file format.
3. Convert the DICOM files to the STL file format using an open-source 3D modeling software program (In-Vesalius 3; CTI) with a custom threshold (from –72 to 348) (Fig 2).
4. Import the STL file into a 3D slicing software (PreForm; Formlabs), and print the duplicated denture with a desktop stereolithography (SLA) 3D printer (Form 2; Formlabs) using light-polymerizing resin material (Dental SG; Formlabs).
5. Remove the 3D-printed denture from the build plate, and place it in a plastic container filled with isopropyl alcohol (91% isopropyl alcohol; Walgreens) to rinse off the residual light-polymerizing resin. Place the 3D-printed denture in a dental light-polymerizing unit (Enterra VLC Curing Unit; Dentsply Sirona) for 20 minutes to ensure complete polymerization.
6. Separate the supporting structures of the duplicated denture with a cutting plier (Cutting tool; Hakko Corp). Polish the duplicated denture with laboratory instruments (Ultra Denture System; Brasseler USA) (Fig 3).
7. Try in the duplicated denture, and verify the clinical outcomes intraorally (Fig 4). Relieve 2 mm of space at the intaglio surface, and apply the tray adhesive (Polyether Tray Adhesive; 3M) to the duplicated denture. Make the final maxillary impression with the duplicate denture and polyether impression material (Impregum Penta Soft Medium Body; 3M) (Fig 5). Trim the excessive impression material, and reposition the duplicate denture intraorally. Record the maxillomandibular relationship with vinyl polysiloxane material (Imprint Bite; 3M) (Fig 6).
8. Make the diagnostic impression for the mandibular prosthesis with irreversible hydrocolloid impression material (Jeltrate Fast Set; Dentsply Sirona). Fabricate the maxillary and mandibular casts with type III dental stone (Buff stone; Whip Mix Corp). Articulate the casts

Figure 4 Trial insertion of the duplicated denture.

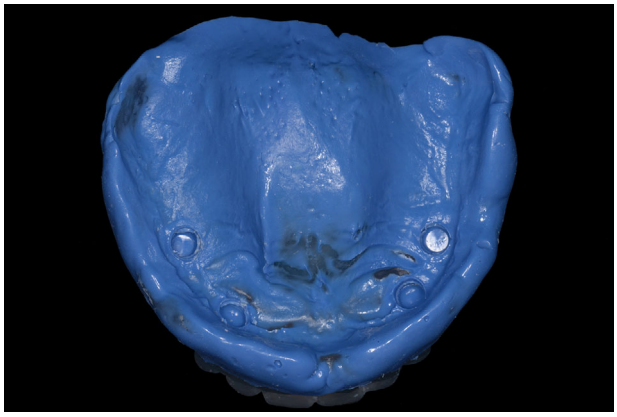

Figure 5 Definitive impression made with duplicated denture.

Figure 6 Maxillomandibular relationship recorded with duplicated denture.

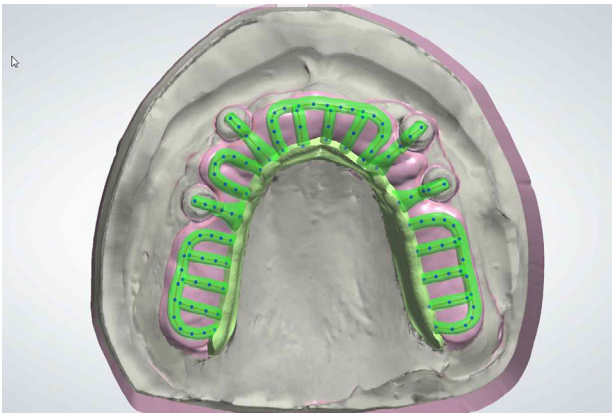

Figure 7 Framework design on the virtual cast.

Figure 8 3D-printed metal framework.

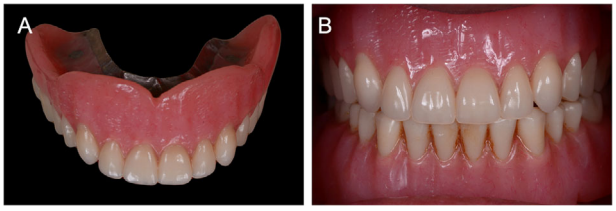

Figure 9 Definitive implant overdenture. (A), extraoral view, (B), intraoral view.

onto an articulator (Stratos 300; Ivoclar Vivadent) with the facebow transfer and maxillomandibular records (UTS 3D; Ivoclar Vivadent).

9. Scan the maxillary cast using a laboratory laser scanner (7Series Model and Impression Scanner; Dental Wings Inc). Design the framework using a 3D software (Dental System; Wieland 3Shape) (Fig 7), then manufacture the framework using a direct metal printing (DMP) 3D printer (ProX DMP 200; 3D Systems Inc) and cobalt-chromium alloy (LaserForm Co-Cr; 3D Systems Inc) (Fig 8).
10. Arrange the denture teeth on the articulated casts using 3D-printed duplicated denture as a reference. Test the diagnostic tooth arrangement intraorally to confirm the esthetics, occlusion, and phonetics. Fabricate the

definitive implant overdenture following the conventional processing procedures (Fig 9).

Discussion

This technique report presents a workflow to fabricate an implant overdenture using digital denture duplication and 3D printing. After implant placement, multiple steps are needed to make a new implant overdenture in a traditional way, such as making a preliminary impression, fabricating a custom tray, making a final impression, recording maxillomandibular relationships, fabricating the framework, and completing diagnostic tooth arrangement. Uncertainties may arise as different manual procedures are involved in the workflow. For patients who are satisfied with the existing interim or definitive complete removable dental prosthesis, this technique may simplify the clinical laboratory procedures. In this protocol, the final impression and maxillomandibular relationship record can be obtained easily with less chairside time using a duplicated denture. Moreover, the tooth selection and arrangement can be achieved using the 3D-printed duplicated denture as a reference. The limitations of this technique include that additional laboratory steps and preparation time are required for the denture duplication. The precision and printing speed of a 3D printer could be limiting factors for denture duplication. An intraoral scanner can be considered as an alternative to scanning the existing interim denture if the CBCT scanner is not available.

The feasibility and accuracy of this technique have been investigated in previous studies.[13,14] With the open-source software, the DICOM file can be converted to a 3D printable STL format. Therefore, the clinician can duplicate the existing prosthesis without outsourcing the laboratory procedures to a dental laboratory. This in-house digital workflow could be time-saving and cost-saving. The digital cast for the CAD/CAM framework design can be obtained either by scanning the physical cast with a laboratory scanner or by scanning the definitive impression with CBCT.

The 3D-printed metal framework has clinical acceptable adaptation because of its high accuracy.[17] Traditional tooth arrangement and denture processing procedures were applied for this treatment presentation because a 3D-printed metal framework was added to strengthen the implant overdenture. An alternative full digital workflow is to design the new implant overdenture by copying the design of the 3D-printed duplicated denture in the software program, and mill the definitive implant overdenture using a pre-polymerized, multichromatic acrylic resin block.[15]

Summary

This technical report describes a workflow to fabricate an implant overdenture using the digital denture duplication and 3D printing. The use of CBCT imaging, open-source CAD/CAM software program, desktop 3D printer, and direct metal 3D printer enable clinicians to perform the treatment process with favorable clinical outcomes.

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