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DENTAL TECHNIQUE

Complete digital workflow in prosthesis prototype fabrication for complete-arch implant rehabilitation: A technique

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ABSTRACT

During complete-arch digital implant scanning, one of the most technique-sensitive steps is the data registration and superimposition or matching of different surface geometry data sets because of the absence of fixed landmarks. This article describes a straightforward technique for facilitating the accurate superimposition or matching of surface scan files from digital scans for the fabrication of the prosthesis prototype with a complete digital workflow. (J Prosthet Dent 2019;122:189-92)

Digital dental technology is gaining popularity and is being incorporated into the workflow for complete-arch implant-supported restorations.[1-3] The clinical applications of digital technology in fixed implant-supported restorations include 3D diagnostic imaging and related digital implant treatment planning, computer-guided implant surgery, and the digital scanning and computer-aided design and computer-aided manufacturing (CAD-CAM) of prosthetic components.[1-9]

While digital planning and computer-guided surgery have become well established, implant scanning has been more recently established. Especially for the edentulous jaw, the conventional open-tray splinted complete-arch impression technique remains the standard protocol.[10] However, complete-arch digital scans are emerging and gaining popularity, primarily because of the wish to expand the applicability of the digital workflow.[11-16] In vitro studies of digital scanning have reported accuracy comparable with that of conventional impressions.[10-16] However, clinical data are lacking.

While clinical research is necessary to validate the use of complete-arch digital implant scanning, data registration and articulation of the standard tessellation language (STL) files generated from the digital scan of the implant scan bodies and the screw-retained interim prosthesis are also needed. Typically, with an ideal screw-retained interim prosthesis, the STL files from the 2 scans need to be superimposed and imported into the CAD software for further designing and milling of the prosthesis prototype from prefabricated polymethyl methacrylate (PMMA) or polyetheretherketone (PEEK) blocks.[4,5,17-20]

The use of monolithic zirconia for complete-arch implant restorations has been increasing.[4,5,17-20] The prosthesis prototype (duplicate of the interim prosthesis) is an integral part of the workflow for monolithic zirconia restorations.[4,5,21,22] The prosthesis prototype includes all the necessary patient-relevant information for the manufacture of the definitive prosthesis, such as contours, buccal corridors, esthetics, vertical dimension of occlusion, occlusal and tooth morphology, and the maxillomandibular relationship.[4,5,9,18]

Different techniques have been described for superimposing and virtually articulating the STL files of partially edentulous patients to fabricate prosthesis prototypes using the teeth as landmarks.[23,24] For edentulous jaws, the absence of anatomic landmarks such as teeth represents a challenge for the registration and superimposition of data.[25] To the authors' knowledge, no technique has been described for superimposing STL files in complete-arch fixed implant-supported restorations with monolithic zirconia in a complete digital workflow. The

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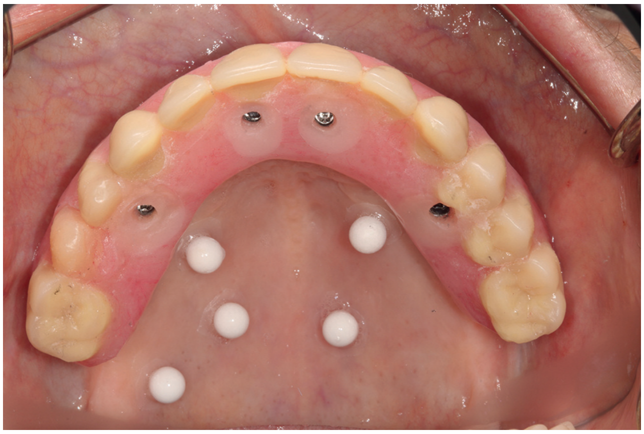

Figure 1. Maxillary screw-retained abutment-level interim prosthesis before digital scanning. Same fiducial markers will be used for superimposition of STL files generated from digital scans. STL, standard tessellation language.

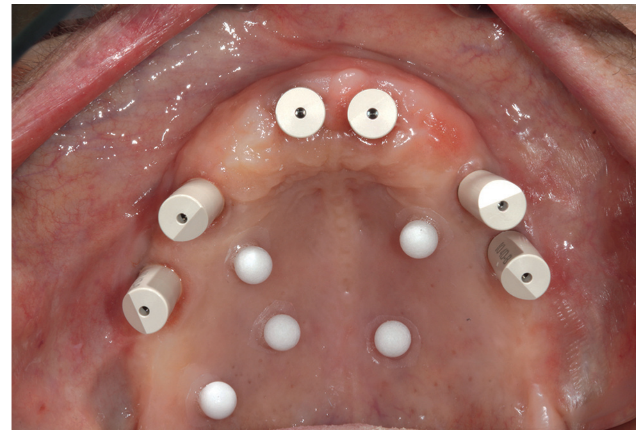

Figure 2. Intraoral scan bodies connected before maxillary abutment-level complete-arch digital scanning. Fiducial markers attached to hard palate to facilitate superimposition of 2 digital scans.

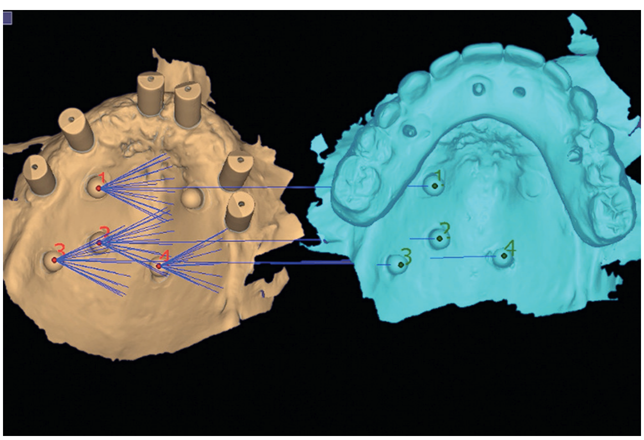

Figure 3. STL files before superimposition with aid of fiducial markers. Note that one marker not registered on second digital scan. STL, standard tessellation language.

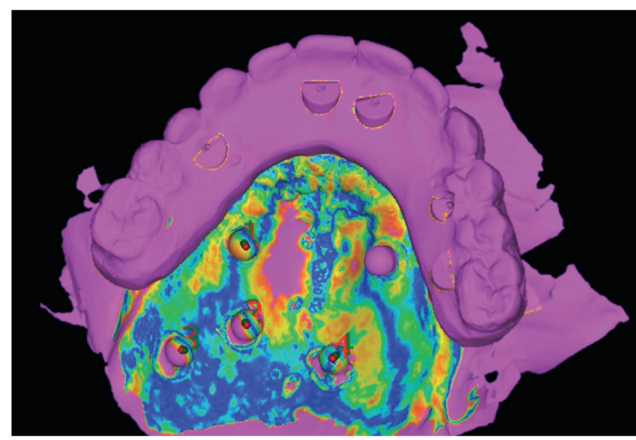

Figure 4. STL file superimposition before import into CAD software. CAD, computer-aided design; STL, standard tessellation language.

purpose of this article was to describe a straightforward and effective technique to facilitate the accurate superimposition of STL files from complete-arch digital scans for a complete digital workflow in the fabrication of the prosthesis prototype without the need for printing a physical cast or making a conventional impression. In addition, this technique aids in the transfer of all patient-relevant information from the existing interim prosthesis to virtually articulate the edentulous arch, and it enables the integration of the obtained information into the next steps of the definitive rehabilitation.

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1. Assess the existing screw-retained interim prosthesis for esthetics, phonetics, and function.

Figure 5. Prosthesis prototype generated from superimposed STL files and CAD-CAM software. CAD-CAM, computer-aided design and computer-aided manufacture; STL, standard tessellation language.

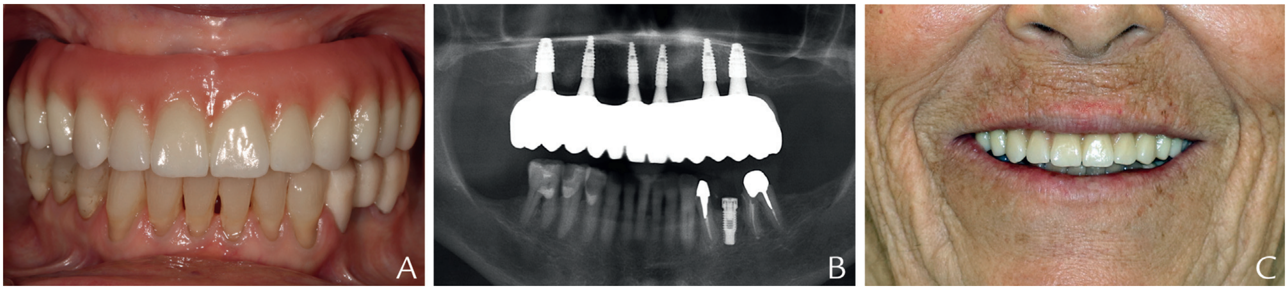

Figure 6. Definitive monolithic zirconia prosthesis. A, Intraoral view. B, Postinsertion panoramic radiograph. C, Postinsertion smile.

2. Attach a minimum of 5 sphere-shaped markers (CT-SPOT 120; Beekley Medical) on keratinized mucosal areas such as the hard palate, alveolar ridge, and retromolar pads. These radiopaque fiducial markers are self-adhesive (Fig. 1) and strongly adhere to the keratinized mucosa as long as the mucosa is air-dried. Alternatively, a tissue adhesive (PeriAcryl Periodontal Tissue Adhesive; GluStitch Inc) can be used to fix the markers.
3. Use an intraoral scanner (IOS) (TRIOS; 3shape) to scan the edentulous arch, including the interim prosthesis and soft tissue with attached radiopaque markers. Save the STL file.
4. Remove the screw-retained interim fixed prosthesis and connect intraoral implant scan bodies (ELOS Dental; MedTech) at the multiunit abutments (Fig. 2). Use an IOS to scan the edentulous arch, including the abutment-level implant scan bodies and soft tissues with radiopaque fiducial markers. Save the STL file.
5. Once digital scanning is completed, reinsert the screw-retained interim fixed prosthesis and scan the opposing dental arch. In addition, scan the buccal aspects of the screw-retained interim prosthesis in centric occlusion with the opposing dental arch to register the maxillomandibular relationship. Save the STL files.
6. Import the saved STL files into the CAD software (exocad DentalCAD; exocad GmbH) and superimpose them with the aid of the markers (Figs. 3, 4). Once the STL files are superimposed, mill the prosthesis prototype from prefabricated PMMA blocks (ZCAD Temp-Fix 98; Harvest Dental Products) inserted into a CAM milling unit (Tizian Cut eco plus; Schutz Dental Group). Cement abutment-level titanium bases (ELOS Dental; MedTech) on the interface of the prototype in the laboratory.
7. Clinically evaluate the prosthesis prototype and adjust if necessary (Fig. 5). Use the screw resistance test and periapical radiographs to assess the clinical fit of the prosthesis prototype.[4,5,9,25] When the multiunit abutment-prosthesis interface is equigingival, inspect visually. An explorer can be used supplementally.[4,5,9] The adjusted prosthesis prototype will be rescanned in a complete digital workflow for the CAD-CAM fabrication of the definitive milled monolithic zirconia prosthesis.
8. Minimally cut back and veneer the facial of the monolithic zirconia prosthesis with porcelain for enhanced esthetics (Fig. 6A).[4,5,17-20] Confirm the fit of the definitive milled zirconia prosthesis clinically with the screw resistance test and periapical radiographs (Fig. 6B).[4,5,17-20] Assess the occlusion by using articulating paper (AccuFilm II; Parkell Inc) and shimstock foil (GMH; Hanel Medizinal). Tighten the prosthesis to 15 Ncm and fill the screw-access holes with Teflon tape and composite resin. Provide oral hygiene instructions to ensure the patient is able to clean around the implant prosthesis (Fig. 6C).

DISCUSSION

This article introduces a straightforward yet effective technique for facilitating the accurate superimposition of STL files from complete-arch digital scanning for a complete digital workflow in the fabrication of the PMMA prosthesis prototype for a definitive monolithic zirconia prosthesis. Superimposition of the STL files from digital scans is achieved with self-adhesive radiopaque fiducial markers. The retentive sticker surface adheres strongly to the keratinized mucosa as long as the mucosa is air-dried before adhesion of the sticker. The accurate superimposition of the STL files leads to the CAD-CAM fabrication of the prosthesis prototype. The prosthesis prototype is evaluated clinically, adjusted if necessary, and then rescanned for the milling of the definitive prosthesis. Alternatively, a verification device or a pickup impression of the prototype can be made to generate an index cast for the fabrication of the definitive prosthesis. If misfit is detected during the assessment of the prosthesis prototype, the prototype can be easily sectioned and reconnected intraorally with additional PMMA material.

Advantages of the technique include that it is straightforward and inexpensive and that it allows for the fabrication of the prosthesis prototype with a complete digital workflow without a physical cast. This technique may eliminate the need for a virtual face bow because the prototype contains all the necessary information as well as the maxillomandibular relationship.[4,5,9,18]

For edentulous patients, the absence of solid landmarks such as teeth represents a challenge for the registration and superimposition of data. A technique for complete-arch digital implant scanning with an auxiliary polymeric device has been described.[25] However, the technique involves additional steps of duplicating the interim fixed prosthesis or diagnostic trial tooth arrangement. In the present report, fiducial markers were used to superimpose the STL files in an efficient and inexpensive manner. All the data were registered digitally and imported into the CAD software for superimposition of the 2 STL data sets and for prosthesis designing. Alternative techniques for superimposition may include the use of soft-tissue anatomic landmarks such as the palatal rugae, which may not be reliable because they are difficult for IOSs to capture.[21,22,24]

Limitations of the present technique pertain to the accuracy of fit of the generated prosthesis prototype, which is directly dependent on the accuracy of the complete-arch digital implant scan. However, in vitro testing suggests that the complete digital workflow as presented may solve the problems encountered with 3D printing complete-arch physical casts and incorporating additional errors in the cascade of fabrication of the prosthesis prototype.[4,5,11-16]

SUMMARY

The presented technique facilitates accurate superimposition of STL files from complete-arch digital scans and aids in the transfer of all patient-relevant information from the existing interim prosthesis to virtually articulate the edentulous arch. This technique simplifies the clinical procedures and enables the integration of the complete digital workflow without the need to manufacture and articulate physical casts after the digital scan.

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