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DENTAL TECHNIQUE

Impression technique for a complete-arch prosthesis with multiple implants using additive manufacturing technologies

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ABSTRACT

This article describes an impression technique for a complete-arch prosthesis supported by multiple implants where additive manufacturing technologies were used to fabricate a splinting framework and a custom tray. The technique presented uses a shim method to control the homogenous splinting acrylic resin and impression material during the procedure, thereby reducing laboratory and chairside time and the number of impression copings and laboratory analogs needed. (J Prosthet Dent 2017;117:714-720)

When fabricating implant-supported fixed dental prostheses (FDPs), the accurate reproduction of the implant position on the definitive cast is essential. The definitive cast has to represent the 3-dimensional (3D) orientation of the implants in position.[1] The precision of the definitive cast is essential for the fit of an implant-supported FDP, and a precise impression technique is needed to produce an accurate implant position on the definitive cast.[2] The accuracy of impressions is affected by splinting impression copings,[3] implant angulation,[4,5] number of implants,[3] polymerization shrinkage of the impression material,[6-8] setting expansion of the dental stone,[6-8] and the design and rigidity of the impression tray.[6-8] Among all possible factors affecting the accuracy of impressions, splinting or not splinting seems to be the most significant,[3] especially when 4 or more implants are present in the dental arch.[3,9]

During splinting, distortion of the splint materials and/or fracture of the connection between the splint material and the impression copings may affect accuracy.[10] Also, polymerization shrinkage of autopolymerizing acrylic resin produces inaccuracy in the definitive impression. This shrinkage ranges between 7% and 9%, with 80% occurring within 17 minutes when materials were mixed at room temperature.[11]

Additive manufacturing (AM) technologies have the potential to substitute for subtractive ones.[12] The ASTM International committee F42 on AM technologies has defined 7 categories: stereolithography, material jetting, material extrusion, binder jetting, powder bed fusion, sheet lamination, and direct energy deposition.[13] Among these categories, direct metal laser sintering is a metal AM technology that is based on a high-power laser beam focused onto a bed of powdered metal that fuses into a thin, solid layer. When a framework is fabricated in this way, the unused remaining powder is filtered and used in the next batch.[14,15] AM technologies use a design created in a 3D modeling software and digital light processing (DLP) technology to print the 3D object.[16,17] In this technique, a vat of a liquid polymer is exposed to light from a DLP projector under light-protected conditions. The DLP projector then displays the image of the 3D model onto the liquid polymer, and the exposed liquid polymer sets. The process is repeated until the 3D model is complete and the vat is drained of liquid, revealing the solidified model.

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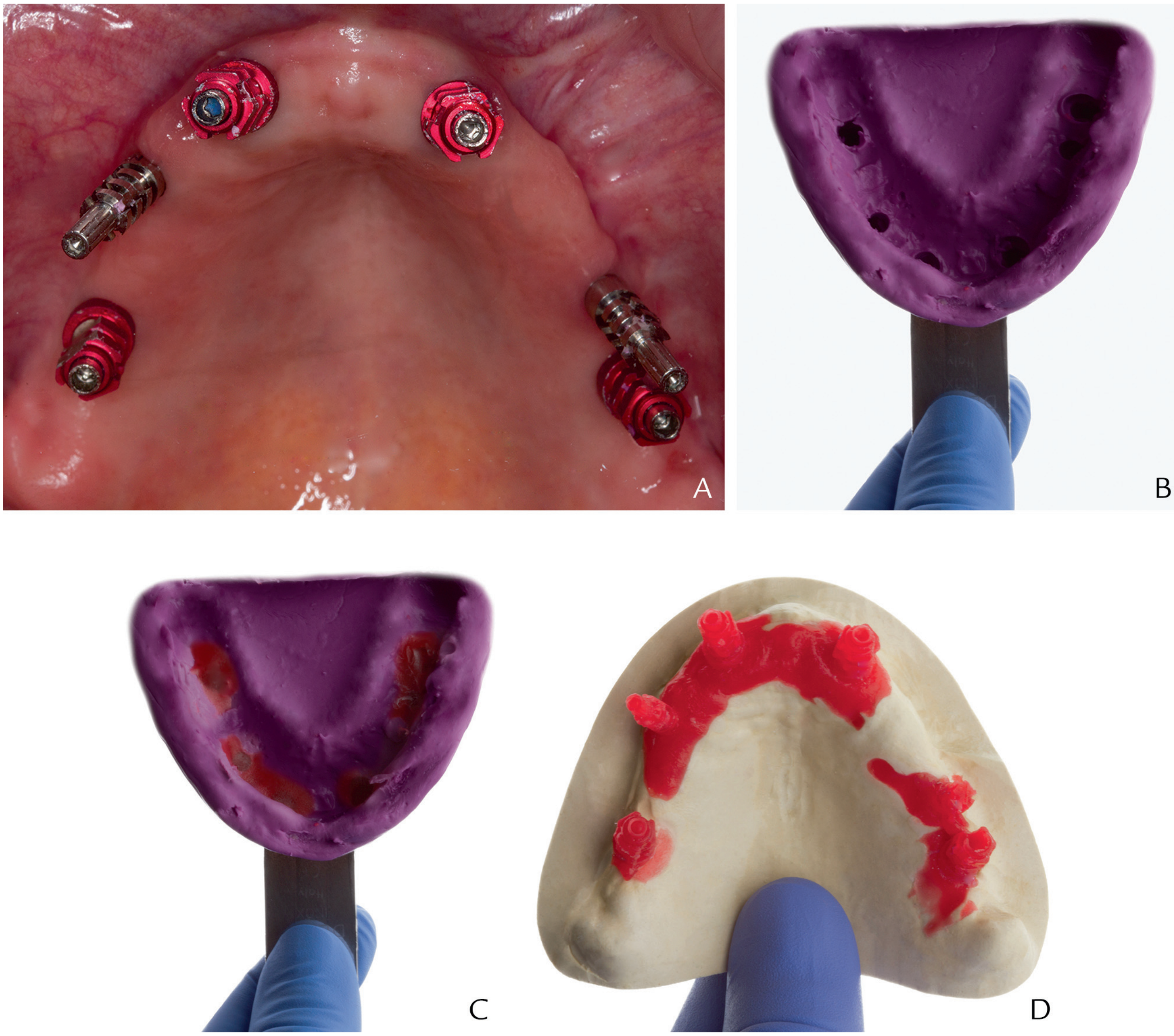

Figure 1. A, Impression coping abutments attached to implant fixtures. B, Irreversible hydrocolloid impression. C, Preliminary impression poured with acrylic resin for impression copings. D, Preliminary cast obtained by pouring irreversible hydrocolloid impression.

Previous studies have demonstrated acceptable accuracy of intraoral scanning devices,[18-22] but procedures requiring multiple steps can accumulate errors that could result in poor fit between the implants and the restorative components.[23] Modified techniques for splinting implants in a complete-arch implant impression procedure have been described.[24,25] The present report describes an impression technique for the complete arch with multiple implants where AM technologies were used to fabricate a splinting framework and a custom tray that reduces the manual procedures.

TECHNIQUE

A patient with an edentulous maxilla having 6 implants (4 Tissue Level RN and 2 Tissue Level NNC; Straumann AG) was referred for a metal–acrylic resin implant–supported FDP. The following technique describes a situation where direct metal laser sintering was used for the metal splinting structure and DLP for the custom tray fabrication

1. Remove the healing abutments with a specific screwdriver (Straumann screwdriver; Straumann AG) and irrigate the internal connection of each implant at the preliminary impression appointment. For a conventional impression, secure the 6 open tray impression copings (Straumann AG) to the implants to a preload of 15 Ncm with a torque wrench (Straumann AG). Make a preliminary irreversible impression using hydrocolloid impression material in a conventional metal impression

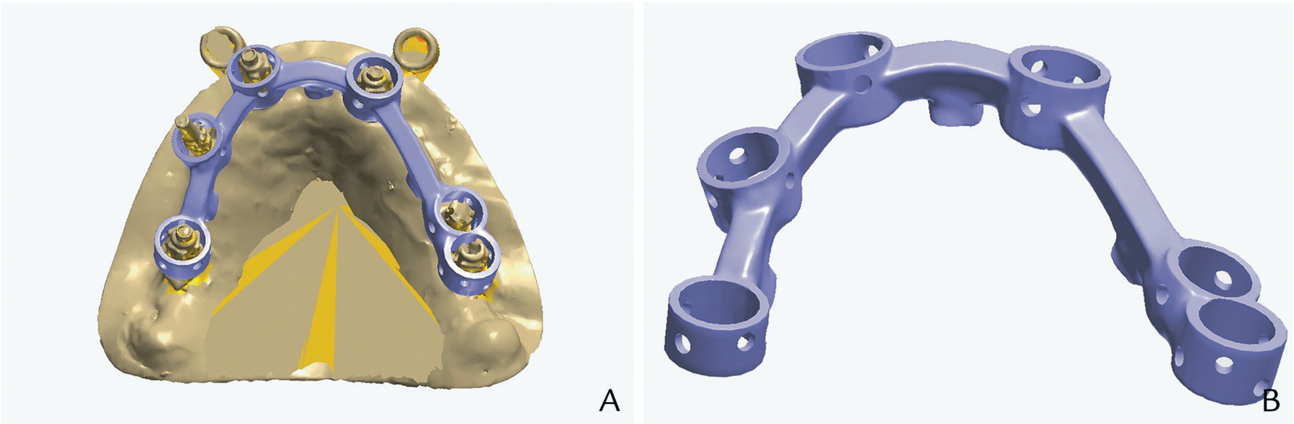

Figure 2. A, Digital preliminary cast obtained by digital impression technique using intraoral scanner. B, Digital design of splinting framework for impression.

tray. When the impression material has polymerized, recover the impression and remove the impression copings (Fig. 1A). For digital impressions, secure the intraoral scan-bodies (Scan-bodies for RN Straumann implant; 3Shape). Make an intraoral digital impression with an intraoral scanning device (Trios; 3Shape) and remove the intraoral scan-bodies. Then replace the healing abutments on each implant.

2. Transfer the data to the specific dental software to design the splinting structure and the custom tray. For the conventional impression, load a disposable syringe (Monoject 412 Syringe; Salvin Dental) with a thin mix of autopolymerizing acrylic resin (1 part polymer to 2 parts monomer) (Pattern Resin; GC Corp) and inject the material into the impression coping sites inside the preliminary impression (Fig. 1B). After polymerization, pour the rest of the impression with die stone (Fujirock EP; GC Corp) at a ratio of 22 mL water to 110 g dental stone mixed under vacuum for 30 seconds. Recover the preliminary cast after the dental stone has completely set (Fig. 1C). For the intraoral digital impression, spray a thin, homogenous layer of the specific scanning spray (Cerec Optispray; Dentsply Sirona) and use an optical laboratory scanner (3Shape; 3Dental Dental Laboratory). Import the data from the digital impression to the software (3Shape) to obtain the digital preliminary cast.
3. Use the tools of the dental software to design the splinting framework (Fig. 2) from the digital cast. Leave a uniform space of 1.5 mm around each impression coping. Send the standard tessellation language (STL) file to the laboratory for fabrication (EOS M270 printer; 3Dental Dental Laboratory) (Fig. 3).
4. Use the tools of the dental software to design the custom tray over the splinting structure (Fig. 4). Leave a uniform space of 2 to 3 mm for the impression material. Send the STL file to the laboratory for fabrication (Rapidshape D40; 3Dental Dental Laboratory) (Fig. 5).

Figure 3. Splinting framework produced through direct metal laser sintering additive manufacturing technology.

5. Remove the healing abutments; irrigate the internal connection of each implant with chlorhexidine before making the definitive impression. Secure the impression copings with a preload of 15 Ncm with a torque wrench (Fig. 6).
6. Evaluate the splinting structure and the custom tray in the patient's mouth.
7. Apply autopolymerizing resin (Pattern Resin; GC Corp) around the impression copings with intraoral tips on the composite resin syringe. Pick up one impression coping at a time, and after the acrylic resin has completely polymerized, continue with the subsequent copings (Fig. 7).
8. Evaluate the custom tray for border extension and mold the borders as in the conventional complete denture impression procedures (Fig. 8). Then remove, clean, and dry the tray, and coat adhesive

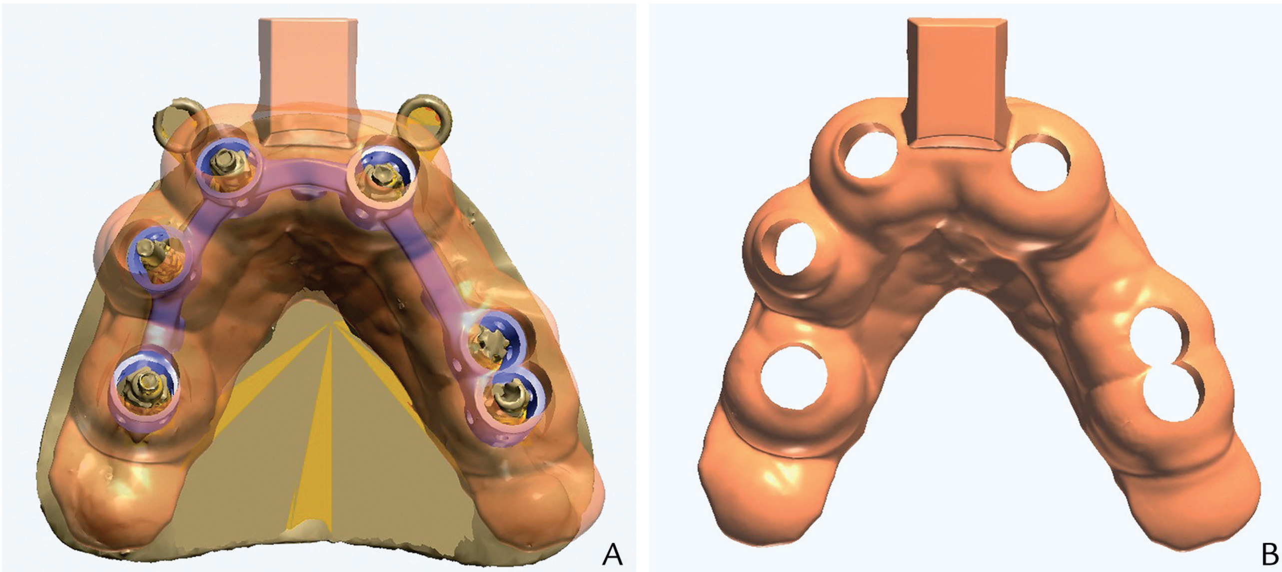

Figure 4. A, Digital design of custom tray for impression on digital cast. B, After removal from cast.

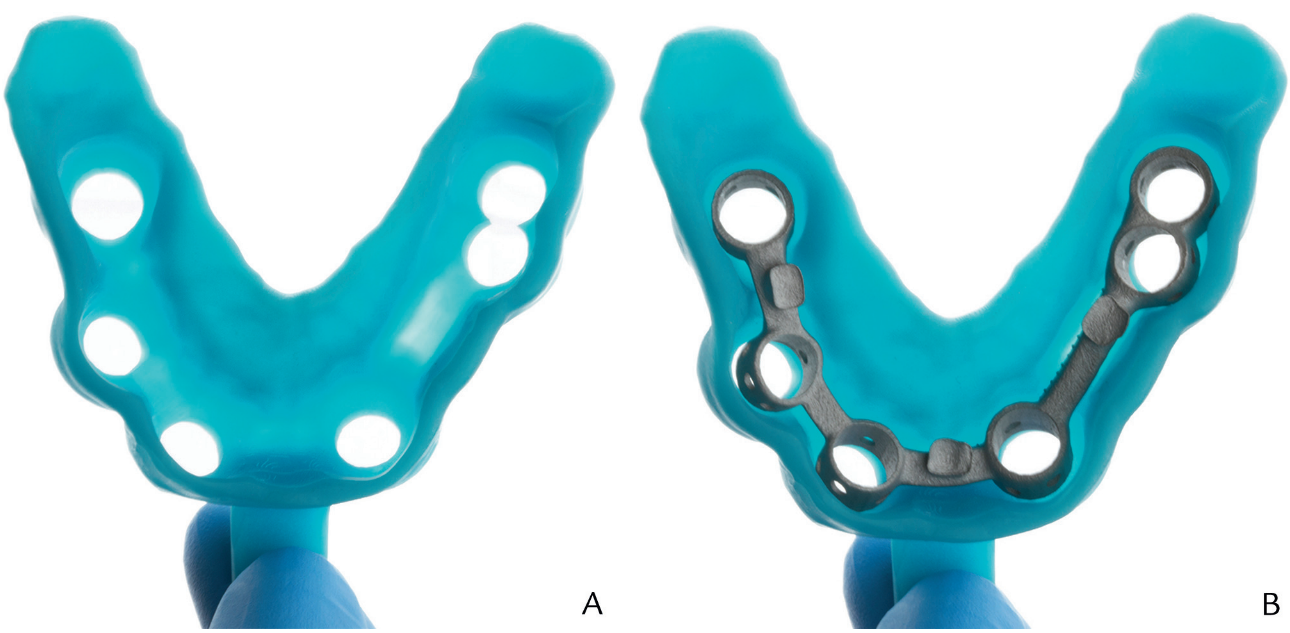

Figure 5. A, Custom tray produced through DLP additive manufacturing technology. B, Splinting framework positioned in custom tray.

(Impregum adhesive; 3M ESPE) on its internal surface and over the modeling plastic impression compound at the borders.

9. Dispense medium viscosity impression material (Impregum; 3M ESPE) into both the impression syringe and the custom tray. Inject the impression material underneath the splinting structure with a polyether syringe and seat the custom tray.
10. Recover the impression after the polyether impression material has polymerized completely and pour the impression following conventional procedures (Fig. 9).

DISCUSSION

The presented method describes an implant impression technique for a complete arch where AM technologies were used to fabricate the custom tray and the metal splinting structure. Figure 10 shows radiographic evaluation of metal–acrylic resin implant–supported prosthesis. The clinical procedures for the impression making are similar to previously described techniques.[24] However, the application of AM technologies provides different advantages to the conventional procedures: manual procedures are eliminated, homogeneous space for the splinting

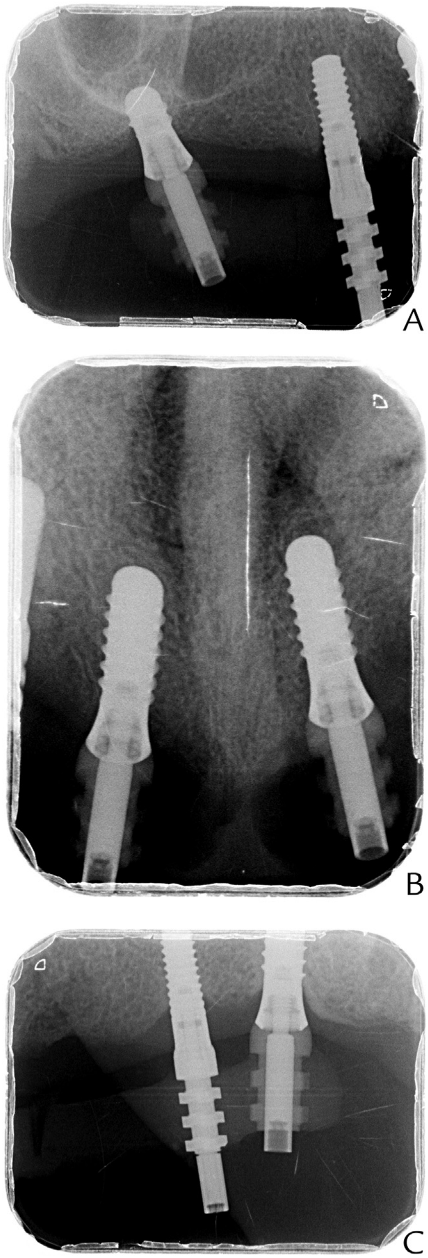

Figure 6. Periapical radiographs showing complete seating of impression copings. A, Maxillary right first molar and canine. B, Maxillary right central incisor, maxillary left central incisor. C, Maxillary left second premolar and first molar.

material between the impression abutments and the splinting structure is achieved, uniform space for the impression material between the splinting structure and the custom tray is controlled, and an open custom tray around the impression abutments is maintained.

During the described technique, and as an alternative to conventional procedures, an intraoral scanning device was used to obtain the preliminary cast. The function of the preliminary cast model was to represent the 3D implant position and replicate the surrounding buccal structures.

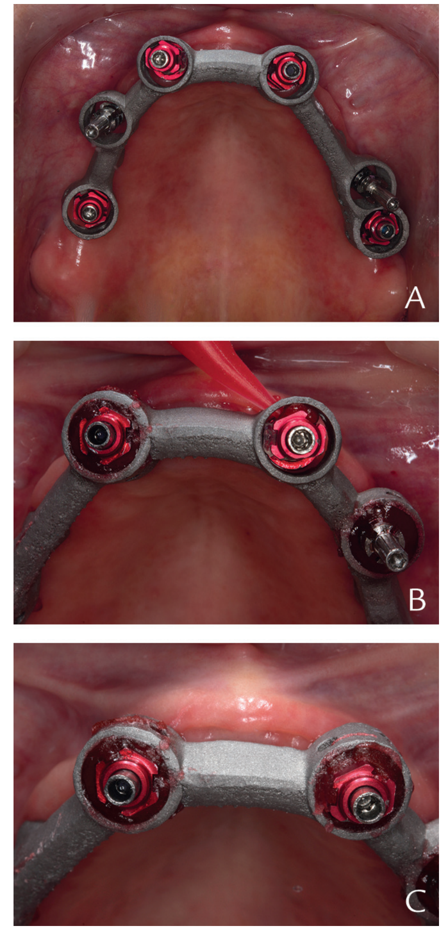

Figure 7. A, Impression copings secured in 3D printed metal splinting framework. B, Autopolymerizing acrylic resin around impression copings. C, Complete polymerization of acrylic resin before making polyether impression.

Figure 8. Border molding custom tray.

Furthermore, the cast model would allow fabrication of the custom splinting structure and the open custom tray.

Compared with methods where the custom tray and the splinting structure were fabricated with a manual protocol,[24,25] this technique using AM could eliminate some of the laboratory procedures. Possible limiting

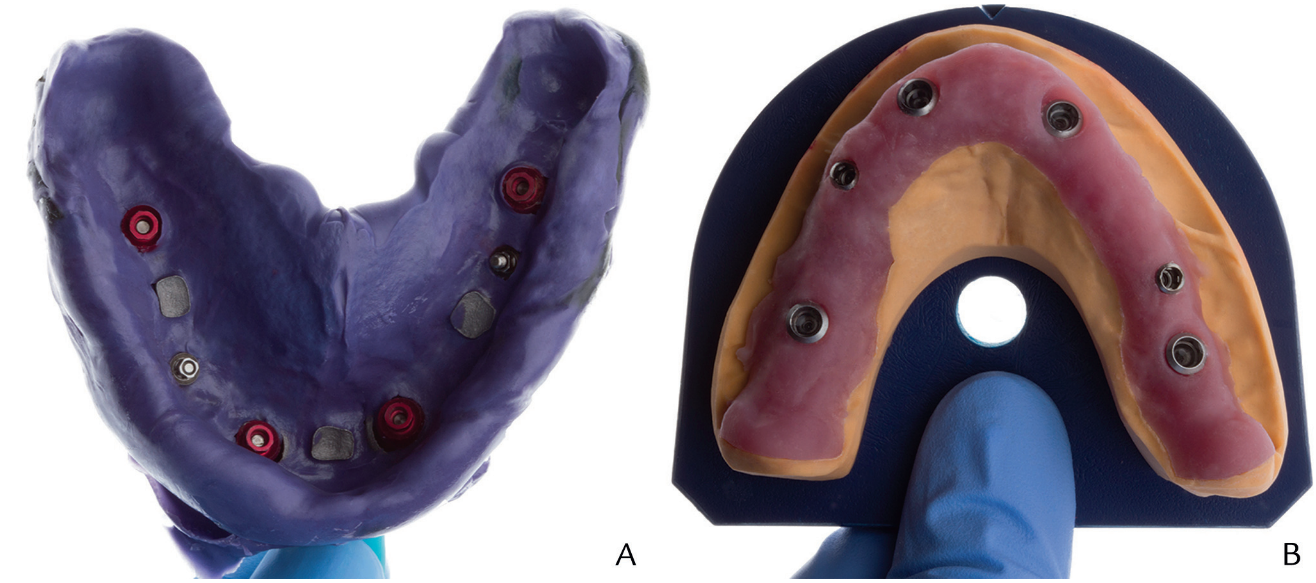

Figure 9. A, Definitive impression with polyether impression material. B, Definitive cast.

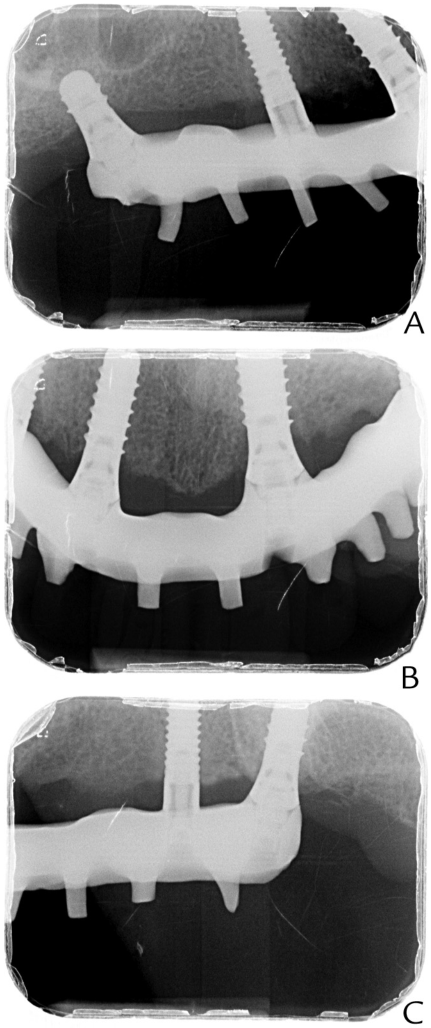

Figure 10. Radiographic evaluation of metal–acrylic resin implant–supported prosthesis. A, Maxillary right first molar and canine. B, Maxillary right central incisor, maxillary left central incisor. C, Maxillary left second premolar and first molar.

factors such as implant angulation, interimplant distance, and open mouth limitations should be evaluated in future studies.

SUMMARY

The described impression technique uses AM technologies to fabricate a splinting framework and a custom tray for a complete arch containing multiple implants.

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Noteworthy Abstracts of the Current Literature

Three-dimensional accuracy of digital implant impressions: Effects of different scanners and implant level

Chew AA, Esguerra RJ, Teoh KH, Wong KM, Ng SD, Tan KB

Int J Oral Maxillofac Implants 2017;32:70-80

Purpose. To compare the three-dimensional (3D) accuracy of conventional direct implant impressions with digital implant impressions from three intraoral scanners, as well as different implant levels-bone level (BL) and tissue level (TL).

Material and Methods. Two-implant master models were used to simulate a three unit implant-supported fixed dental prosthesis. Conventional test models were made with direct impression copings and polyether impressions. Scan bodies were hand-tightened onto master models and scanned with the three scanners. This was done for the TL and BL test groups, for a total of eight test groups (n=5 each). A coordinate measuring machine measured linear distortions (dx, dy, dz), global linear distortion (dR), angular distortions (dθy, dθx), and absolute angular distortions (Absdθy, Absdθx) between the master models, test models, and .stl files of the digital scans.

Results. The mean dR ranged from 35 to 66 μm; mean dθy angular distortions ranged from -0.186 to 0.315 degrees; and mean dθx angular distortions ranged from -0.206 to 0.164 degrees. Two-way analysis of variance showed that the impression type had a significant effect on dx, dz, and Absdθy, and the implant level had a significant effect on dx and Absdθx (P<.05). Among the BL groups, the mean dR of the conventional group was lower than and significantly different from the digital test groups (P=.010), while among the TL groups, there was no statistically significant difference (P=.572).

Conclusions. The 3D accuracy of implant impressions varied according to the impression technique and implant level. For BL test groups, the conventional impression group had significantly lower distortion than the digital impression groups. Among the digital test groups, the TR system had comparable mean linear and absolute angular distortions to the other two systems but exhibited the smallest standard deviations.

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