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DENTAL TECHNIQUE

Three-dimensional printing in contemporary fixed prosthodontics: A technique article

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ABSTRACT

Digital dentistry has gained in popularity among clinicians and laboratory technicians because of its versatile applications. Three-dimensional (3D) printing has been applied in many areas of dentistry as it offers efficiency, affordability, accessibility, reproducibility, speed, and accuracy. This article describes a technique where 3D printing is used to fabricate a die-trimmed cast and to replicate gingival tissue and implant analogs. The digital workflow that replaces the conventional laboratory procedure is outlined. (J Prosthet Dent 2017;■:■-■)

The wide adoption of digital dentistry and dental technology has been rapid.[1-4] Computer-aided design and computer-aided manufacturing (CAD-CAM) has been successfully used in both removable and fixed prosthodontics,[5-7] and 3-dimensional (3D) printing has been an area of digital technology growth.[2,8]

Three-dimensional printing or rapid prototyping technology has been extensively used in the industrial, engineering, and medical fields, enabling manufacturers to fabricate parts and end products.[8] Furthermore, rapid prototyping has been used in different fields of dentistry, including surgical planning,[8] fabricating maxillofacial prostheses,[9] making fixed and removable dental prosthodontics,[2,10,11] orthodontics,[12] and implant dentistry.[13] Advances in this technology will have a great impact on dentistry.

Affordable desktop 3D printers along with user-friendly 3D software provide opportunities for the use of polymer-based 3D-printed materials across all aspects of dentistry.[14-22] They enable the in-office printing of diagnostic casts, teaching aids, die-trimmed casts of prepared teeth, and surgical guides.[13-16]

This report introduces the use of 3D printing technology to replace the conventional fixed prosthodontic laboratory process. This includes the reproduction of a combination of natural tooth preparation dies, implant restoration dies, and the soft tissue profile in a single printable cast.

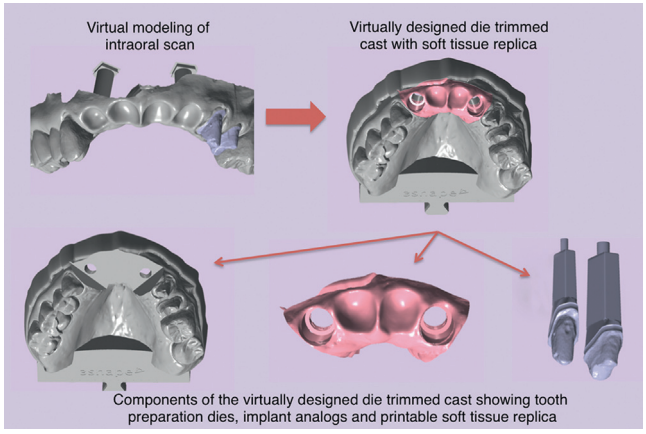

Figure 1. Virtual die-trimmed cast designed with contemporary fixed prosthodontics approach, including designing tooth preparation dies, implant analogs, and soft tissue emergence profile replica for both implant abutments and pontic areas.

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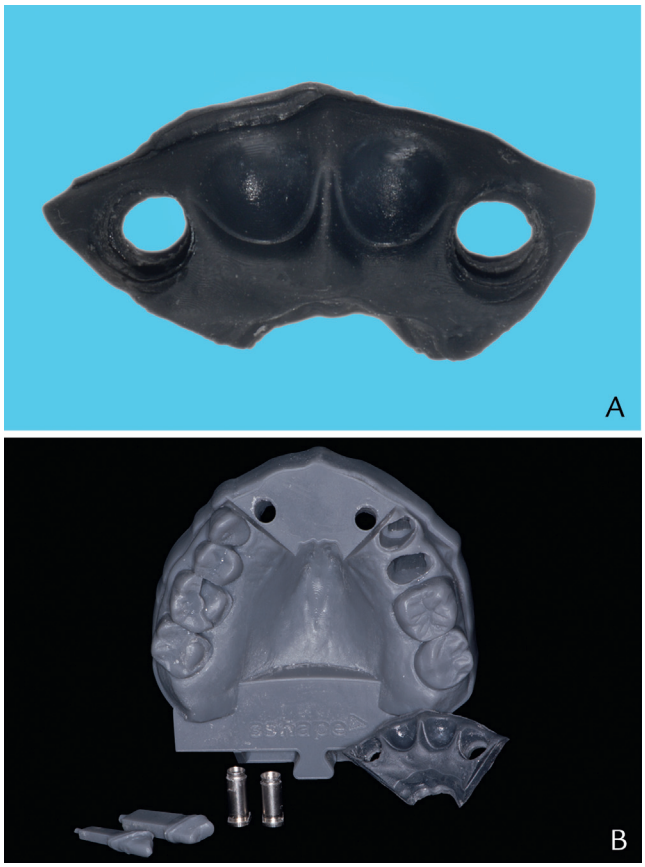

Figure 2. A, Gingival tissue insert printed from flexible resin. B, Printed cast with dies, gingival tissue insert, and implant analogs.

TECHNIQUE

A technique for fabricating both implant- and tooth-supported interim or definitive restorations follows:

1. Prepare the teeth and place gingival displacement cord.
2. Remove healing abutments on implants and immediately perform the intraoral scan (TRIOS 3 Mono Intraoral Scanner; 3Shape). Record a scan of the opposing arch along with an occlusal registration.
3. Place scan bodies (NC Straumann, CARES, Mono Scanbody; Straumann) on the implants and record a second intraoral scan.
4. Import recorded scans into CAD software (Dental System; 3Shape), transferring information on implant location, tooth preparations, soft-tissue volume, and occlusion.
5. Using CAD software (Dental System; 3Shape), design appropriate emergence profile and crown anatomy.
6. Transfer restoration design into the cast design software (Model Builder; 3Shape). A combined die and cast with integrated implant analogs is then created (Fig. 1). The designed restorations with appropriate emergence profile and/or pontic shapes are transferred to the cast.
7. Cut the cast digitally at the level of the implant platform to create a soft tissue insert (Fig. 1).
8. Export the maxillary and mandibular casts, dies, and gingival tissue as standard tessellation language files (Fig. 1).

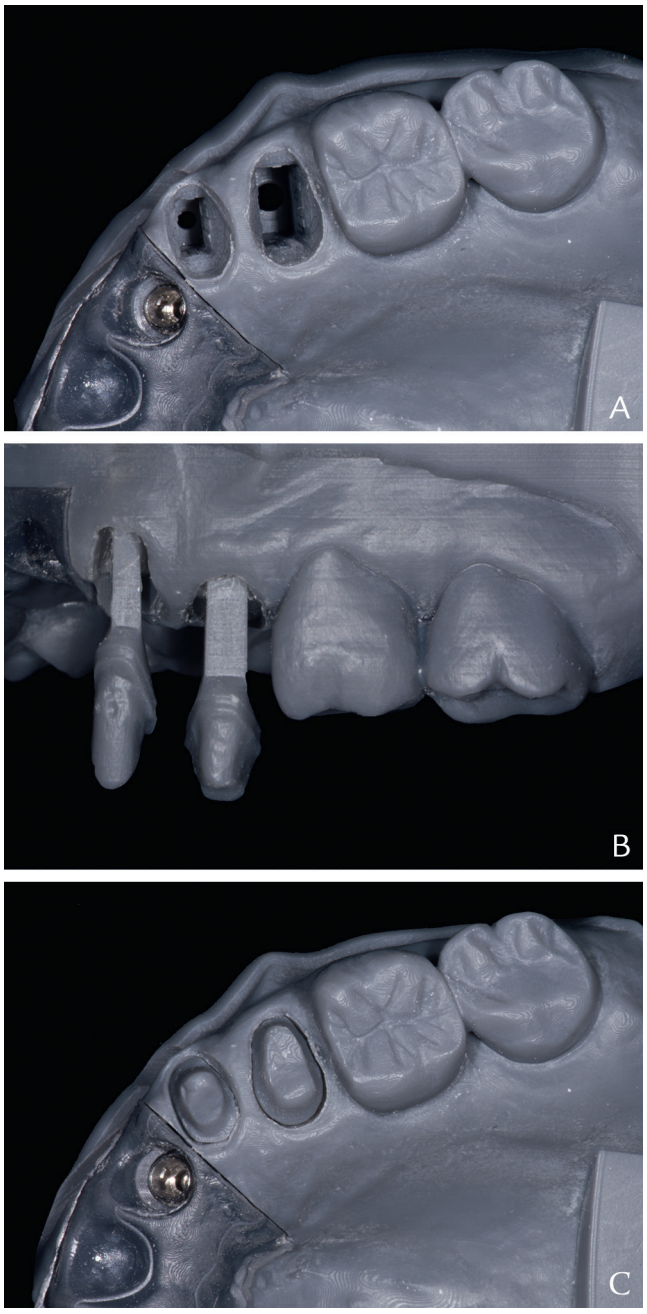

Figure 3. A, Occlusal view of printed cast showing die spaces in maxillary left canine and first premolar tooth areas. B, Lateral view of printed cast showing printed dies. C, Occlusal view of printed cast showing seated dies.

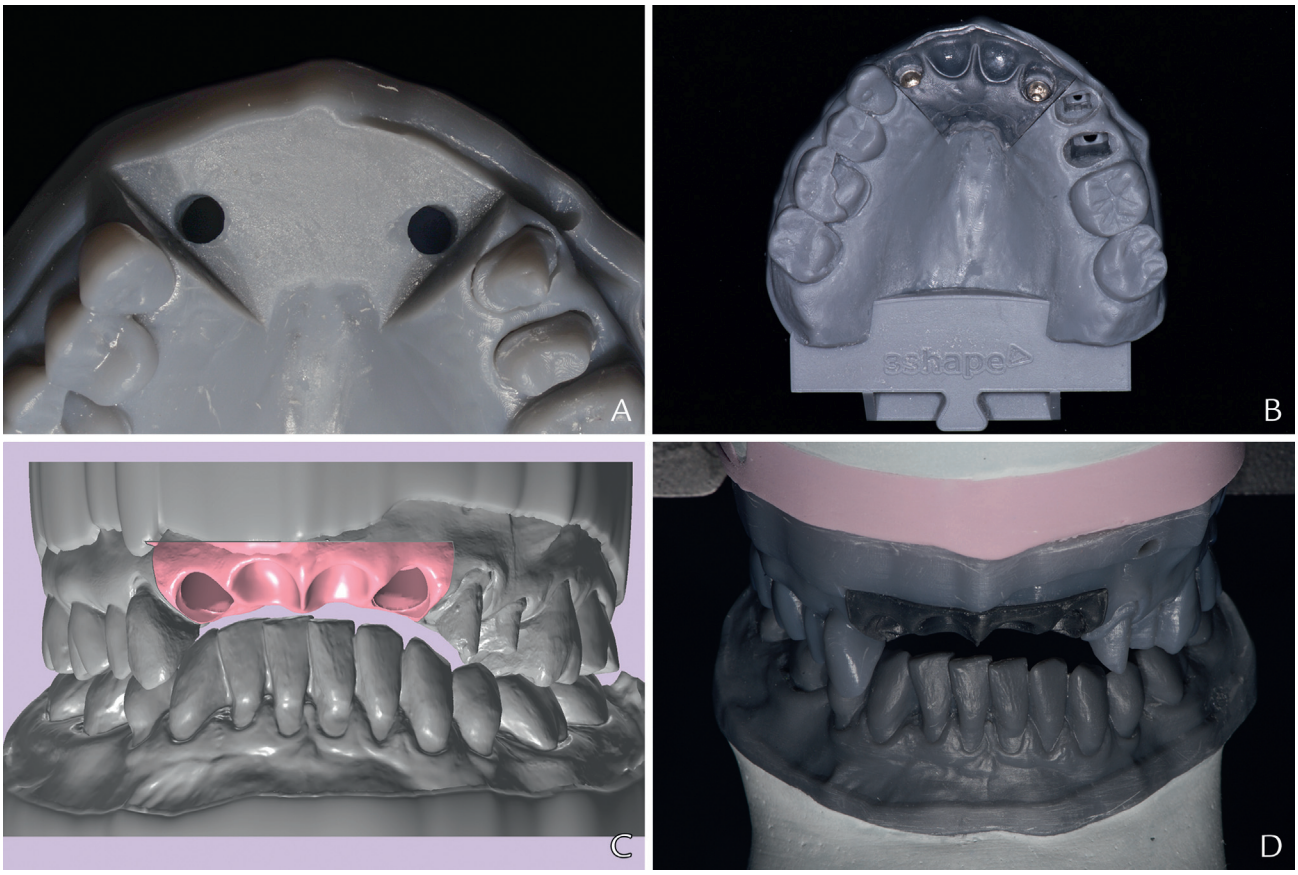

Figure 4. A, Occlusal view of printed cast showing implant analog spaces in areas of maxillary right and left lateral incisors. B, Occlusal view of printed cast showing gingival tissue insert, implant analogs, and die spaces. C, Virtually mounted maxillary and mandibular casts. D, Frontal view of mounted printed maxillary and mandibular casts.

9. Fabricate the maxillary and mandibular casts along with dies by using a 3D printer (Form 2; Formlabs). Print the casts and the dies by using Formlabs standard gray resin.
10. Print the gingival tissue insert separately on the same printer by using Formlabs flexible resin (Fig. 2A).
11. Clean and prepare the printed components for assembly (Fig. 2B). A special type of implant analog is used for the printed cast (Impression analog model Str NC; Core 3D Centres).
12. Mill the designed restorations (Roland DWX-50; Whip Mix Corp) from a poly(methylmethacrylate) (PMMA) blank (Telio CAD; Ivoclar Vivadent AG) of the appropriate shade.
13. Assemble the printed cast with dies (Fig. 3), implant analogs, and gingival tissue insert (Fig. 4A, B) and mount the casts on an articulator (Fig. 4C, D).
14. Attach titanium bases to the implant analogs and then evaluate the milled interim restorations on the titanium bases. Adjust the proximal and occlusal contacts as needed.
15. Cement the titanium bases to the milled interim restorations with resin cement (Panavia F 2.0; Kuraray America Inc) (Fig. 5A).
16. Seat the interim restorations intraorally to evaluate esthetics and function (Fig. 5B).
17. Following trial placement of the interim restorations and patient acceptance, the definitive restorations can be fabricated using a similar digital protocol (Fig. 6).

DISCUSSION

A technique for fabricating a 3D die-trimmed cast for natural teeth and implant restorations, maintaining soft tissue profile around both types of restorative abutments, is presented. The technique allows for better visualization and design of the restorative emergence profile. Desktop 3D printers usually use a liquid photopolymerizing resin composed of methacrylate acid esters, acrylic acid esters, and photo-initiators that harden upon exposure to ultraviolet light. This material provides casts that are accurate,[17,18] lightweight, dense,[16] and resistant to wear

Figure 5. A, Frontal view of interim restoration seated on printed cast. B, Frontal view of interim restoration seated in patient mouth. C, Intraoral frontal view showing soft tissue contour after 2 months of healing.

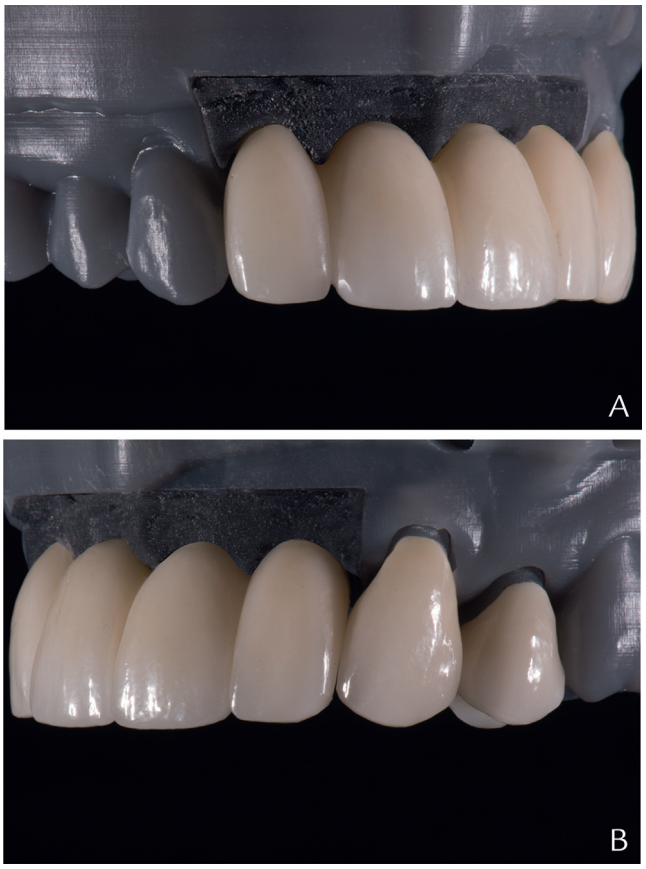

Figure 6. Definitive restoration on printed cast. A, Right lateral view. B, Left lateral view.

and damage during restoration fabrication. In addition, the ability to store these data in a digital format eliminates the need for the physical storage space associated with conventional casts. Should a physical cast be needed, it can be rapidly fabricated with the same precision and quality as the original cast.[10]

An alternative to 3D printing is computer numerical controlled (CNC) milling. However, the drawbacks of CNC milling include difficulties in creating complex geometries and accurate reproduction of undercuts and the significant amount of wasted material.[19] Furthermore, advanced industrial printers provide the ability to print multiple different materials simultaneously. Three-dimensional printing technology has been successfully used to print wax patterns for metal framework casting, removable partial denture metal frameworks, and metal prostheses.[10,20,21] The main advantages of this technology are reduced labor costs, reduced fabrication errors, and increased production efficiency.[16]

The lower cost of the consumer grade 3D printers[16] and the ability to incorporate this technology into clinical practice have appealed to many clinicians, who mostly use them to print casts and surgical guides.[13,14,16,18] Printed casts can also be used for treatment planning and to rehearse surgical procedures.[8,22]

The learning curve for the CAD software, the high initial cost of purchasing and licensing CAD software along with the printer, production time, available printable materials, and post-processing procedures still limit the use of 3D printers in a dental office. The higher the accuracy the smaller the vertical resolution used for the printed part, increasing the number of printed layers and thus the time required to print the cast.[18] Developing a biocompatible, printable material with the desired dental

properties remains a challenge. The current US Food and Drug Administration-approved printable materials are limited in type and color. In the presented technique, a dark-shade resin was used to print both the soft tissue insert and the cast. Recently Formlabs introduced a new amber-colored resin for casts. Another pink flexible resin material for printing the soft tissue inserts (Next Dent Gingiva Mask; Next Dent) is available but was not compatible with the 3D printer (Form2; Formlabs) used in this report.

SUMMARY

Rapid advances in 3D printing technology will certainly further influence many aspects of traditional dentistry. The capabilities and usefulness of 3D printing in prosthetic dentistry has yet to be fully studied and developed. This technique article provides an example of the use of 3D printing to create a definitive cast.

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