DENTAL TECHNIQUE

3D-printed custom trays with a Gothic arch for centric relation recording and definitive impression making for complete dentures: A dental technique

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Centric relation (CR) recording is an important step in the fabrication of a complete denture. Wax occlusion rims (static) and Gothic arch (functional) tracing are the most commonly used methods for CR recording for complete dentures.[1,2] Gothic arch tracing is the more accurate method but is more technique-sensitive and time-consuming than the occlusion rim technique.[1,3] The use of a digital workflow for complete dentures has become popular, with computer-aided design and computer-aided manufacturing (CAD-CAM) and rapid prototyping (RP) technologies helping to reduce costs and simplify treatment.[4-7]

Sun et al[8] applied 3-dimensional (3D) printing using a cross-sectional scanner and a laser scanner to obtain the surface data of artificial teeth. Inokoshi et al[9] evaluated different complete dentures fabricated using RP and traditional methods. Schwiger et al[10] combined 3D scanning data of the face, impressions, and occlusal rim to develop a virtual patient. However, reports focusing on the fabrication of a Gothic arch using digital workflow are scarce. This article describes an appliance fabricated by CAD-CAM and 3D printing to combine definitive impression making and centric relation recording into a single step.

ABSTRACT

An appliance was designed and fabricated by using computer-aided design and computer-aided manufacturing (CAD-CAM) and 3-dimensional (3D) printing to combine a custom tray with an intraoral Gothic arch. This helped simplify centric relation recording and combined definitive impression making and centric relation recording into a single step. (J Prosthet Dent 2019;121:32-6)

TECHNIQUE

1. Measure and record the vertical dimension and preliminary centric relation with a centric tray

Figure 1. Vertical dimension and preliminary centric relation recorded with centric tray.
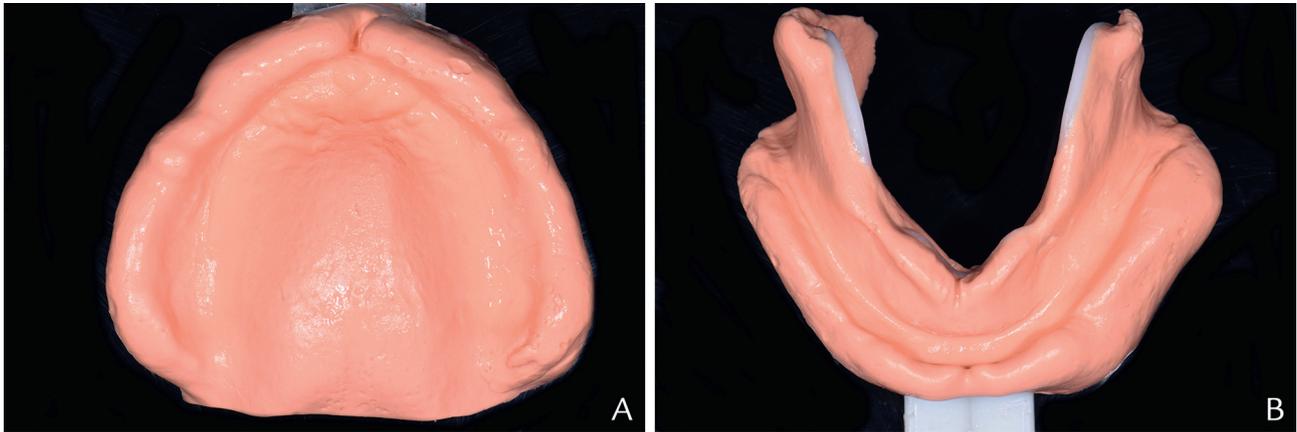
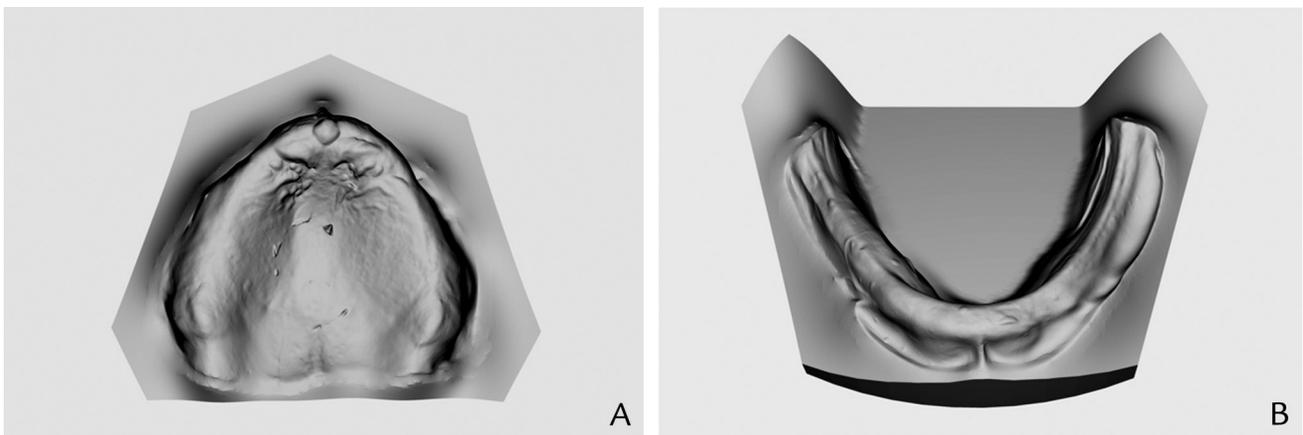**Figure 2.** Preliminary impressions. A, Maxillary. B, Mandibular.

Figure 3. Virtual casts. A, Maxillary. B, Mandibular.

(Ivoclar Vivadent AG). Draw 2 points on the nasal point and chin of the patient. Then, ask the patient to open the mouth and close slowly until the lips touch to achieve the physiologic rest position. Use a ruler to measure the distance between the 2 points and subtract an interocclusal rest space of 2 mm from the distance to achieve vertical dimension. Put impression silicone (Silagum-Putty; DMG) on the centric tray and insert the centric tray into the patient's mouth. Ask the patient to close the mouth slowly to cover the residual ridge crest with impression silicone. When the distance between the 2 points reaches the previously measured vertical dimension, ask the patient to swallow. After the impression silicone has polymerized, remove the centric tray (Fig. 1).

2. Make preliminary impressions (Alginoplast, regular set; Kulzer GmbH) (Fig. 2).

3. Scan the preliminary impressions and centric tray with a 3D scanner (iSCAN-I; Hangzhou Shining 3D) with software (intraOralScan, v1.2.0.0; Hangzhou Shining 3D). Obtain standard tessellation language (STL) data of the vertical dimension and the maxillary and mandibular preliminary impressions.

4. Use reverse-engineering software (Geomagic Studio 2013; 3D Systems) to edit and trim the preliminary impression data. Then, reverse and align the maxillary and mandibular impression data to obtain the STL data for the virtual casts (Fig. 3).

5. Import the STL data of the virtual casts into the CAD design software (3Shape Appliance Designer 2015-1; 3Shape A/S). The software uses 3D migration, deformation, telescoping, importing external accessories, and Boolean addition and subtraction to obtain the CAD data of the maxillary custom tray with the Gothic arch tracing plate, mandibular custom tray, and Gothic arch guide plate (Fig. 4).

6. Import the CAD data into software (Shining 3DDLP, v1.0.0.1; Hangzhou Shining 3D) to set the type, and cut into slices to prepare for 3D printing. Then, use a 3D printer (Sino II 3D printer, Beijing
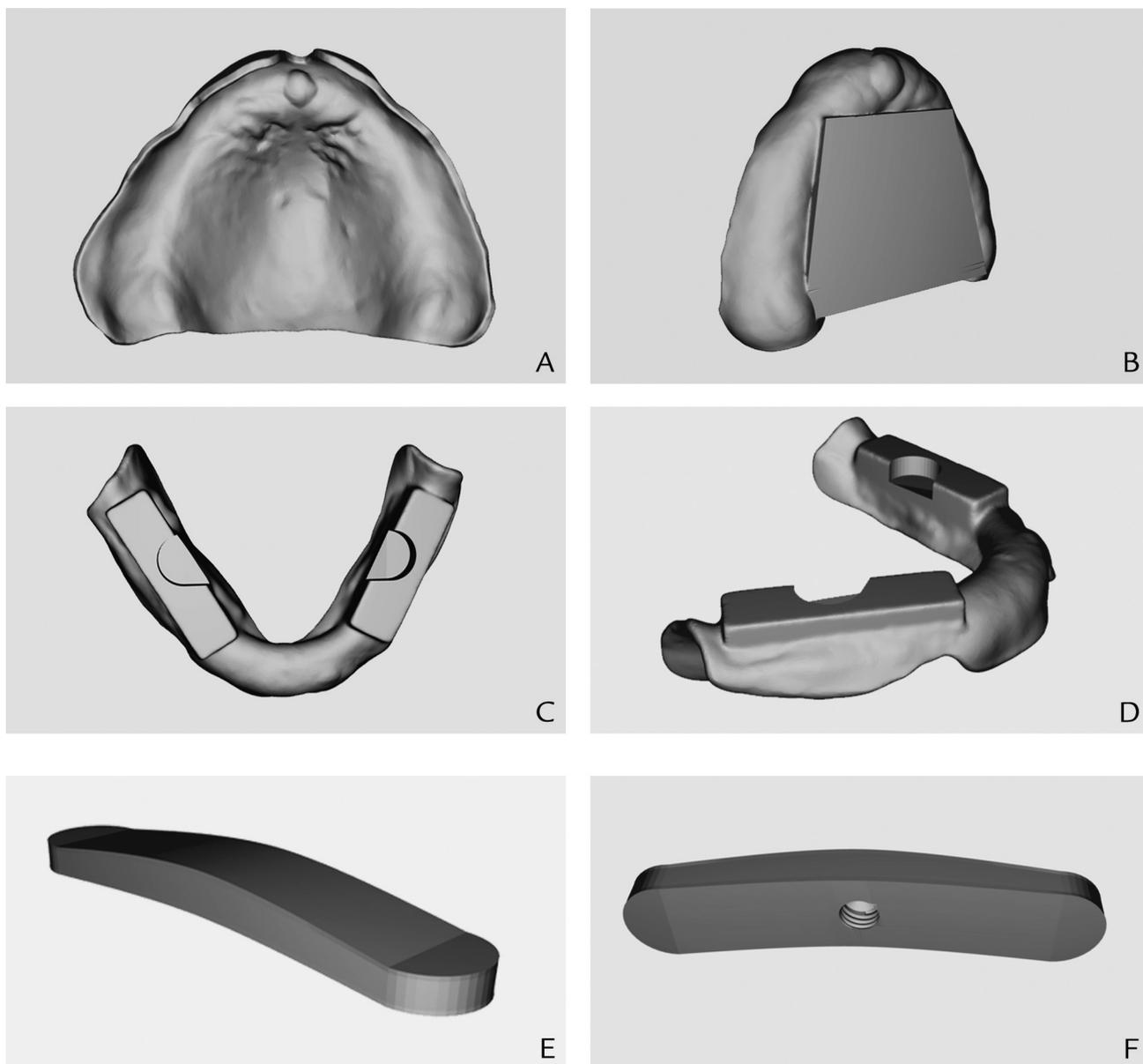
Figure 4. A, Frontal view of virtual maxillary custom tray with Gothic arch tracing plate. B, Lateral view of virtual maxillary custom tray with Gothic arch tracing plate. C, Frontal view of virtual mandibular custom tray. D, Lateral view of virtual mandibular custom tray. E, Lateral view of virtual Gothic arch guide plate. F, Virtual Gothic arch guide plate with screw hole.

Baden Technology Co Ltd) with polylactic acid (PLA; Beijing Baden Technology Co Ltd). Set the height at 0.1 mm, and print the custom trays with the Gothic arch (Fig. 5).

7. Make the occlusion rim on the maxillary custom tray with wax. Evaluate the wax occlusion rim to determine the occlusal plane, fullness of lips, and appearance.

8. Use putty silicone (Silagum-Medium; DMG) and impression silicone (Honigum-Light; DMG) to process the border molding and make a definitive impression with the custom trays (Fig. 6).

9. Assemble the mandibular Gothic arch guide plate and the preformed tracing screw (Massad Jaw Recorder Starter Kit; Nobilium Co). Put the entire appliance into the patient's mouth and adjust the height of the tracing screw to the previously recorded vertical dimension. Ask the patient to slowly perform lateral and anteroposterior mandibular movements while the maxillary and mandibular custom trays are in contact. Then, remove the appliance and coat the maxillary Gothic arch tracing plate with ink. Return the appliance to the mouth, and ask the patient to
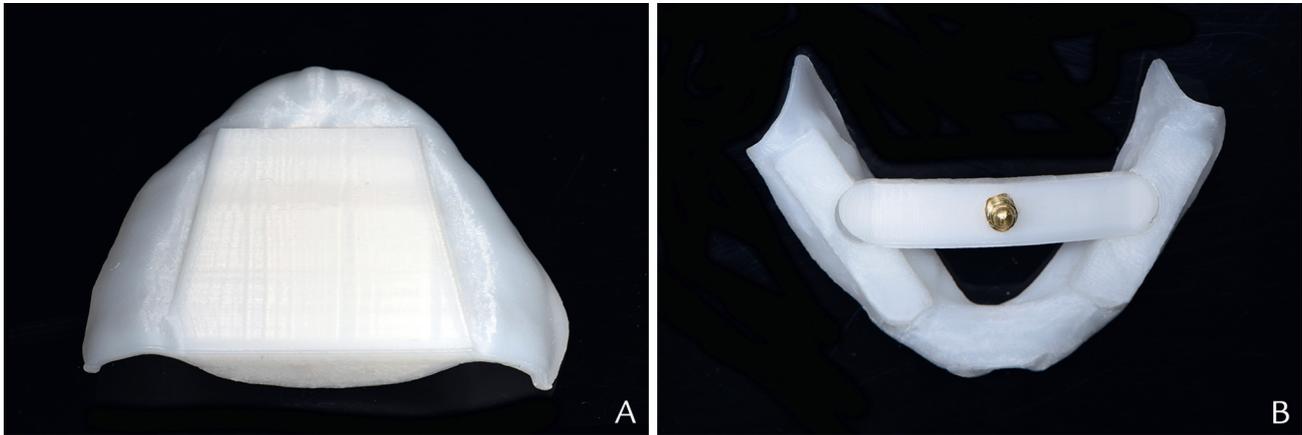
Figure 5. A, 3D-printed maxillary custom tray with Gothic arch tracing plate. B, 3D-printed mandibular custom tray, Gothic-arch guide plate, and commercially available tracing screw.
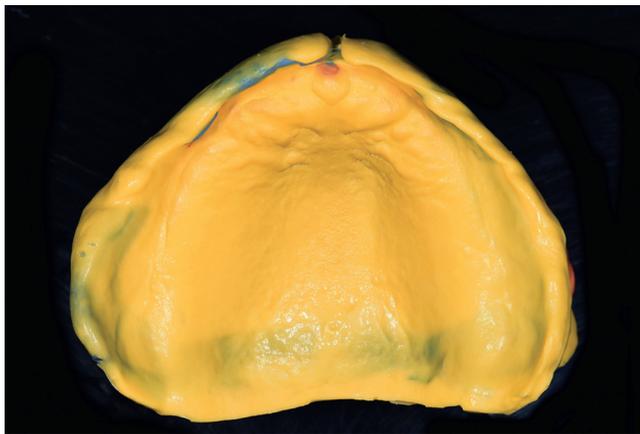

Figure 6. Border-molded definitive maxillary impression.

repeat the previous movements to obtain the mandibular movement tracings (Fig. 7A).

10. Ensure that the tracings are clear and ask the patient to move the mandible to the position where the tracing screw is located at the point of the movement trails. Insert the occlusal record material (O-Bite; DMG) between the custom trays. After the custom trays are fixed, remove them. Then, send the custom trays and centric tray to the laboratory (Fig. 7B).

11. Fabricate the complete denture: fabricate a trial complete denture and make the definitive complete denture according to the trial procedure (Fig. 8).

DISCUSSION

This appliance enables clinicians to simplify the assembly and test the Gothic arch, resulting in a more convenient centric relation recording. Also, 3D printing helps to match the anatomic structures more accurately. However, the designing step presents some issues. First,

the measurement and recording of the vertical dimension is a necessary step to ensure the accuracy of the centric relation recording. A centric tray was used to record the vertical dimension and preliminary centric relation. The preliminary centric relation helped to align the virtual casts and provided more details in the designing of the custom trays. Meanwhile, the data of the vertical dimension also acted as a reference for making the occlusion rim.

Second, because the mandibular Gothic arch guide plate is removable to allow the tongue to move during border molding, 2 semicircular grooves should be designed in the mandibular custom tray to ensure the stability of the connection between the mandibular Gothic arch guide plate and the mandibular custom tray. Third, a hole prepared for the tracing screw should be reserved in the center of the guide plate. The tracing screw could not be manufactured because the accuracy of the 3D printer used for this technique was limited; this aspect of the procedure needs further improvement.

Polylactic acid (PLA, Beijing Baden Technology Co Ltd) was used as the printing material. Depending on the different forming patterns, the RP materials commonly used in this procedure include acrylonitrile butadiene styrene, PLA, photosensitive resin, cobalt chromium alloy, and other metals.[11,12] Initially, photosensitive resin (Hangzhou Shining 3D) was chosen because it is commonly used to print casts and wax patterns. However, the silicone impression material (Honigum-Light; DMG) that was in contact with the custom trays did not polymerize. No reports were found on the interaction of photosensitizing resin with this kind of silicone material. Therefore, according to the manufacturer's guidance, PLA (Beijing Baden Technology Co Ltd) was used to solve this problem. However, the PLA used had a rough surface, which required polishing before use. The roughness was improved by setting the height of the printing layer.
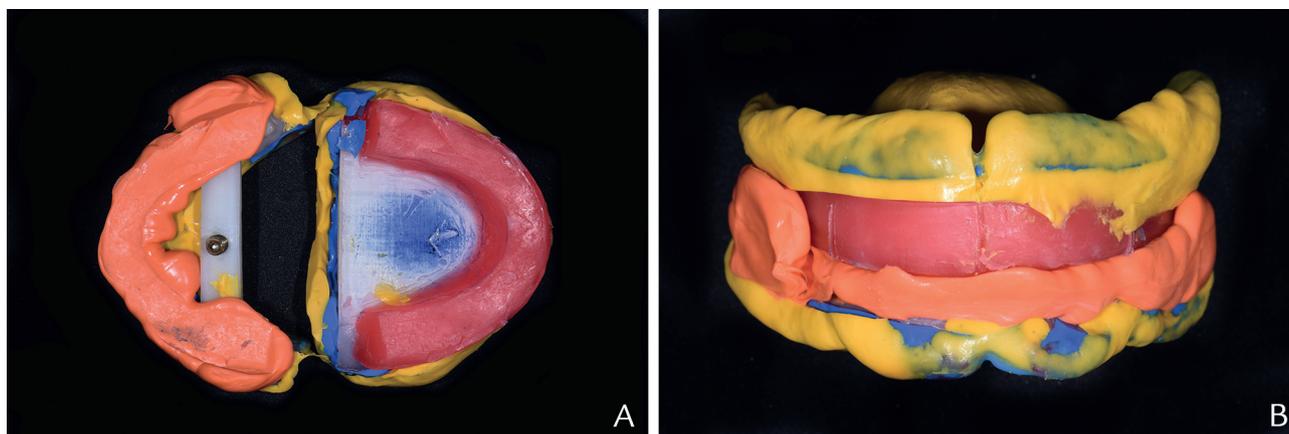
Figure 7. A, Mandibular movements traced with Gothic arch. B, Maxillomandibular relationship recorded.

Figure 8. Intraoral view of complete dentures.

Therefore, the layer height was set at 0.1 mm to obtain a satisfactory surface. These experiences suggest that more accurate 3D printing remains a challenge.

SUMMARY

This article describes an appliance fabricated by using CAD-CAM and 3D printing that aims to simplify centric relation recording by combining it with definitive impression making in a single step.

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