

Digital Denture Fabrication: A Technical Note

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Abstract: Fabricating a complete denture in a conventional manner may be complicated and difficult. The purpose of this article was to describe the benefits of a fully digital workflow and fabrication procedure of complete dentures based on digital impressions of edentulous jaws. The digital data for the workflow were acquired using an intraoral scanner and were then used to design the denture base and teeth. The resulting data were exported to a 3D printer or a milling machine for denture fabrication.

Keywords: digital denture; edentulous jaw; intraoral scanner; CAD/CAM



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1. Introduction

In the past decades, dentists have used the conventional method for complete denture fabrication, which is complicated, difficult, and time consuming [1–3]. The conventional method uses functional impression, cast pouring, wax rim fabrication, mounting the models in an articulator, and curing the denture. The conventional process is associated with human processing errors, inaccuracies, and multiple clinical appointments. Recently, computer-aided design and computer-aided manufacturing (CAD/CAM) technology was applied to the fabrication of complete dentures. The introduction and evolution of computer-aided technology can overcome the complications related to the conventional method, thereby facilitating the fabrication process [4–8]. The process of fabricating complete dentures with digital technology involves digitization of clinical information registered from the patient's mouth, digital designing of complete dentures on computer software, and an automatized process of manufacturing. The high accuracy of digitalized dental fabrication has been proved by several studies compared to conventional methods [3,9–14]. This chapter describes the CAD/CAM fabrication of complete dentures based on digital impressions of edentulous jaws obtained using an intraoral scanner.

2. Advantages of Digital Denture

- **More Accurate** The CAD/CAM fabrication process is a more accurate and reproducible denture fabrication technique in comparison to the conventional method;
- **More Efficient** The CAD/CAM fabrication process needs a reduced total number of appointments (two or three visits) in comparison to the conventional protocol (more than five visits) and a significantly reduced clinical treatment time for the digital fabrication process (approximately 3.5 h less compared to the conventional protocol);
- **Improved Retention** Digital dentures are better in retention, fit, and stability compared to conventional dentures [10,15]. The improved retention of digital dentures could be explained by their superior fit and absence of polymerization shrinkage;
- **Teeth Arrangement** In the digital denture workflow, the teeth are arranged on the digital denture design software, and the digital preview of the teeth setup of complete dentures is reviewed and easily modified;
- **Remake Dentures** The most beneficial feature of CAD/CAM dentures in comparison to conventional dentures is the stored digital files that allow the fabrication of new

prostheses when dentures are lost or damaged. Therefore, the electronic achieving of all clinical data from the patient along with the design of the manufactured prostheses enables making spare or new dentures, in case of breakage or loss, without clinical appointments [16];

- **Better Fracture Resistance** The material used for digital denture fabrication was significantly improved in its properties [17,18]. Increased toughness, ultimate strength, and higher elastic modulus provide clinical benefits regarding the denture base design with minimal thickness, without the common occurrence of denture fractures.

The process of digital denture fabrication may have some disadvantages related to additive cost. Nevertheless, the above-mentioned benefits and especially increased level of patient satisfaction can help to overcome the other disadvantages.

3. Digital Denture Fabrication Procedure

First, a trial denture is fabricated. Thereafter, the trial denture is used as a custom tray for the final impression. Finally, a final denture is fabricated by scanning the impression. The digital denture fabrication procedure is as follows:

3.1. Step 1. Trial Denture Fabrication

The procedure for fabricating a trial denture is as follows:

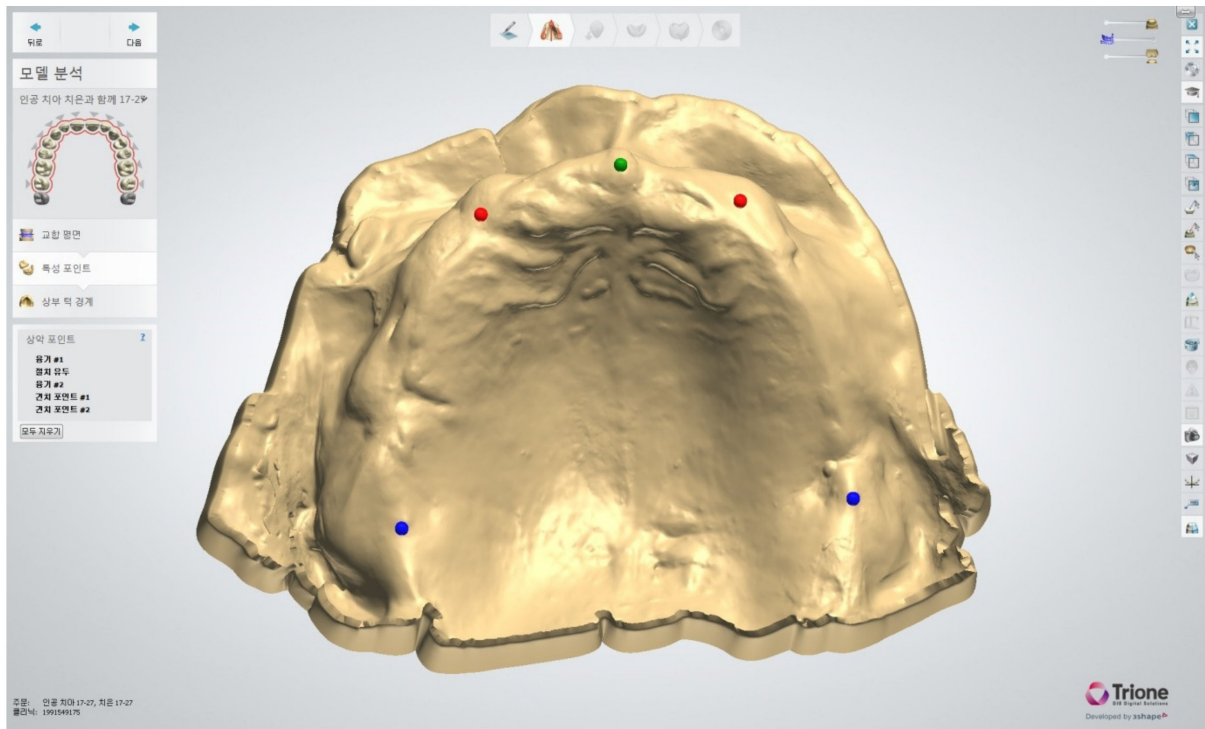
- (1) **Trial denture design** After the images of the edentulous ridge and opposite teeth with the interarch relationship are obtained by recording the digital impression and all the jaw relationships are recorded using an intraoral scanner, trial denture designing begins using the 3Shape Dental software (3Shape, Copenhagen, Denmark). Anatomic structures (incisal papilla, retro-molar pad, and tuberosities) are identified on the edentulous image to correctly place the teeth (Figure 1A). Thereafter, the limit of the future denture base is drawn (Figure 1B). The occlusal plane is determined by considering the jaw relationships, the curve of Spee, and the curve of Wilson. Subsequently, denture teeth are arranged using the denture designing software (Figure 1C). The software contains a library of teeth of different brands and shapes and a function with an automatic setup of tooth position, axis, and height that are matched with the arches and the occlusal plane (Figure 1D);
- (2) **Fabricating trial denture** After the design is finalized, the digital STL files are sent to the three-dimensional (3D) printing machine. The trial denture is 3D printed as a monolithic denture, teeth, and base in one unit (Figure 1E,F);
- (3) **Verifying jaw relation with trial denture** At the trial placement, the horizontal and vertical jaw relationships are evaluated with the trial denture.

Verifying vertical relationship: The vertical jaw relationship is evaluated by considering the following aspects:

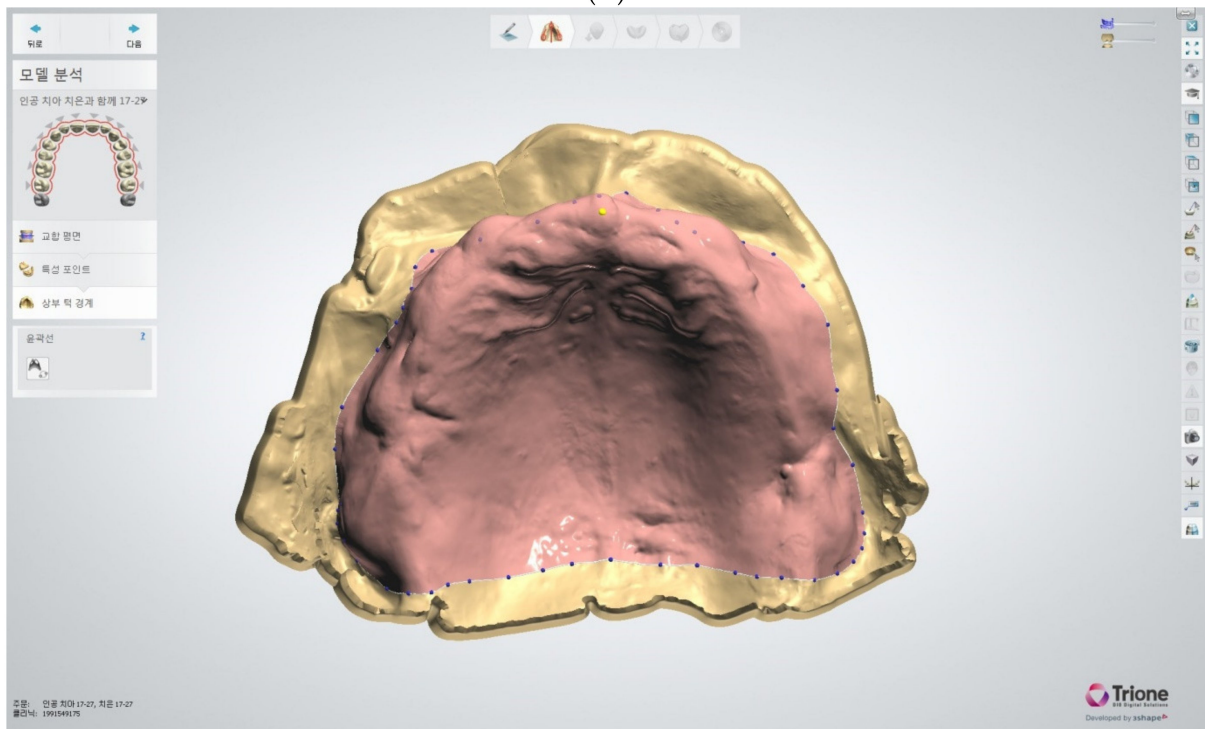
- Midline regarding the maxillary midline being aligned with the center of the nose;
- Resting interocclusal distance;
- Phonetics and esthetic appearance;
- Vertical dimension at the rest position;
- Facial measurements;
- Lip length in relation to the teeth;
- Lip support;
- Smile line;
- Occlusal plane parallel to the interpupillary line.

Verifying Centric Relation (CR): After verifying the vertical relationship, the patient is guided into CR. Any error in CR will be apparent when the teeth slide over each other;

- (4) **Occlusal adjustment** After confirming the CR, occlusal adjustment is carried out to achieve a bilateral balanced occlusion.

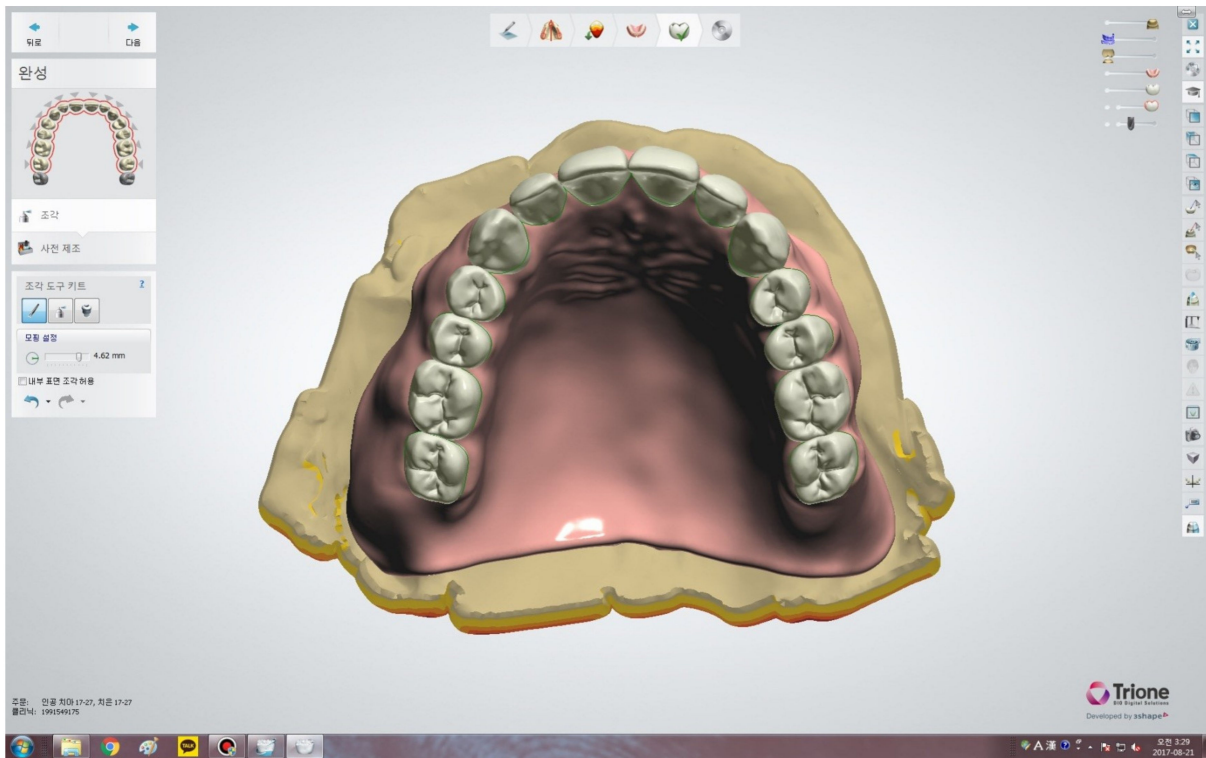


(A)

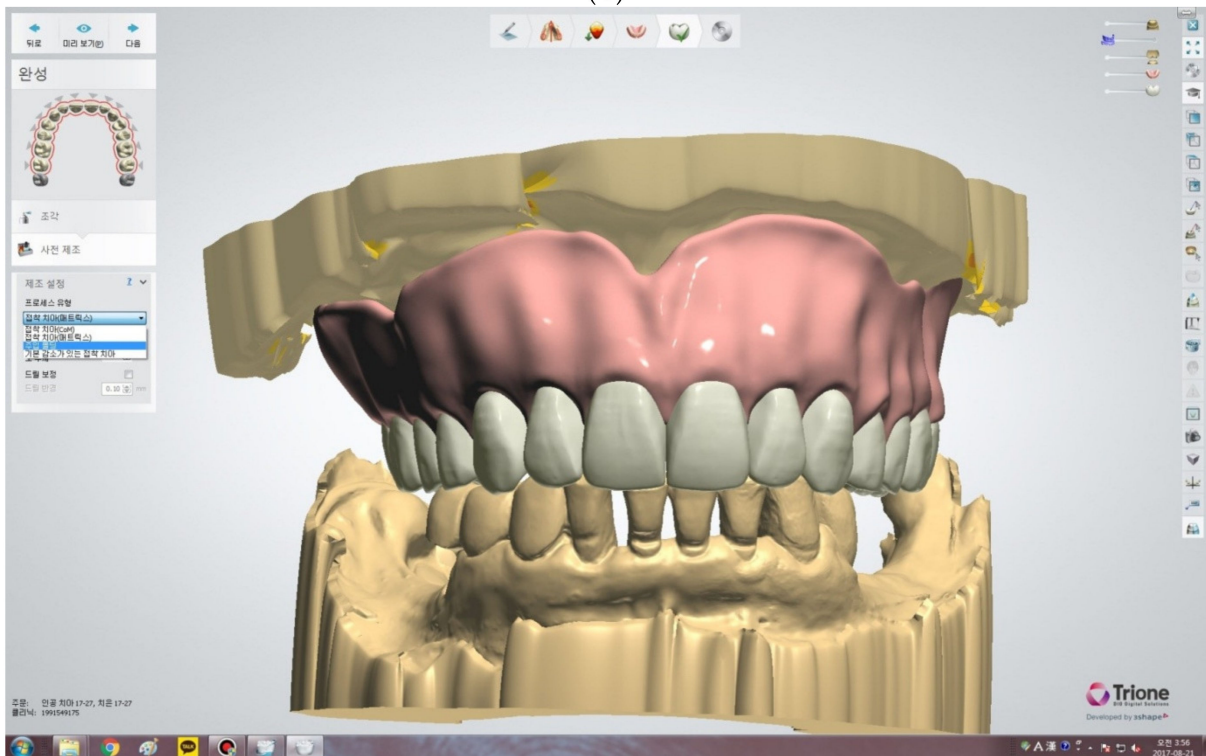


(B)

Figure 1. Cont.

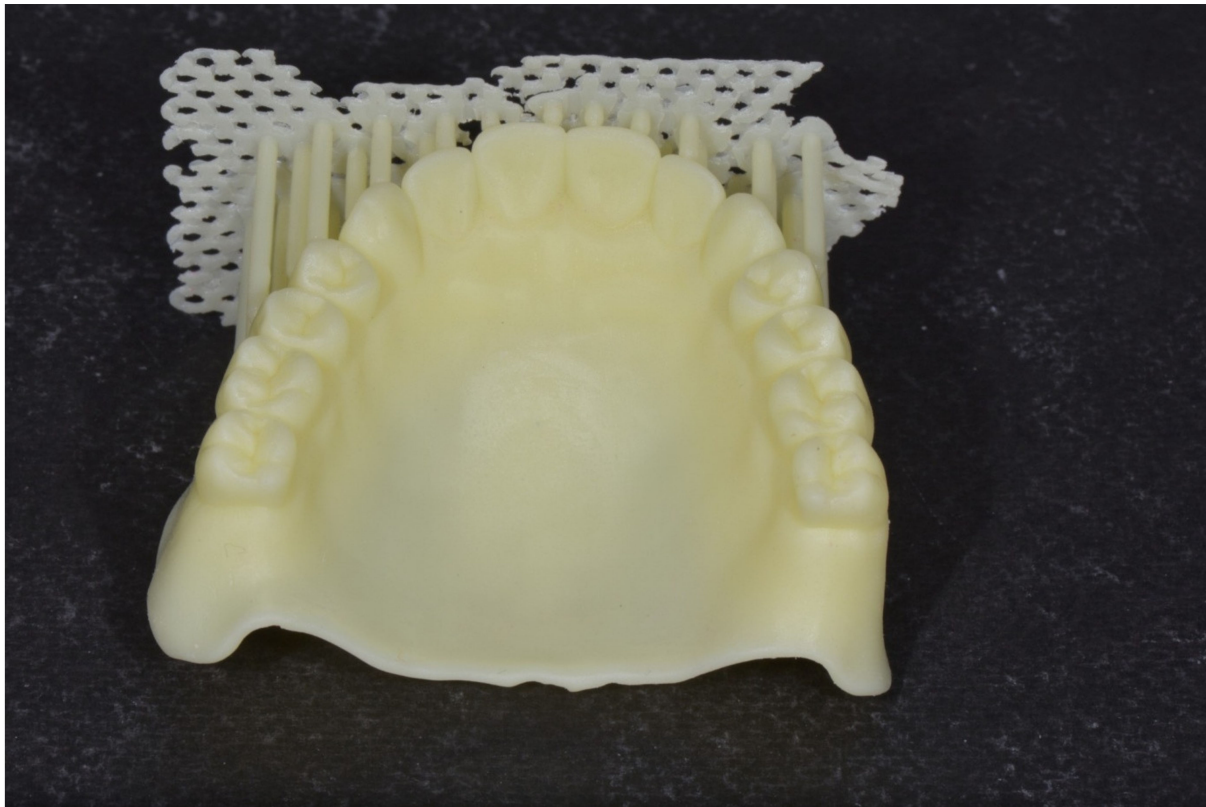


(C)



(D)

Figure 1. Cont.



(E)



(F)

Figure 1. Trial denture fabrication. (A): Anatomic structures are identified on the edentulous ridge image. (B): Limit of the future denture base is drawn. (C): Denture teeth are arranged. (D): Denture base is designed. (E): Printed trial denture. (F): Trial denture is printed as a monolithic denture, teeth, and base in one unit.

3.2. Step 2. Final Impression

- (1) **Border molding** The trial denture is checked in the mouth to ascertain that the borders are approximately 2 mm short of the vestibular reflections. Border molding is performed by adding a modeling compound to the trial denture borders and moving the tongue, lips, and cheeks for adjustment (Figure 2A,B). The trial denture is adapted closely to the tissues of the vestibule before making the final impression;
- (2) **Recording final impression** The final impression is made with the border-molded trial denture (Figure 2C). After obtaining the impression, the denture is removed from the mouth and is scanned using an intraoral scanner (Figure 2D). The denture scanning area should include all areas of the denture, such as the denture base, border, teeth, and palate (Figure 2E).

3.3. Step 3. Final Denture Fabrication

Digital images of the trial denture obtained by scanning the final impression are used to design the definitive denture [19–22] (Figure 3A). If any modifications in the jaw relationship or teeth arrangement are required, these are made in the digital images. After the modifications are made, the definitive denture is fabricated during either milling or 3D printing (Figure 3B). In the case of using a 3D printer, it can print the artificial teeth and the pink denture base separately or both in a single unit [23] (Figure 4A–C). When the artificial teeth and denture base are printed in one unit, tissue-colored composite resin is applied onto the denture flange (Figure 5A,B). In the case of using a milling machine, the denture base is milled from a pink block of prepolymerized cross-linked polymethyl methacrylate (PMMA) disks. The teeth are also milled from the PMMA disk. The milled teeth are securely bonded onto the milled denture base (Figure 6A,B). The monolithic denture is more accurate than the bonded denture because of the lack of bonding processing errors.



(A)

Figure 2. Cont.

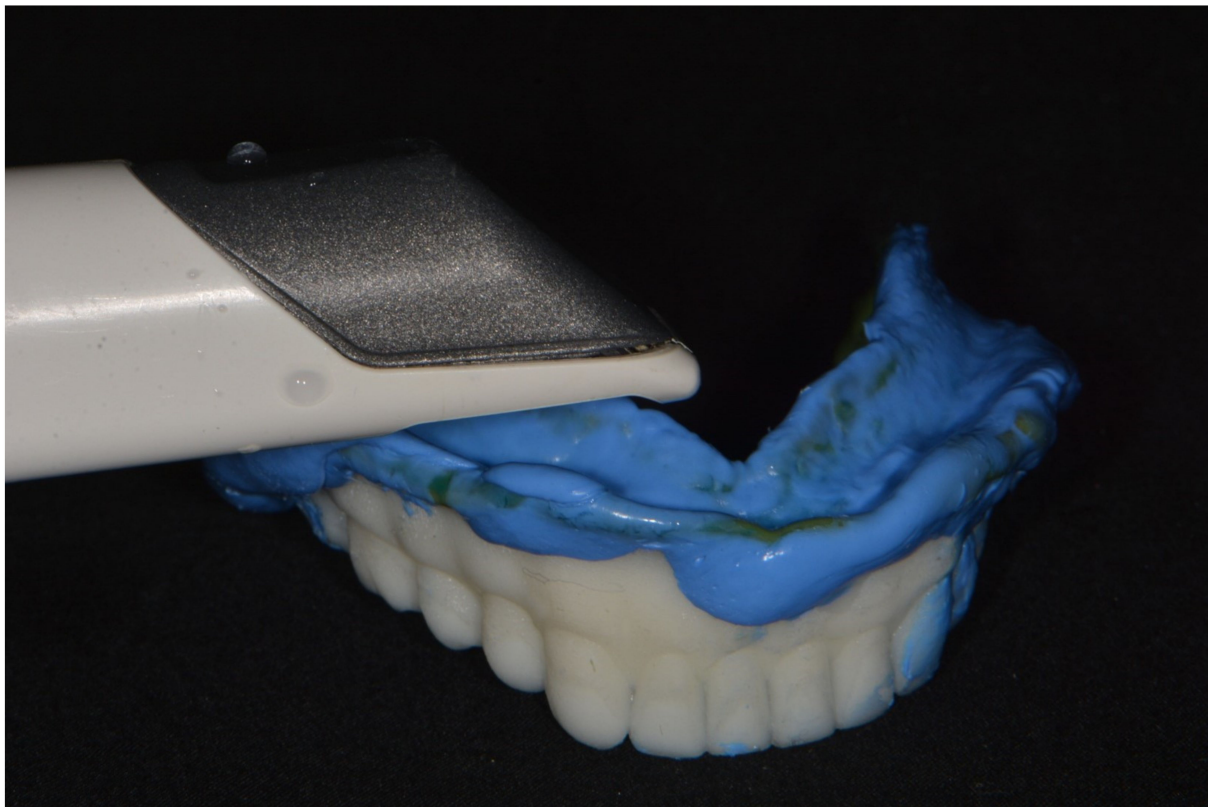


(B)

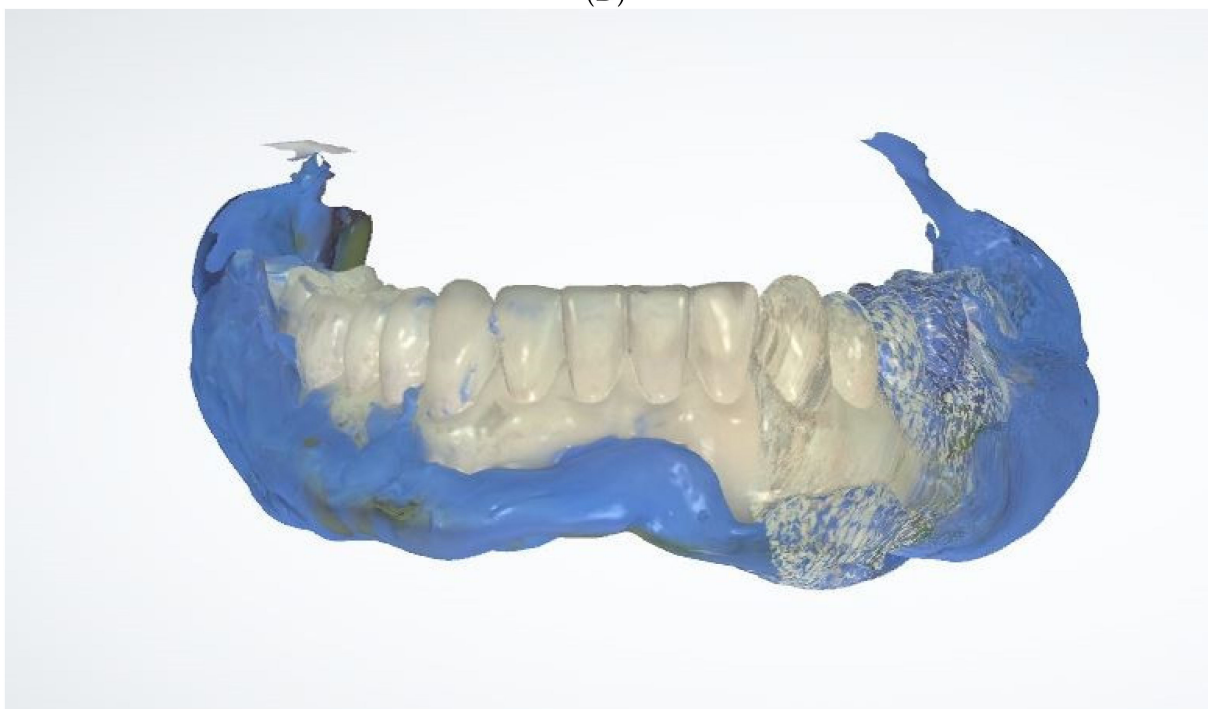


(C)

Figure 2. Cont.

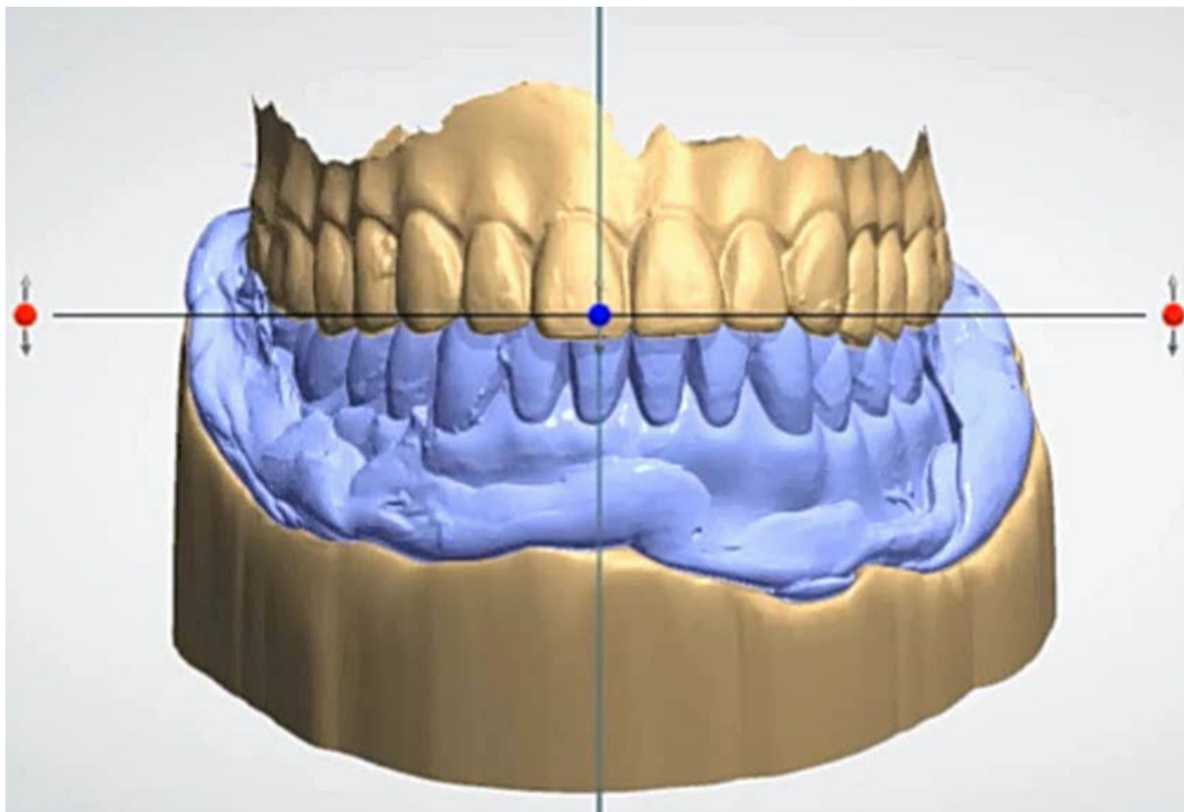


(D)



(E)

Figure 2. Final impression using trial denture. (A): Trial denture borders are approximately 2 mm short of the vestibular reflections. (B): Border molding is performed by adding modeling compound to the trial denture borders. (C): Final impression is obtained with the border-molded trial denture. (D): The trial denture is scanned using an intraoral scanner. (E): Scan image of the trial denture.

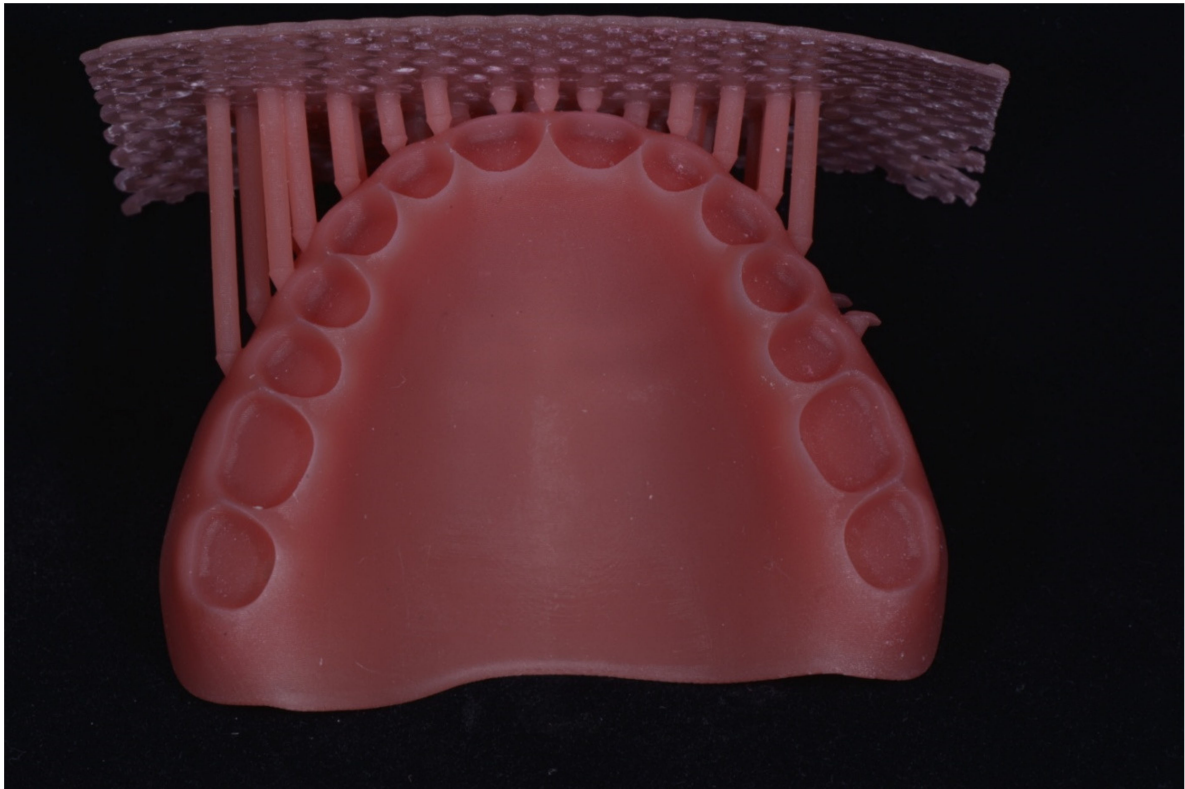


(A)



(B)

Figure 3. Final denture fabrication. (A): Final denture is designed using the digital images of the trial denture obtained by scanning the final impression. (B): Printed final denture.



(A)



(B)

Figure 4. Cont.



(C)

Figure 4. Bonded printed denture. (A): Printed denture base. (B): Printed artificial teeth. (C): Printed artificial teeth are bonded onto the printed denture base.



(A)

Figure 5. Cont.



(B)

Figure 5. Monolithic printed denture. (A): Artificial teeth and denture base are printed in one unit. (B): Tissue-colored composite resin is applied onto the denture flange.



(A)

Figure 6. Cont.



(B)

Figure 6. (A): Milled denture base. (B): Milled artificial teeth.

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