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CASE REPORT

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A novel implant placement technique using a three-dimensionally printed duplicate denture for implant-supported overdenture in patients with severe residual ridge resorption: A case report

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Key Clinical Message

The treatment method of placing a small number of implants in the mandible as a removable implant-supported overdenture (IOD) enables implant placement and denture stability, even in cases with severe residual ridge resorption. In this case report, a new implant placement technique was performed using a three-dimensionally (3D)-printed duplicate denture fabricated by a 3D printer, resulting in the restoration of masticatory function through IOD.

KEYWORDS

3-dimensional printing, dental implantation, denture design, implant-supported denture

1 | INTRODUCTION

In cases of edentulous mandibles with severe residual ridge resorption, it is difficult to stabilize completely removed dentures, leading to impaired masticatory function. While implant treatment using a fixed superstructure offers excellent functional recovery, it cannot be applied to patients with insufficient bone height due to alveolar ridge resorption.[1,2] In such cases, a treatment method involving a removable implant-supported overdenture (IOD), supported by a small number of implants, allows for implant placement even in cases of inadequate bone height and ensures denture stability.[3,4] In the case of IOD, the implant body has no mandibular nerve running between the mental foramen on both sides, making it the safety site for implant body placement.

Furthermore, treatment using IOD with two implants placed in the mandible is recommended for achieving excellent functional restoration.[5] Utilizing a duplicate denture as a template for computed tomography (CT) imaging in implant placement planning is not only straightforward but also serves as a surgical guide plate for precise positioning of the attachment. Previously, duplicate dentures were fabricated by creating impressions using a flask and pouring resin into the impressions.[6] This method required no special equipment, but the preparation steps were complicated, making the process tedious.[7]

Recently, the introduction of digital devices into dentistry has sparked significant interest. Several researchers have reported a technique to scan dentures and fabricate duplicate dentures using CAD/CAM and

three-dimensional (3D) printing.[8] Hwang et al. reported that denture bases manufactured using 3D printers have the best trueness and adaptation compared to conventional techniques such as press pack and milling techniques.[9] In this study, we describe a novel implant placement technique, wherein we used a 3D-printed (3Dp) duplicate denture as a template for CT imaging and a surgical guide plate to restore masticatory function with IOD.

2 | CASE PRESENTATION

2.1 | Case history/examination

This was a case report study, and informed consent for reporting was obtained from the patient. A 63-year-old male presented at the hospital with a chief complaint of being unable to use his existing denture. He had complete edentulous maxilla and mandibula and had been previously treated with complete-denture prosthodontics to restore function. However, he experienced issues with chewing and had difficulty in pronunciation due to no improvement in his mandibular denture. The bilateral mandibular crests, particularly, the molar portions were highly resorbed. Therefore, the mandibular denture was adjusted for a year, however no improvement was observed. To improve denture stability, a prosthetic treatment using an IOD was proposed. The patient did not have any systemic diseases that might contraindicate implant placement. Moreover, he was not a smoker and did not complain about the temporomandibular dysfunction.

1. Introduction of conventional and 3D denture fabrication methods using digital processing

Figure 1 shows the conventional and 3Dp duplicate denture fabrication methods. The conventional method has the advantage of requiring no special equipment, only needing a flask. However, it has drawbacks of ill-fitting dentures and requiring correction and polishing, resulting in a longer fabrication time.

On the contrary, 3Dp denture replicas fit well and do not necessarily require morphological modification or polishing. Additionally, they offer the advantage of a shorter fabrication time (scanning times of 40 and 30 s). In this case, 3Dp denture fabrication method was selected.

2. Preparation of the 3Dp duplicate denture as a contrast-enhanced template for CT imaging

The CT template was created using the following procedure. First, the morphology of the mandibular denture was captured using an indirect scanner (Katana®E4, 3Shape, Denmark) to record both the denture-polished surface and intaglio surface morphology. Next, the denture was digitally designed using CAD (3 shape dental system, 3Shape), and a 3D printer (NextDent5100, 3D Systems, US) was used to manufacture a 3D-printed duplicate denture. The contrast material (gutta-percha points, GC, Japan) was then placed at regular intervals on the 3Dp duplicate denture as a template for CT imaging (Figure 2).

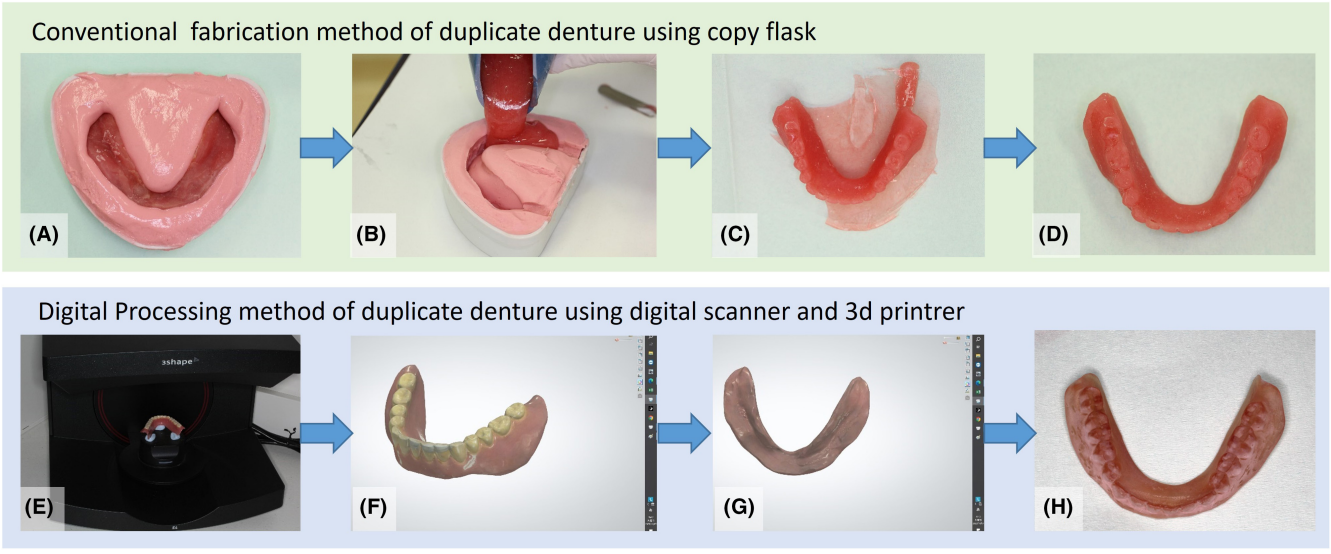

FIGURE 1 (A–D) Conventional method of duplicate denture steps. (A) Impression of a base denture. (B) Pouring resin material. (C) Extraction of duplicate dentures. (D) Duplicate denture after adjustment. (E–H) Digital processing method of duplicate denture steps. (E) Scanning of the base denture. (F) Polished surface morphology on CAD. (G) Intaglio surface morphology on CAD. (H) Duplicate dentures fabricated with a 3D printer.

3. Preparation of the 3Dp duplicate denture as a surgical guide plate for implant placement

After CT imaging, implant placement planning was performed using simulation software (Simplant Pro 14, Dentsply Sirona, US). A guide hole was created in the area corresponding to the 3Dp duplicate denture at the designated implantation site to serve as a surgical guide plate. Based on the CT simulation images, we confirmed the positional relationship between the mental foramen and contrast medium and determined the location of the guide hole (Figure 3).

4. Clinical procedure

After confirming the position of the implant placement bed's position with a guide plate, two implants (Brånemark TiUnite MK III, Nobel Biocare, Switzerland, 3.75 mm in diameter and 10.0 mm in length) were individually placed (Figure 4). Three months post-implant placement, a locator abutment (Locator abutment Bmk RP 2 mm, ZEST Dental Solutions, US) was attached to the implant body, along with an attachment (Locator® Implant Attachment System, ZEST Dental Solutions) to the inner surface of the resin complete denture to create an IOD (Figure 5).

5. Masticatory performance assessment

Masticatory performance was evaluated using a gummy jelly extraction test conducted preoperatively and postoperatively during implant treatment.[10]

A gummy jelly (diameter: 14 mm; height: 8 mm; weight: approximately 2 g; GC, Japan) was used as the test food. The patient was instructed to chew gummy jelly for 20 s and was then asked to hold 10 mL of water in the mouth before spitting into a cup with a filter. The filtrate collected in the cup was used as a test sample, and the glucose concentration measured using a glucose-measuring device (GS-2; GC, Japan) was used as the amount of glucose elution in mg/dL. The result is shown Table 1.

3 | DISCUSSION

With the advent of digital technology in implant treatment, a method of fabricating surgical guides using CAD/CAM has emerged. Traditionally, duplicate dentures have been fabricated from a denture and used as templates for CT imaging.

The conventional method involves taking an impression of the denture form, injecting room-temperature curing resin, and completing the denture. Although this method is widely used, it is a complex process requiring morphological modifications and polishing. In addition, the fit of the denture is inferior to that of the original denture due to polymerization shrinkage and impression material deformation.[11,12] In contrast, the method that records the denture form with a scanner and creates it with a 3D printer or NC machining requires digital equipment, offers a shorter operation time, and a simpler process. Additionally, polymerization shrinkage is smaller than that of room-temperature-cured resin, resulting in a denture that closely resembles the original with a good fit. Other researchers have reported that conventional denture duplication methods were less true and efficient than methods using digital technology.[13,14]

There is a concern that the CT template in the edentulous jaw may become unstable in the oral cavity, potentially leading to inaccurate contrast media points. However, in this study, the 3Dp template used was almost equivalent to the original denture in terms of occlusal

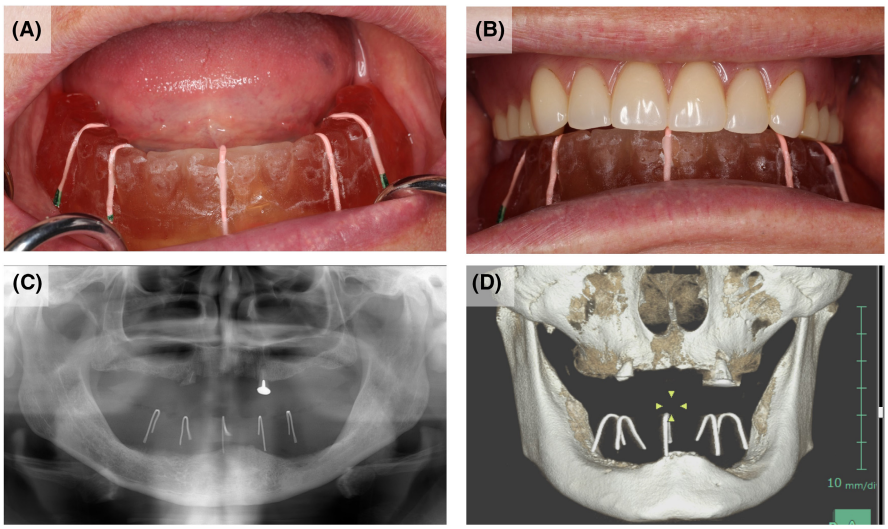

FIGURE 2 (A) Computed tomography (CT) imaging template in the mandibular crest, showing a good fit between the template and intaglio surface. (B) CT imaging template in a case of stable occlusion with a maxillary complete denture. (C) Panoramic radiographic image of the CT imaging template installed. (D) Three-dimensional constructed image of the CT imaging template installed.

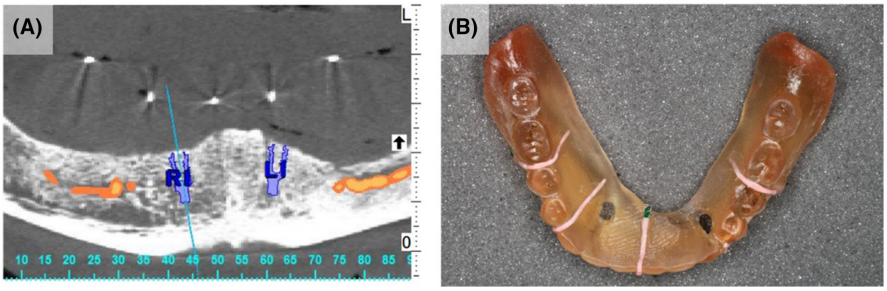

FIGURE 3 (A) Implant placement planning using simulation software. (B) Guide hole for implant insertion socket preparation installed in a 3D-printed template.

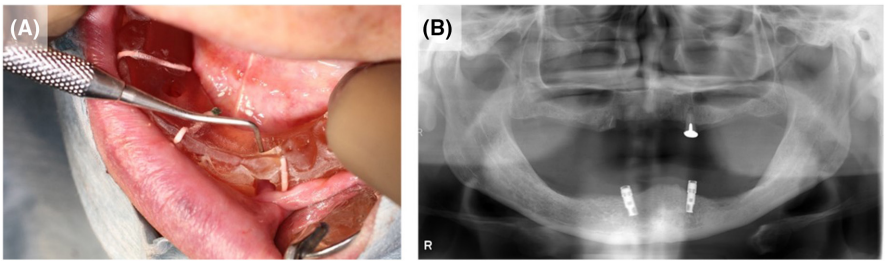

FIGURE 4 (A) Guide plate placed in the mandible. Confirmation of the starting point for implant insertion socket preparation. (B) Implant body has been placed.

FIGURE 5 (A) Intraoral fitted locator abutments. (B) Denture intaglio surface; attached locator attachments. (C) Maxillary and mandibular complete dentures in occlusion.

TABLE 1 Masticatory performance.

	Masticatory performance (mg/dL)
Before treatment	111
After treatment	252

and polished surfaces. Consequently, the fit in the mandibular crest and occlusion with the maxillary denture were excellent, allowing for CT imaging without abnormalities in the template's position. Finally, the template was used as a surgical guide, which enabled placement according to the implantation plan during surgery. The glucose dissolution test was used to assess masticatory function before and after treatment, by measuring the concentration of eluted glucose after chewing gummy jellies. Before IOD, the denture was unstable due to jaw crest resorption, with a concentration of approximately 100 mg/dL. After IOD, the denture became stable, and the measured value doubled to 250 mg/dL, indicating improved masticatory function.[15]

With the advent of digital technology in implant treatment, a method of fabricating surgical guides using CAD/CAM has emerged. This method enables accurate implant placement akin to placement simulations and allows for flapless surgery. However, even with this method, a template is required for CT imaging. In this case, a novel approach was introduced, wherein a 3Dp duplicate denture serves as both an imaging template and a surgical guide plate. This method offers the advantage of stabilizing the template during CT imaging, thereby ensuring accurate implantation planning. While it may not match the accuracy of surgical guides fabricated with CAD/CAM when used as a surgical guide plate, it proves to be a viable option for IOD. Given that the implant is placed between the mental foramen in IOD cases, concerns about severe complication, such as flapless surgery or proximity to nerves, are mitigated. Instead, it has the advantage of being implanted in the position of attachment by reflecting the shape of the denture. Furthermore, the number of materials used can be reduced, which is cost-effective. Therefore, this case suggests that employing a 3Dp duplicate denture

as a template for CT imaging and a surgical guide is an effective method for IOD treatment planning.

In summary, the case report underscores the success of a unique approach using a 3D-printed duplicate denture as both a CT imaging template and a surgical guide plate for IOD in a patient with severe residual ridge resorption. The method demonstrated precision in implantation planning, addressing challenges in cases where traditional methods might fall short. Despite some limitations compared to CAD/CAM guides, the 3D-printed denture proved practical for IOD, particularly considering anatomical nuances like the absence of mandibular nerves. The technique showcased cost-effectiveness, making it a promising option for IOD treatment planning, pending further research for validation and widespread adoption.

AUTHOR CONTRIBUTIONS

Tomoko Izumikawa: Conceptualization; investigation; visualization; writing – original draft. **Kazuya Doi:** Conceptualization; data curation; investigation; resources; writing – original draft. **Shogo Iwaguro:** Methodology; software; visualization. **Kazuhiro Tsuga:** Supervision.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journals patient consent policy.

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