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DENTAL TECHNIQUE

A metal template for preparing guiding planes for removable partial dentures

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ABSTRACT

Precise preparation of guiding planes is essential for removable partial dentures (RPDs). This report introduces a metal template fabricated by computer-aided design and computer-aided manufacturing (CAD-CAM) to help prepare guiding planes for RPDs. (J Prosthet Dent 2020;■:■-■)

Well-prepared guiding planes can eliminate harmful strain to abutment teeth, provide frictional retention force, ensure the stability of removable partial dentures (RPDs), reduce plaque accumulation, and avoid food impaction.[1-5] Parallel guiding planes are difficult to prepare freehand, especially in different quadrants. Several methods have been described to prepare parallel guiding planes, including the use of parallelometers, which are complex devices and require a large mouth opening.[6] Recently, the preparation of guiding planes assisted by resin devices fabricated by computer-aided design and computer-aided manufacturing (CAD-CAM) technology has been described.[7,8] However, wear of the resin and a single guiding surface that cannot completely restrict the movement of the diamond rotary instrument during preparation are limitations of this method. Additionally, soft-tissue trauma may occur if the dentist's direct vision of the prepared surfaces is impaired.[9] This report introduces a metal template fabricated by CAD-CAM to help prepare guiding planes for RPDs.

TECHNIQUE

1. Scan the cast of a partially edentulous mandible by using a laboratory scanner (Activity 880; SmartOptics AS) and export the scanned image as a standard tessellation language (STL) file.

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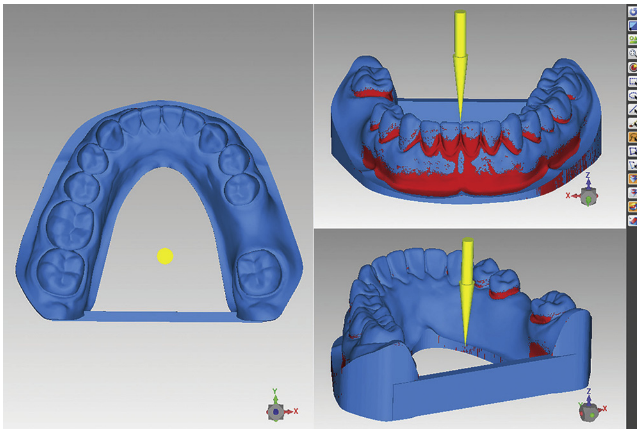

Figure 1. Digital surveying of cast of partially edentulous mandible. Direction of path of placement (*yellow arrow*), undercut (*red*).

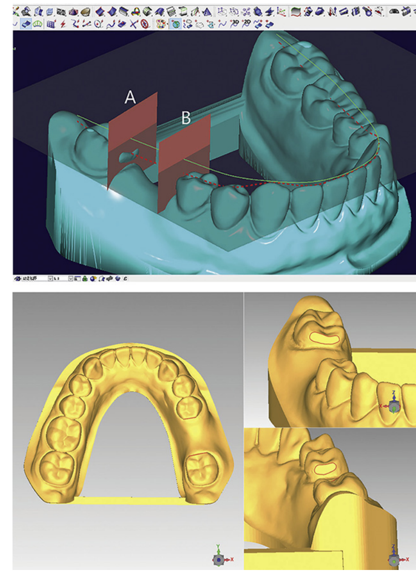

Figure 2. A, Position and size of guiding planes determined by path of placement and dentition. Dental arch curve (*red dotted line*), projection curve (*green solid line*). Planes A and B (*red*), perpendicular to projection curve and parallel to direction of path of placement. B, Virtual guiding planes in prepared cast.

2. Import the 3D image into a reverse engineering software program (Geomagic studio 2012; 3D System) and select an appropriate path of placement. Survey the cast and sign the undercut. Name it as "initial cast" and export as an STL file (Fig. 1).
3. Import initial cast into another reverse engineering software program (Imageware 13.0; NX). Create a curve to simulate the dental arch by connecting center points on the occlusal surfaces or incisal edges of teeth (Fig. 2A, dotted line). Project the dental arch curve into a 2D plane perpendicular to the direction of the path of placement (Fig. 2A, semitransparent plane) to obtain the projection curve (Fig. 2A, solid line). Create planes on the proximal surface of the mandibular right second premolar and the mandibular right second molar (Fig. 2A, red planes A and B), which are perpendicular to the projection curve and parallel to the direction of the path of placement. Move the plane along the projection curve until the intersecting section of the plane and the abutment tooth satisfies the size and position requirements of the guiding plane. Repeat the aforementioned processes until each abutment tooth has an appropriate guiding plane. Subtract each plane from initial cast via a Boolean operation to obtain the "virtual guiding planes-prepared cast" and export it as an STL file (Fig. 2B).
4. Insert a straight flat-end diamond rotary instrument (SF-31; MANI) into the handpiece (Boralina 1600373-001; Bien Air Dental). Measure the following parameters of the diamond rotary instrument: D1, diameter of the working part; D2, diameter of the shank; L1, length outside the handpiece; and L2, length of the working part (Fig. 3A). Build a 3D model of the diamond rotary instrument in Geomagic from these parameters (Fig. 3B). To simulate the process of preparing guiding planes, create a section along the medial axis of the diamond rotary instrument (Fig. 3C, green wireframe plane) and sweep the diamond rotary instrument perpendicularly to the section to build a "movement model." Export it as an STL file (Fig. 3C).
5. Import the initial cast into a CAD software program (Dental System 2018; 3Shape). Design a 0.9-mm-thick major connector covering the abutment teeth and residual alveolar ridge with the window named "retainer of template" (Fig. 4). Export it as an STL file.
6. Import the movement model (Fig. 5A, cyan part), virtual guiding planes-prepared cast (Fig. 5A, green cast) and retainer of template (Fig. 5B, pink part) into a forward engineering software program (Magics 21.0; Materialise). Align the movement model to the guiding plane of each abutment tooth, adjusting the axis of the movement model parallel to the path of placement and the bottom of the movement model between the bottom of the guiding plane and the gingival tissue. Create a 2-mm-thick and unilateral 1.5-mm-wide "handpiece guide rail" at the height of L1 from the diamond rotary instrument's apex for each abutment tooth around the movement model (Fig. 5B, yellow part), the upper surface of which is perpendicular to the path of placement (Fig. 5B).

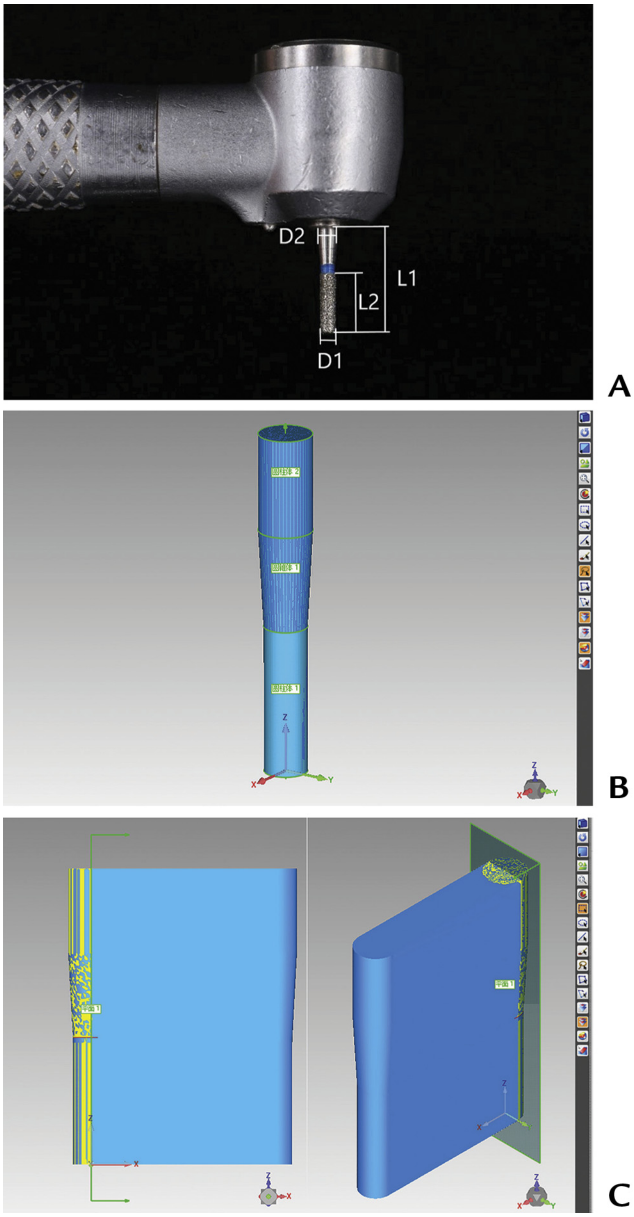

Figure 3. A, Parameter measurement of diamond rotary instrument. B, Three-dimensional modeling of diamond rotary instrument. C, Three-dimensional modeling of movement path of diamond rotary instrument.

7. Subtract the movement model from the retainer of template and handpiece guide rail via Boolean operation and design the passageway of the diamond rotary instrument on the buccal side of the guide rail (Fig. 6A).
8. Combine the retainer of template with handpiece guide rail of each abutment teeth with a 0.6-mm-thick lingual plate. Add support bars to weak parts of the template (Fig. 6B, purple part) and export as an STL file.

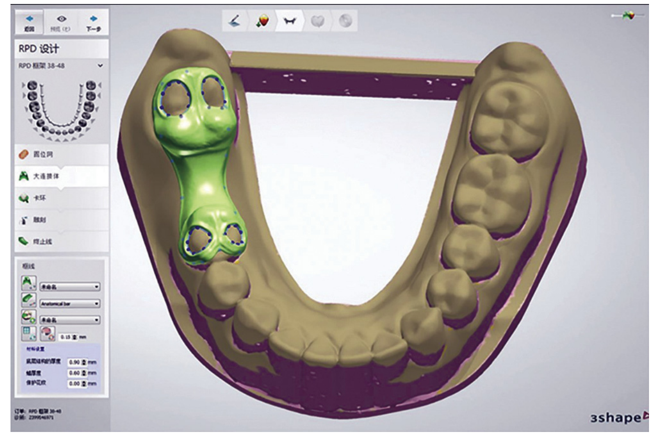

Figure 4. Major connector with windows covering abutment teeth and residual alveolar ridge as retainer of template.

9. Print the template with cobalt-chromium alloy powder (MetcoAdd 78A; Oerlikon) by using a selective laser melting 3D printer (Ti200; Profeta). Place the upper surface of the handpiece guide rail perpendicular to the substrate of the printer and the lingual plate close to the substrate of the printer and add support structures (Fig. 7).
10. Seat the template on the teeth. Press the template with the fingers to keep it fixed and stable if necessary. Move the diamond rotary instrument along the guide rail from the buccal side to the lingual side of the abutment tooth with water spray. Prepare the guiding planes in sequence (Figs. 8, 9).

DISCUSSION

This technique describes a CAD-CAM template which can exert a triple rigid limit on the movement of a diamond rotary instrument and precisely assist in preparing parallel guiding planes. The first guide is the upper surface of the handpiece guide rail, which limits the preparation depth of the diamond rotary instrument and protects the gingiva (Fig. 10, blue lines). The second guide is the inner axial planes of the handpiece guide rail, which prevents the diamond rotary instrument from rotating in the distal or mesial direction of the abutment teeth at the bottom part of the diamond rotary instrument (Fig. 10, red lines). The third guide is the track groove and the surface above the guiding plane in the retainer of the template, which prevents the diamond rotary instrument from rotating in the distal or mesial direction at the top part of the diamond rotary instrument (Fig. 10, black lines). The hardness of the cobalt-chromium alloy prevents excessive preparation, although the retainer of template could be damaged by a diamond rotary instrument. Therefore, designing the

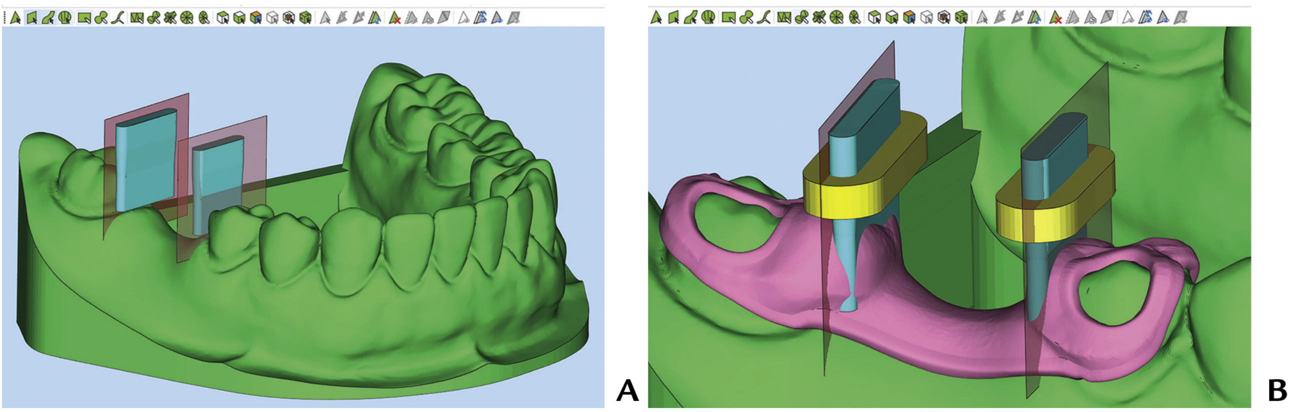

Figure 5. A, Movement model (*cyan*) aligned to guiding planes (*red planes*). B, Modeling of handpiece guide rail (*yellow*) at height of L1 from apex of diamond rotary instrument for each abutment tooth.

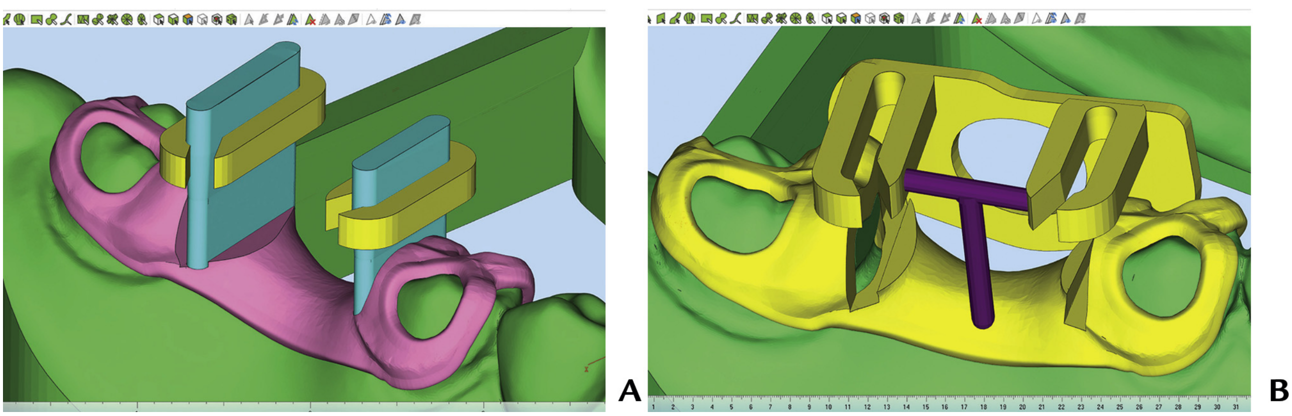

Figure 6. A, Subtraction of movement models of diamond rotary instrument (*cyan*) from retainer of template (*pink*) and handpiece guide rails (*yellow*). Passageways of diamond rotary instrument on buccal side of guide rails. B, Combination of retainer of template and handpiece guide rails with lingual plate and support bars (*purple*).

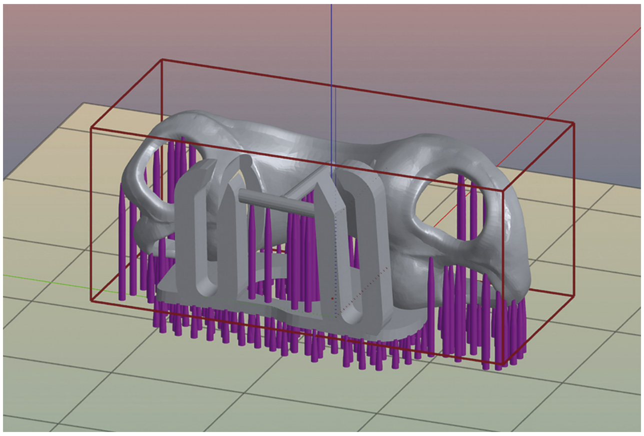

Figure 7. Template printed with cobalt-chromium alloy powder by using selective laser melting 3D printer.

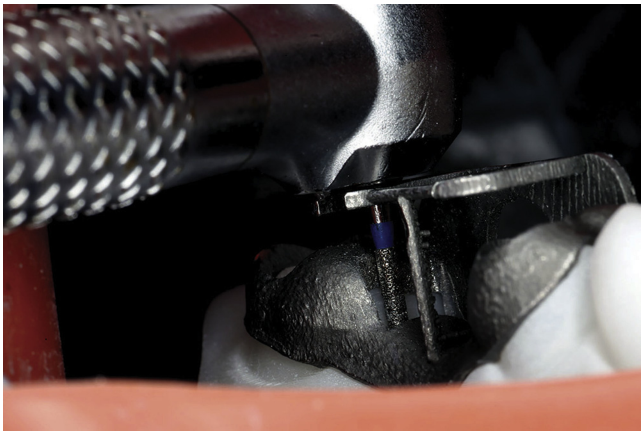

Figure 8. Preparation of guiding planes in mannequin head.

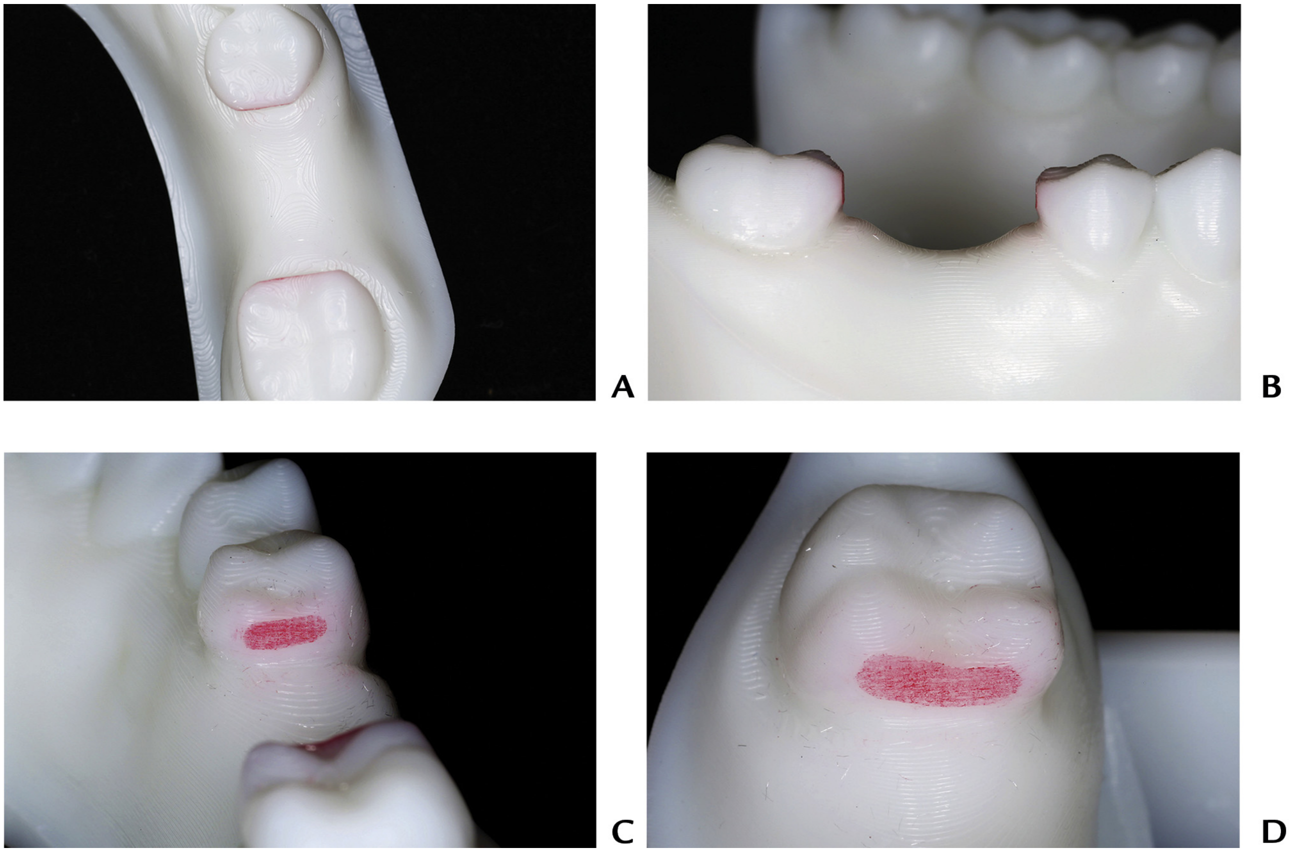

Figure 9. Prepared guiding planes (*red*). A, Occlusal view. B, Buccal view. C, Prepared guiding plane on maxillary right second premolar. D, Prepared guiding plane on maxillary right second molar.

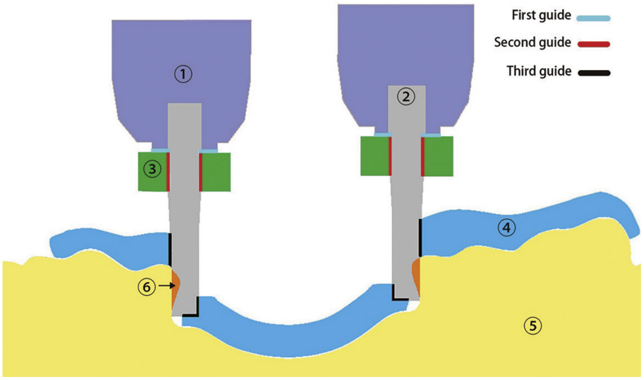

Figure 10. Triple guiding mechanism of template. ① Handpiece. ② Straight flat end diamond rotary instrument. ③ Handpiece guide rail. ④ Retainer of template. ⑤ Cast of partially edentulous mandible. ⑥ Virtual preparation of abutment teeth.

inner axial planes of the handpiece guide rail to contact the smooth shank of the diamond rotary instrument is essential.

In addition, the passageways on the buccal side of the handpiece guide rail reduce the need for excessive mouth opening to seat the diamond rotary instrument from the occlusal side, and the lingual plate protects the lingual soft tissue during preparation. The upper surface of the seated template is 4 to 5 mm above the occlusal surface of the teeth, which depends on the height of the teeth and the length of the diamond rotary instrument. In this example, the mandibular second premolar and the mandibular second molar were prepared assisted by the template without interference from the maxillary dentition. When the patient has a small mouth opening, a shorter diamond rotary instrument should be selected. Although the template requires fabrication time and cost, it will shorten the chairside time and improve the quality of RPDs. In the future, different software programs for designing the template will be evaluated to improve the efficiency and convenience of this technique.

SUMMARY

A metal template fabricated with CAD-CAM technology with a triple rigid limit on the movement of a diamond rotary instrument was developed. It can precisely assist in preparing guiding planes of RPDs in a straightforward manner without direct vision.

REFERENCES

1. Mothupi-Peri M, Owen CP. Guide-plane retention in designing removable partial dentures. Int J Prosthodont 2018;31:145-8.
2. Williams RJ, Richard B, Tahseen R. A technique for fabricating patterns for removable partial denture frameworks using digitized casts and electronic surveying. J Prosthet Dent 2004;91:85-8.
3. Ali M, Waters NE, Nairn RI, West F, Sherriff M. A laboratory investigation of the role of guide planes in the retention of cast cobalt-chromium alloy partial denture frameworks. J Dent 2001;29:291-9.
4. Sato Y, Hosokawa R. Proximal plate in conventional circumferential cast clasp retention. J Prosthet Dent 2000;83:319-22.
5. Shimura Y, Wadachi J, Nakamura T, Mizutani H, Igarashi Y. Influence of removable partial dentures on the formation of dental plaque on abutment teeth. J Prosthodont Res 2010;54:29-35.
6. Borges AL, Borges AB, Da SL, Uemura ES, Saavedra GS. A new intraoral device to facilitate preparation of the guide plane for removable dental prostheses. Gen Dent 2012;60:e13-6.
7. Lee JH. Fabricating a reduction guide for parallel guiding planes with computer-aided design and computer-aided manufacturing technology. J Prosthet Dent 2018;121:749-53.
8. Lee H, Kwon KR. A CAD-CAM device for preparing guide planes for removable partial dentures: A dental technique. J Prosthet Dent 2019;122:10-3.
9. Haeberle CB, Abreu A, Metzler K. A technique to facilitate tooth modification for removable partial denture prosthesis guide planes. J Prosthodont 2016;25:414-7.

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