Technique Report

CAD-CAM generated mouth preparation guide for a removable partial denture: a technique report

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Running title: CAD-CAM preparation guided for RPD

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Conflict

These authors declare no conflicts of interest.

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Abstract

Fabricating preparation guides using computer-aided design-computer-aided manufacturing (known as CAD-CAM), a practical technique was performed to ensure the precise intraoral transfer of guiding planes. By using this particular guiding template, such clinical technique described the oral preparation on different axial abutments to create a placement and removal path for removable partial dentures. The guiding template was designed to simultaneously indicate the position of parallel guiding planes and examine the volume calculation for pulp protection.

Key words: CAD-CAM, parallel guiding planes, removable partial denture

Introduction

Major connector, rests, direct retainer, minor connector, guiding plane, and indirect retainer are the main components of a removable dental prosthesis (RPD).[1] In terms of prosthodontic, it is to be defined as guiding plane of two or more vertically parallel surfaces on abutment teeth and/or fixed dental prostheses oriented as well as to contribute the path of placement direction, the removal of RPD, a maxillofacial prosthesis, and an overdenture,[2] which implies two or more vertical parallel surfaces of abutment teeth should be shaped according to the path of placement and set in parallel to each other, preferably in contrast to the long axis of abutment teeth. The following functions have been attributed to guiding plane in providing path of insertion, improving retention through frictional contact, stabilizing or bracing the prosthesis against horizontal forces, providing reciprocation, stabilizing the individual tooth, minimizing the space between the denture and the tooth to reduce the number of gross food traps, facilitating daily denture wear, eliminating detrimental strain on abutment teeth and prosthesis framework components while inserting and removing the prosthesis, as well as minimizing wedging stresses on abutment teeth.

Guiding planes may present in natural crown contours or may be formed by selective grinding of the natural crown contours or contouring of surveyed crowns. However, they are mostly formed by selective grinding when a natural tooth is selected. Dental surveyor[3] is a reliable method for analyzing and acknowledge parallel planes after preparation; though

Figure 1. A. **Maxillary occlusal view B. Mandibular occlusal view**

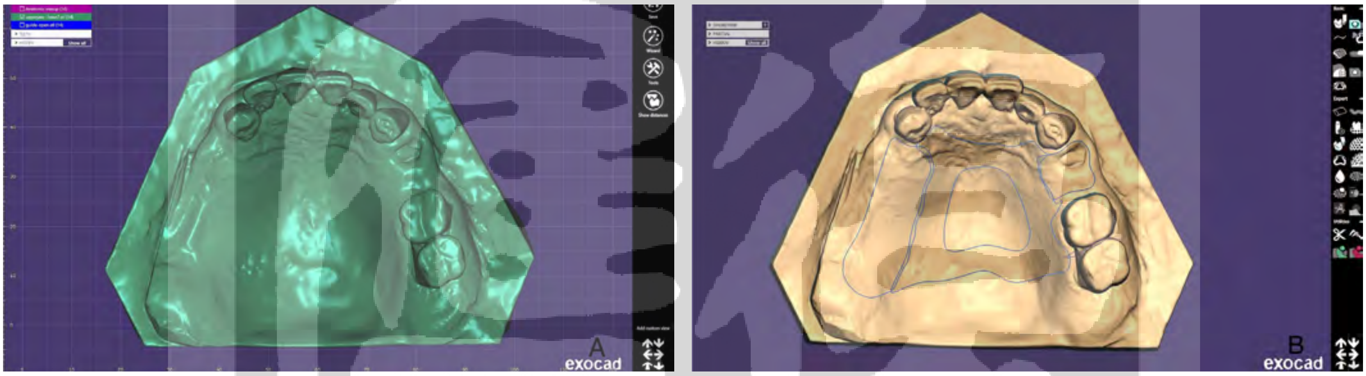

Figure 2. (A) The digital model was constructed using reference scanner and CAD software.
(B) Initial survey and framework designs were shown in the software.

verification is a time-consuming process and the parallelism of guiding plane may exhibit divergence when multiple abutments are prepared freehandedly. Several tools are available for the intraoral transfer of a guiding plane, such as resin caps with a parallel pin,[4] rods on the modeling-plastic index,[5] thermoformed matrix,[6] silicone transfer index,[7] acrylic resin jigs,[8] and parallel intraoral device.[9] All techniques are used to fabricate devices for the intraoral transfer as the path of insertion from the surveying instrument.

Digitalized clinical dentistry by using advanced methods, such as CAD-CAM dental products,[10] digital scanners[11]and implant navigation system[12] are becoming popular in the recent dentistry. Moreover, digital assistance simplifies procedures, reduces operating time and increases accuracy. This study introduces a preparation guide manufactured using CAD-CAM for accurate intraoral transfer of the guiding plane; the guide is expected to improve the quality of RPD and shorten necessary clinical chair times.

Methods

A 73-year-old man presented to the Prosthodontic Clinic Department for restoring oral function by using RPD. Figure 1 A and 1 B shown the condition of this patient who had undergone dental extraction due to secondary caries and periodontitis. After full-mouth evaluation, results revealed mouth opening without clicking sound, deviation, and obstruction; an even occlusal plane; six occlusal pairs from canine to canine; and lack of tooth mobility and bleeding on probing. The patient had former lower Kennedy Class 2, modification 1 RPD fabricated 10 years ago; the denture was passively fitted on the surveying crown without displacement during insertion and removal.

Owing to financial constraints, the patient preferred to proceed conventional RPD without dental implant along with the option of installing an RPD without surveying crowns, which may compromise denture retention and stability. As the result, mouth preparation became the vital procedure for our RPD design and fabrication. The greatest challenge in this option was the precise intraoral transfer of the guiding plane. Therefore, a CAD-CAM preparation guide was designed for the transfer. The technique procedure is as following:

Sequence of design by clicking" Virtual Waxup Bottom→ Gingiva Design→ Gingival Parts→ Antagonist→ More Freely→ ADAPT Occlusal→ Cut Intersections-→ Free-Form Scan Data.

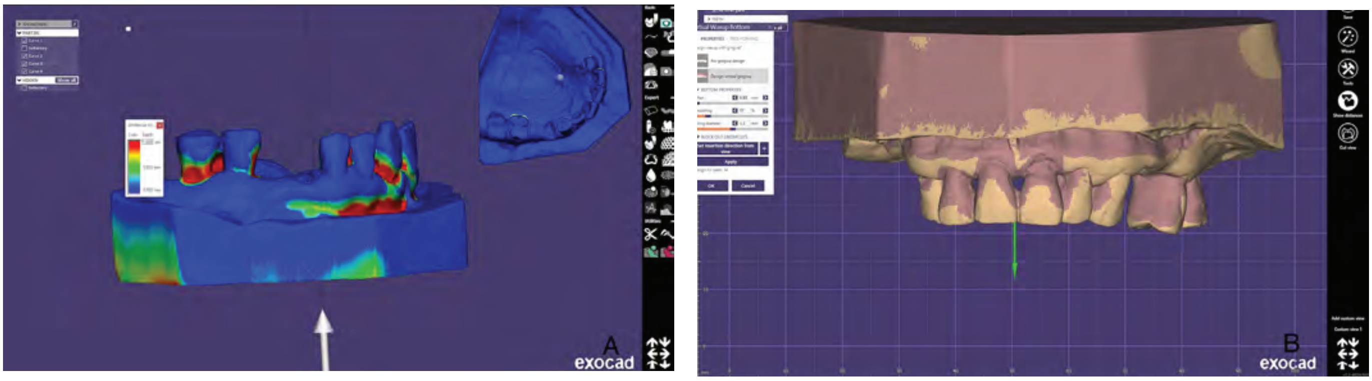

Figure 3. Software analysis for tooth angulation and correction of the final path of insertion. (A) Undercut evaluation with different color scale. (B) Calculate the tooth undercut and soft tissue undercut by software.

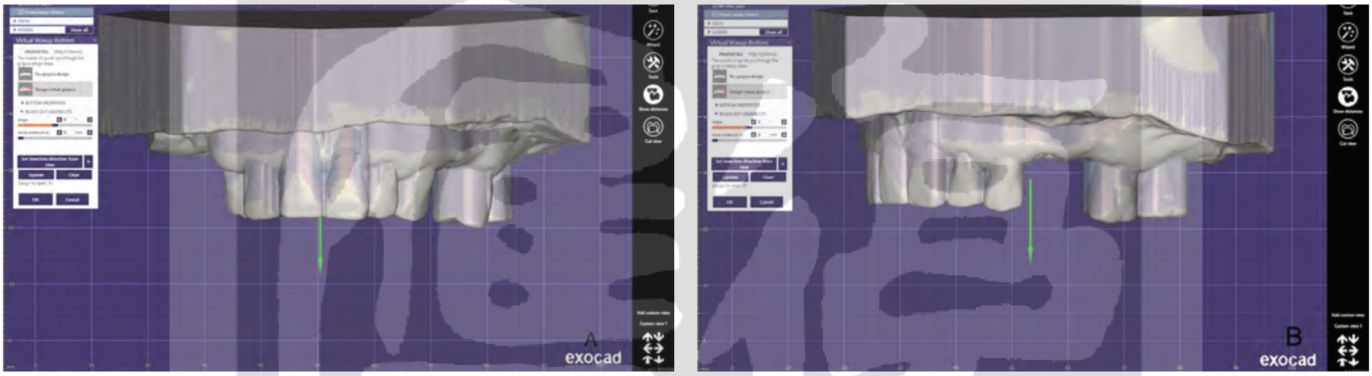

Figure 4. Virtue parallel blockout done by the CAD software. (A) Frontal view (B) Lateral view.

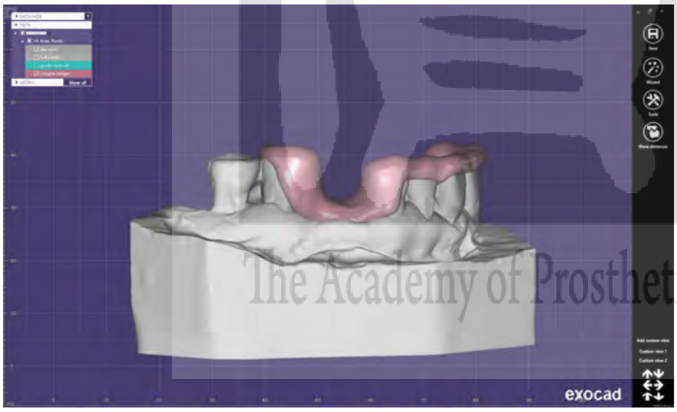

Figure 5. The outline of initial CAD-CAM preparation guiding stent was designed on the blocked-out model.

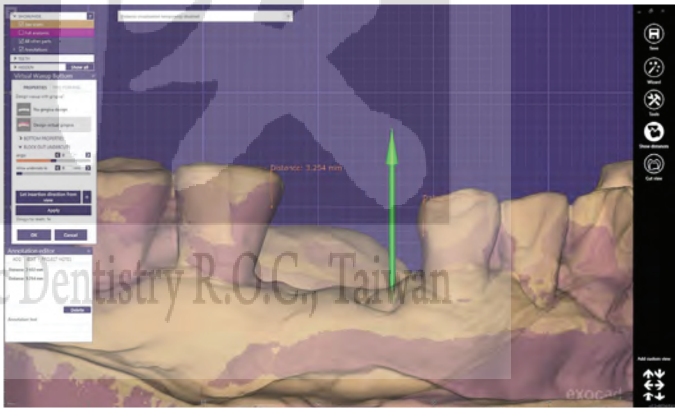

Figure 6. According the RPD design, the amount of preparation for ideal path insertion and preservation of tooth structure for each abutment was measured and calculated by CAD software.

1. Diagnostic casts were fabricated using ISO type III gypsum (Yoshino Gypsum Co., Ltd., Japan). The digital model was constructed by scanning the diagnostic cast with reference scanner (Smart Optics, Activity 880, Bochum, Germany) (Fig. 2A). We used CAD software (Exocad, Exocad GmbH, Darmstadt, Germany) for the following steps, including RPD framework design (Fig. 2B).
2. The model was digitally surveyed (Fig. 3A) via "Virtual Waxup Bottom" in software (Fig. 3B) to decide the ideal path of insertion.
3. Undercut areas were blocked out (Fig. 4A and 4B).
4. The outline of the stent was designed on the blocked-out model via "Gingiva Design" in software (Fig. 5).
5. Each abutment was measured for preparing the guiding plane according to the RPD design. The prepared guide plane, following Krol's concept,[22] was prepared on the abutment occlusal 1/3 with 3.5 mm width of buccal-lingual dimension and 2 mm height (Fig. 6).

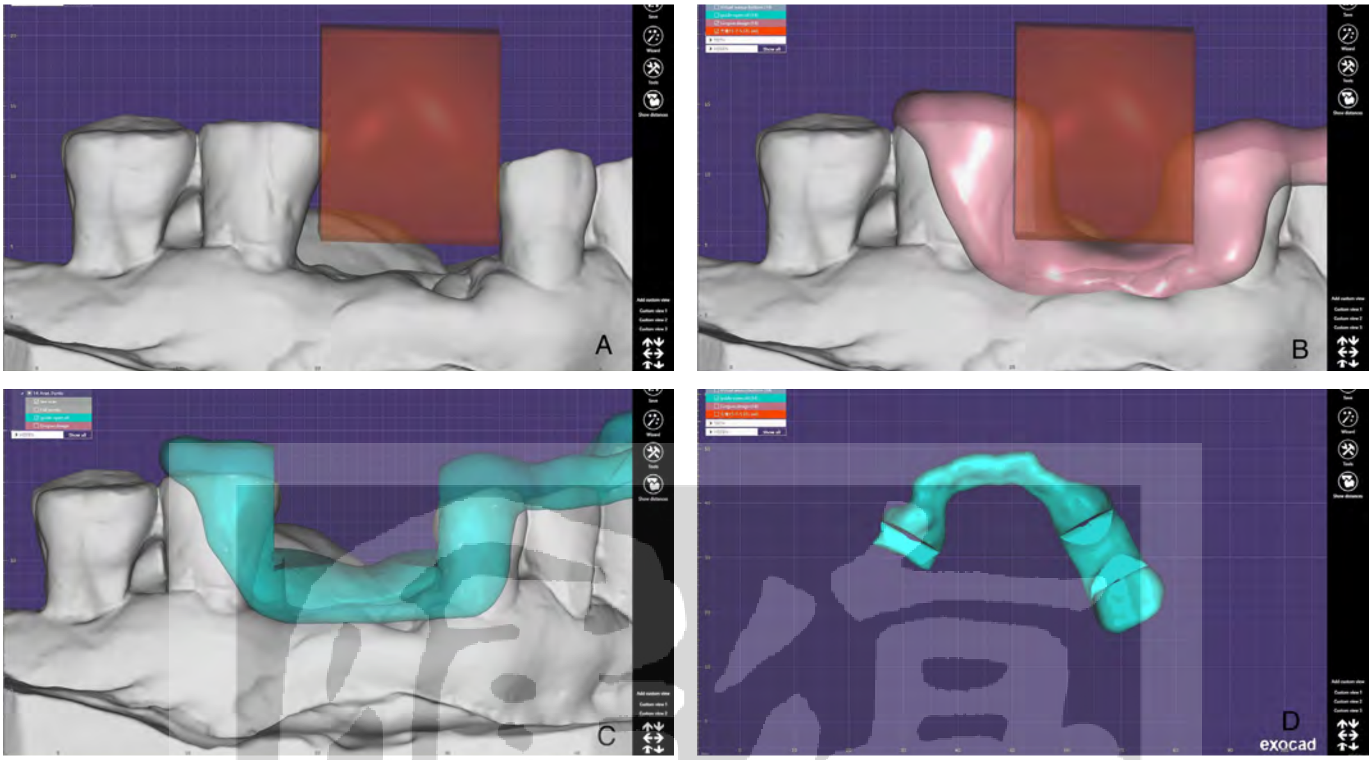

Figure 7. The open window design of preparation guide was achieved by using (A) cubic templet, (B) overlapping the stent, (C) exposing the teeth. (D) Export the design to CAM software and manufacture the guide stent.

Figure 8. (A) CAD–CAM preparation guide with three open windows for proximal plane preparation. (B) Intraoral guide template try-in and the preparation area. (C) Preparing the guiding plane with a diamond bur and finish bur.

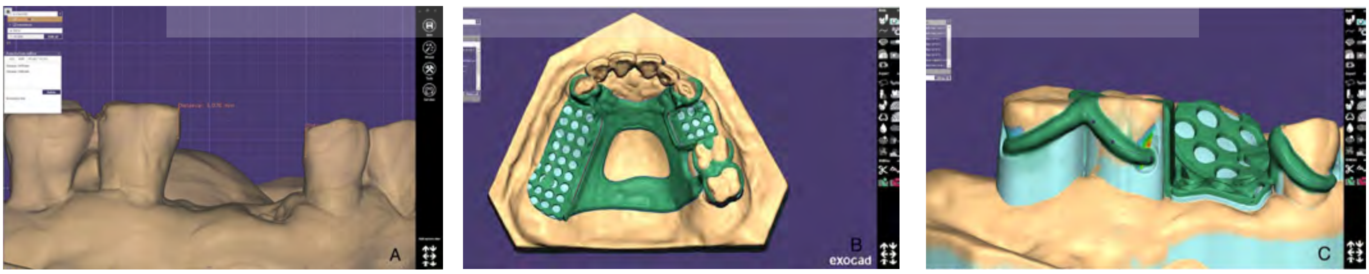

Figure 9. (A) After using CAD-CAM guide stent, the parallel of abutment and path of insertion of RPD was checked again by CAD software.
(B) (C) Final major connector, minor connector, rest, direct and indirect retainers was designed in this final model.

6. A cubic templet was used to define window area of the stent via click the procedure "Gingival Parts→ Antagonist→ More Freely→ ADAPT Occlusal→ Cut Intersections→ Free-Form Scan Data" (Fig. 7A~7D).
7. CAD-CAM preparation guide with three open windows for proximal plane preparation (Fig. 8A). Guiding template during intraoral try-in (Fig. 8B). Preparing the guiding plane with a diamond bur and finish bur (Fig. 8C).
8. The guiding plane was achieved and following our original design (Fig. 9A~9C).

Figure 10 After framework try in and wax denture try in, maxillary removable partial denture delivery.

The standard removable partial denture-fabrication process was followed, and the RPD with great retention and stability was fabricated (Fig. 10). The patient continues to routine follow ups at Prosthetic Clinic Department until now as no further deteriorative change in each abutment was required

Discussion

Krikos[5] reported that guiding planes created using the free-hand method with index are likely to exhibit divergence. As more teeth required to be shaped according to the path, the higher collective error may occur. In order to accurately transfer the orientation of guiding planes from the cast to abutment teeth, several devices and techniques such as verification devices,[8, 9, 13] matrices,[6] indexes,[5, 7] reciprocating dental handpieces,[14] intraoral surveyors[15, 16] and parallel devices,[9, 17] are being described. All methods were designed to enable clinicians to obtain precise final results. One of the advantages with this present method is the dental surveyor results outputted by CAD software which helps to verify pulp position by reviewing the integrated data of dental surveyor results and radiographic images.

The second advantage of the guiding plane is for the template to be milled using a polymethylmethacrylate disc with a standard diameter of 98 mm; it has a clear appearance and rigid. The disc is used in CAD–CAM systems for implanting surgical stents and occlusal devices extensively. Due to the rigidity of the material, the template could be placed on the neighboring tooth and edentulous ridge firmly. The reduction orientation and volume were precisely limited by window areas. Interproximal space was ultimately examined before milling and with the help of our guiding template, the preparation procedure was unaffected by the clinician's experience and required relatively less time.

The disadvantage of this method was the required traditional impression steps, stone pouring, and survey. Although excellent accuracy in single-unit scans has been demonstrated, the accuracy of a full-arch scan by using an intraoral scanner should be validated under clinical conditions.[18, 19, 20, 21] In the future, this technique can be combined with a digital intraoral scanning to simplify the procedure. Without the steps of impression and stone pouring, the deviation between the image and real conditions can be reduced. Guiding plane preparation can become an objectively replicable procedure.

Summary

In this technique report, CAD-CAM preparation guide enabled us to achieve parallel planes on the axial surface of RPD abutment teeth. The patient was satisfied with the high retention and stability of RPD and with no complain regarding food trapping.

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