

DENTAL TECHNIQUE

## Digital workflow for a dental prosthesis that considers lateral mandibular relation



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The ongoing developments in digital dentistry mean that clinical and laboratory processes are increasingly being replaced by digital workflows. The conventional prosthesis fabrication process consists of making an impression, waxing, investing, casting, and polishing. This process requires considerable labor from clinicians and laboratory technicians and is associated with high costs, lengthy fabrication times, and the chance of deformation of the impression or damage to the cast. Since its introduction in the late 1980s,<sup>1</sup> computer-aided design and computer-aided manufacture (CAD-CAM) technology has provided cleaner workflows to clinicians and laboratory technicians, greater quality control, reductions in cost and production time, and the possibility of using innovative materials such as zirconia.<sup>2-5</sup>

A typical CAD-CAM workflow consists of 3 steps: converting geometry into digital data using an instrument such as a laboratory or intraoral scanner, data processing using CAD software, and manufacturing using a milling machine or 3-dimensional printing technology. The use of a CAD-CAM system provides many benefits for prosthesis fabrication and is now used for the full range of prosthodontic procedures.<sup>2</sup> CAD-CAM prostheses have similar clinical performance to conventional prostheses in terms of marginal fit, esthetics, and mechanical properties.<sup>6,7</sup>

However, almost all CAD-CAM prostheses are produced on the basis of the maximal intercuspal

### ABSTRACT

Most digital prosthesis designs consider only the maximal intercuspal position (MIP) and not the lateral movement. During the computer-aided design and computer-aided manufacture (CAD-CAM) prosthesis delivery process, the clinician has to adjust the prosthesis to avoid occlusal interference during lateral excursion. The novel digital workflow described in this report can be divided into 2 steps. After obtaining interocclusal records for the MIP and the lateral excursion position, the crown CAD data were designed using a general digital workflow considering only the MIP. The previous crown CAD data were then adjusted in the lateral excursion state before manufacturing the prosthesis. This process using information for 2 occlusal positions means that the definitive prosthesis design reflects not only static occlusion but also lateral mandibular relation. (*J Prosthet Dent* 2017;117:340-344)

position (MIP) relation, omitting the patient's eccentric movement or dynamic occlusion. This deficiency increases the chair time required to make adjustments to eliminate occlusal interferences. Adjusting the prosthesis at the chairside also damages the anatomic form as designed using the CAD software, and for a zirconia prosthesis may cause tetragonal-to-monoclinic phase transformation, which affects mechanical properties.<sup>8</sup>

CAD designs have considered dynamic occlusion with virtual articulator systems.<sup>9,10</sup> However, the process involved is currently lengthy. The simplified transfer of casts from a mechanical to a virtual articulator has been described,<sup>9-12</sup> but these methods have required bulky and expensive instruments. Using a virtual articulator is not straightforward, so clinicians and laboratory technicians generally design digital prostheses based on MIP interocclusal records.

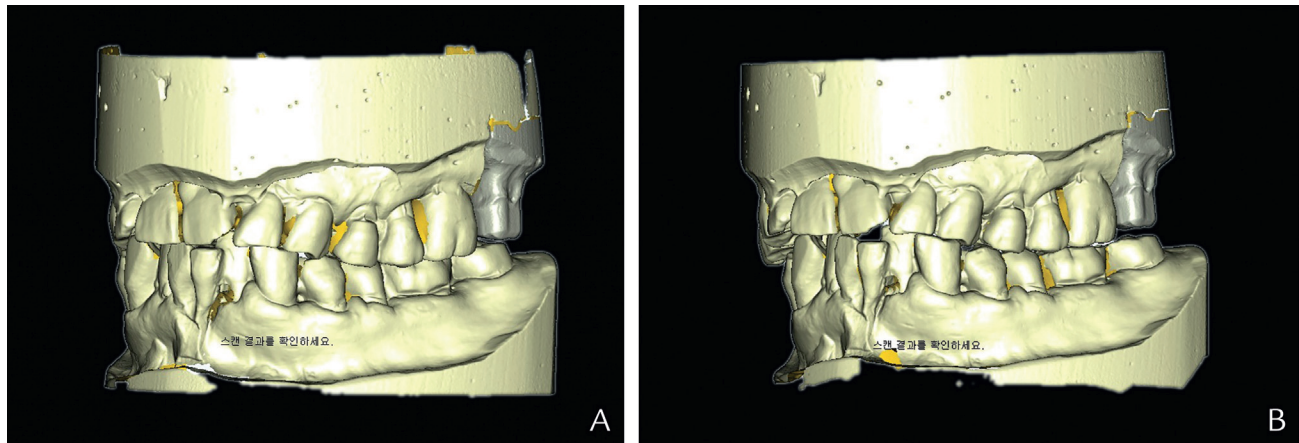
The purpose of this article was to introduce a design process that reflects the MIP and working-side lateral mandibular relation based on obtaining an additional

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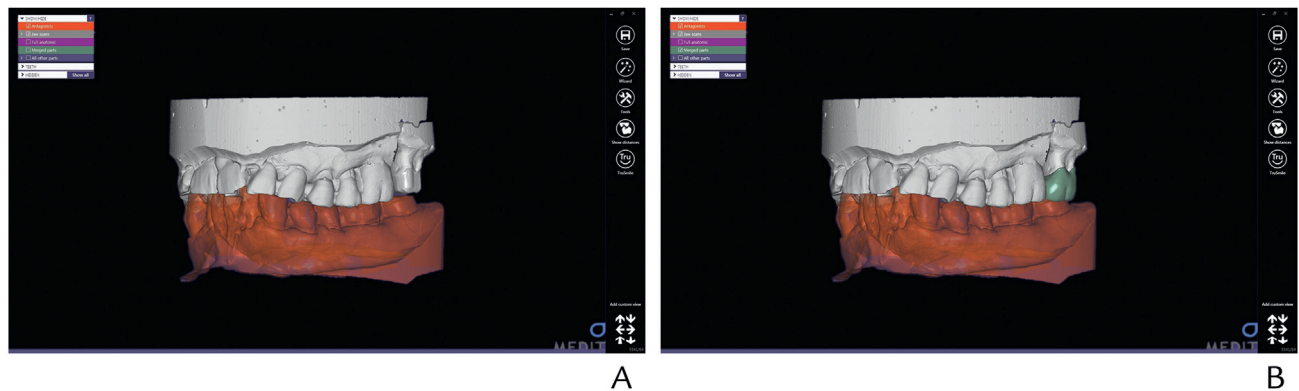
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**Figure 1.** Screenshots of definitive cast scan data. A, Scan data for MIP interocclusal record. B, Scan data for lateral interocclusal record. MIP, maximal intercuspal position.

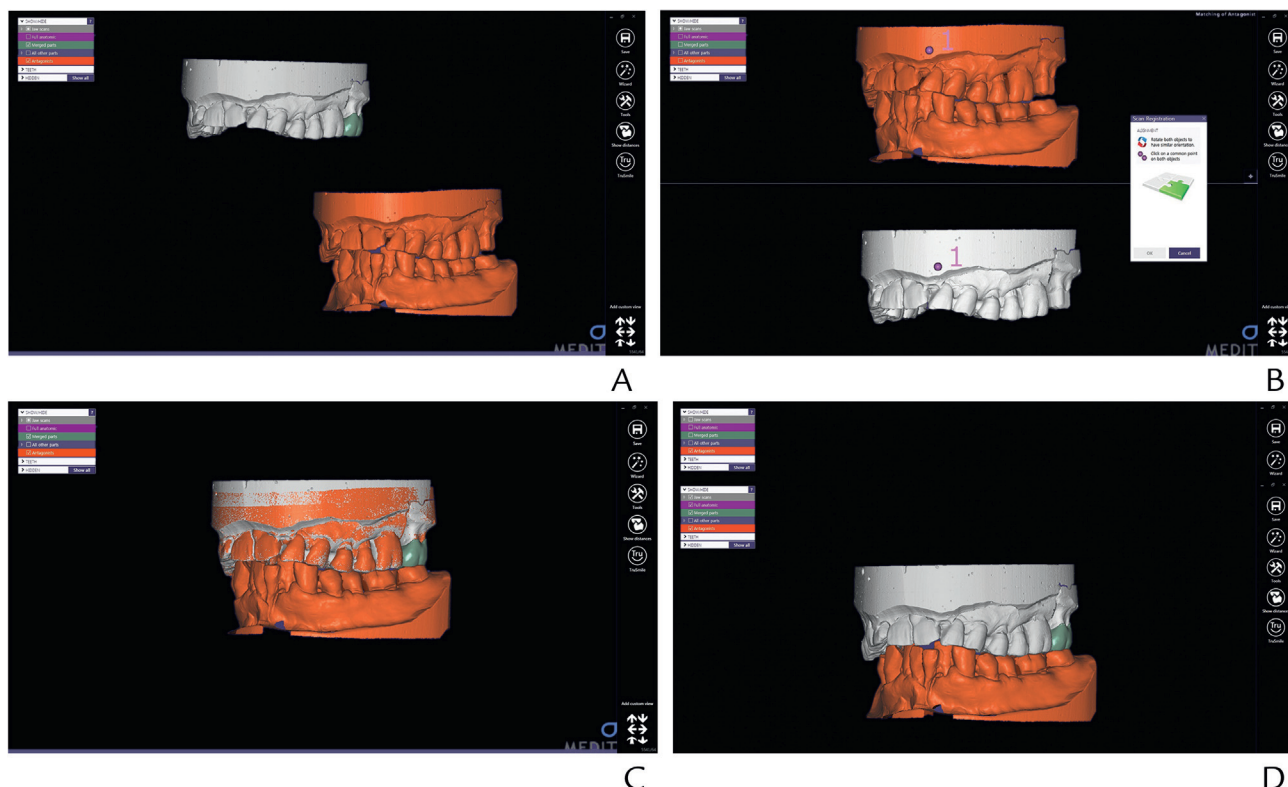


**Figure 2.** General digital workflow. A, MIP scan data imported into CAD software. Gray indicates working cast scan data, and orange indicates antagonist scan data. B, Designing scan data based on MIP relation. Green indicates new crown CAD data. CAD, computer-aided design; MIP, maximal intercuspal position.

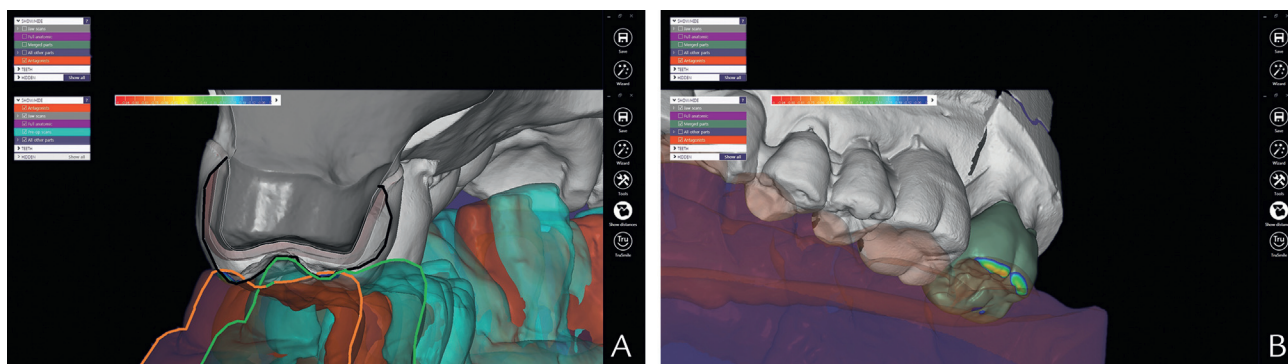
lateral interocclusal record and using an appropriate superimposition technique in CAD software.

## TECHNIQUE

1. Make impressions of the maxilla and mandible after tooth preparation. Obtain the interocclusal records in MIP and in lateral excursion.
2. Fabricate the definitive casts and then scan the maxillary and mandibular casts in MIP using a desktop scanner (Identica Blue; Medit) (Fig. 1A).
3. Scan the definitive casts using the lateral excursion interocclusal record (Fig. 1B).
4. Import the working cast and antagonist cast scan data for the MIP relation into the CAD software (Exocad DentalCAD; Exocad GmbH) (Fig. 2). Design the crown contour using the CAD software according to a general digital workflow.
5. Remove the MIP antagonist scan data and then import the working cast and antagonist cast scan data—relative to the lateral excursion—as 1 unit into the CAD software (Fig. 3A).
6. Superimpose the scan data imported in step 5 onto the remaining working cast scan data using the registration function of the software (Fig. 3B, C).
7. After completing the superimposition, delete all the other scan data except for the MIP working cast scan data and the antagonist scan data for the lateral excursion relation (Fig. 3D).
8. In the CAD software, confirm the overlap area between the designed crown CAD data and the antagonist scan data for the lateral excursion relation (Fig. 4A, B).
9. Remove the overlap area identified in step 8 using the occlusal intersection cutting tool of the CAD software (Fig. 5). This procedure only allows the end position of the excursion to be removed; a



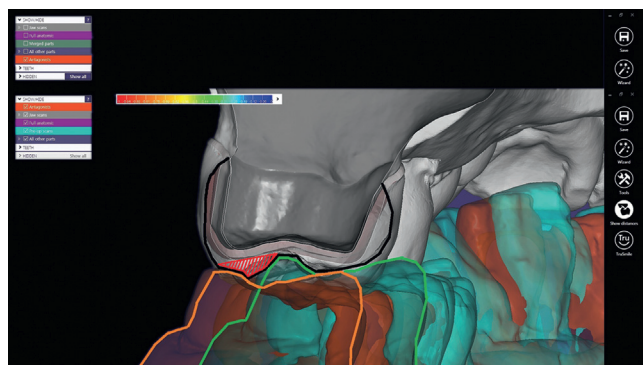
**Figure 3.** Procedure for importing lateral excursion antagonist data. A, Importing maxilla and mandible scan data on relation of lateral excursion as antagonist mesh (orange) combined. B, MIP working cast scan data and lateral excursion working cast scan data with identical geometry. Maxillary restoration shown; antagonist mesh superimposed on MIP working cast scan data. Reference points placed at identical positions in each set of scan data. C, Automatic superimposition. Presence of marbled pattern indicates high-quality superimposition. D, After superimposition, upper part of antagonist mesh removed (orange). Maxilla and mandible scan data shown relative to lateral excursion. MIP, maximal intercusp position.



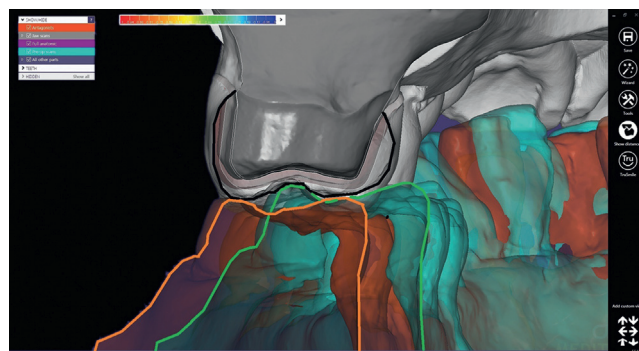
**Figure 4.** Intersection between crown design based on MIP and lateral excursion antagonist. A, Black line represents crown CAD data, green line represents MIP antagonist cast scan data, and orange line represents lateral excursion antagonist cast scan data. Overlap area between crown CAD data and lateral excursion scan data may be seen. B, Screenshot showing overlap area with color coding (blue to red indicates increasing intersection distance). CAD, computer-aided design; MIP, maximal intercusp position.

portion remains between the MIP and the lateral excursion position. Adjust the remaining portion considering the working-side excursion (Fig. 6). The crown designs using the general protocol and the new protocol are different in terms of the cuspal inclination and height (Fig. 7).

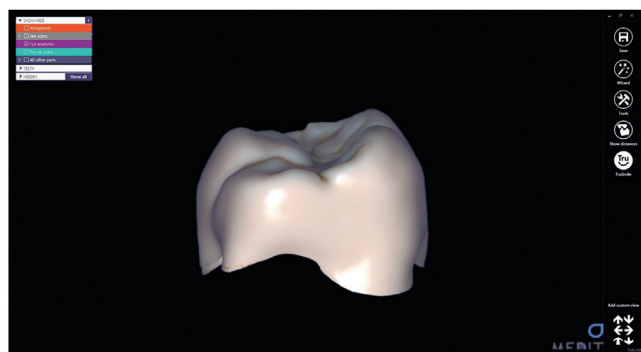
10. Another option for removing the remaining area is to split and integrate the path between the MIP and the lateral excursion position using appropriate mesh-processing software (Ezscan8; Medit). To reconstruct the excursion, calculate a transformation matrix using the iterative-closest-point algorithm.



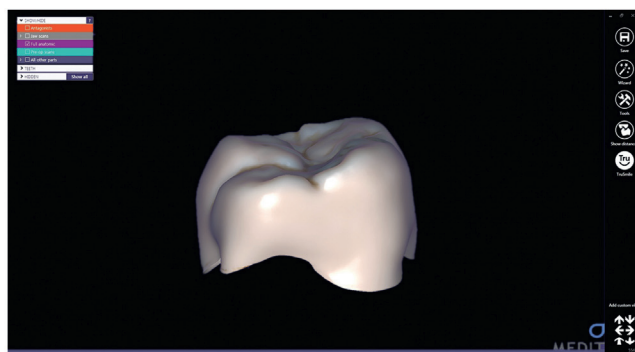
**Figure 5.** Cross-sectional view obtained by cutting intersection. Black line represents crown CAD data, green line represents MIP antagonist cast scan data, and orange line represents lateral excursion antagonist cast scan data. Small red triangle indicates remaining portion between MIP and lateral excursion position. CAD, computer-aided design; MIP, maximal intercusp position.



**Figure 6.** Adaptation between MIP and lateral excursion antagonist considering mandibular movement. Black line represents crown CAD data, green line represents MIP antagonist cast scan data, and orange line represents lateral excursion antagonist cast scan data. CAD, computer-aided design; MIP, maximal intercusp position.



A



B

**Figure 7.** Lateral views for comparing of MIP crown design and definitive design. A, MIP crown design. B, Definitive crown design considering lateral excursion. MIP, maximal intercusp position.

Divide this matrix into an appropriate number of mesh points, and then construct the intermediate positions and the new antagonist data (Fig. 8).

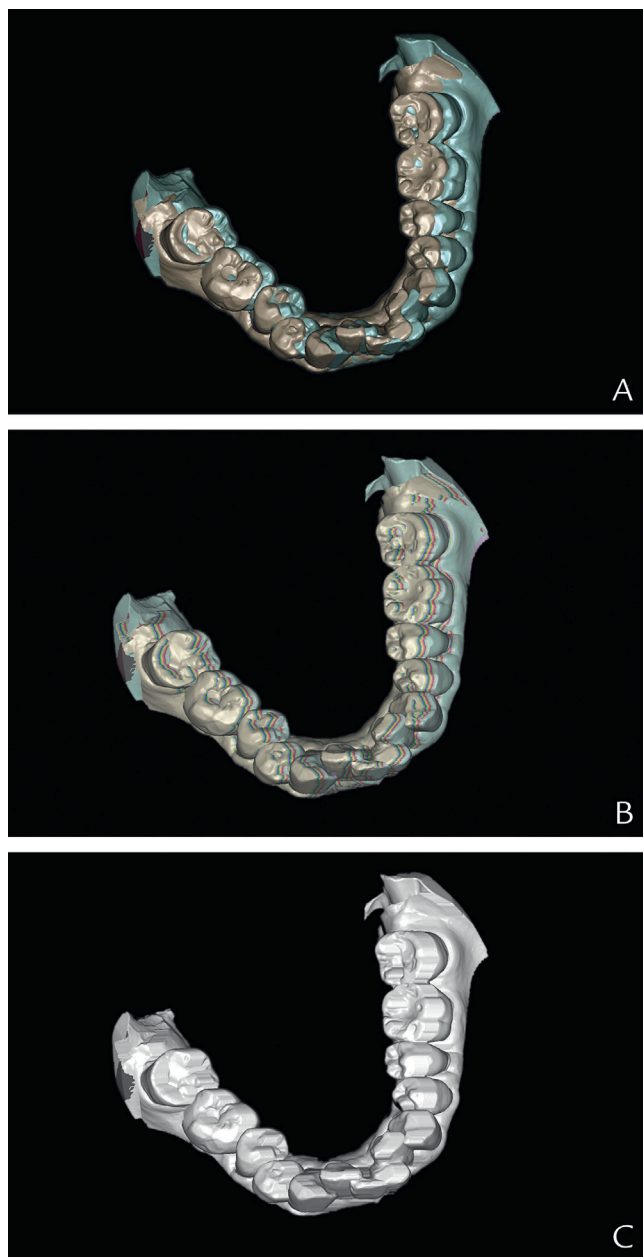
## DISCUSSION

The dental technique described overcomes some important limitations of the general technique for designing a prosthesis with CAD software by obtaining the interocclusal record in the lateral excursion position and reflecting that jaw relation on a virtual crown design. Obtaining a lateral interocclusal record allows for the design of the virtual prosthesis to be harmonized with the occlusion of adjacent teeth. This is accomplished by importing lateral excursion antagonist data and editing the virtual design. This digital work flow presents 2 options to edit the crown CAD data considering excursion. The first option is straightforward in that it does not require mesh-processing software. The alternative method described in step 10 for making a new antagonist mesh involves splitting and integrating a series of

intermediate antagonists that are calculated using a transformation matrix. This provides more precise reconstruction of the lateral excursion, but is more complex and requires additional software.

The new digital workflow allows an occlusal interference to be removed virtually, and the prosthesis can be fabricated without disturbing the existing guidance. The definitive prosthesis design shows a reduced cuspal height and cuspal inclination compared with the prosthesis designed by the general workflow. In addition, adding some volume to the surface of the newly fabricated restoration can help reconstruct group function or canine-protected articulation which is harmonized with the patient's existing occlusion with the patient's existing occlusion.

This digital workflow has some limitations. First, there is an assumption that the excursion path is linear. The MIP interocclusal record and the lateral interocclusal record only provide information about the starting point (the MIP interocclusal record) and the end point of the excursion (interocclusal record for the lateral excursion)



**Figure 8.** Screenshots of lateral excursion reconstruction. A, MIP antagonist scan data (gray) and lateral excursion scan data (light blue). B, Result after calculating transformation matrix, splitting path, and reconstructing intermediate position of antagonist. For this image transformation, matrix was divided by 10, and 9 intermediate positions could be reconstructed. Colored lines indicate 8 intermediate paths. C, Reconstruction of path by integrating intermediate paths in single unit mesh. MIP, maximal intercuspal position.

to the working side. Additional interocclusal records could be obtained between MIP and excursion end point to refine the replication of lateral movement. For complete occlusal replication, other eccentric movements need to be considered, including protrusive and non-working-side lateral movement.

## SUMMARY

The CAD-CAM technique described allows for functional and anatomic virtual crown design while considering a patient's lateral mandibular relation. This makes it possible to reduce the chair time required for occlusal adjustments and to conserve the anatomic form as designed using CAD software.

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