THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

Computer-based implant planning involving a prefabricated custom tray with alumina landmark structures

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ABSTRACT

The purpose of this technical report was to describe a method for the fabrication of a custom tray with landmark structures to coordinate cone beam computed tomography and scan data for use in guided implant surgery in patients with numerous artifact-causing metal prostheses. The fabricated custom tray can be used to coordinate cone beam computed tomography data and scan data from the dentition, as well as to fabricate the prostheses. (J Prosthet Dent 2019;121:373-7)

The traditional method for surgical implant placement involves creating a flap near the lost teeth and assessing alveolar bone quantity and morphology before drilling and implant placement. Although visual assessment of the surgical site is the more direct and confident method, inexperienced surgeons often encounter difficulties in freehand drilling.[1]

Computer-based implant planning[2,3] defines the dental implant position before surgery based on cone beam computed tomography (CBCT) data. Accordingly, this computer-based approach designs and fabricates the template with preoriented depth and direction. Guided implant surgery may allow more accurate surgical implant placement than freehand drilling.[4,5] Typical CBCT data do not reproduce the shape of the teeth with sufficient accuracy to create a drilling template. Therefore, guided implant surgery uses intraoral scan dentition data or a diagnostic stone cast scan and CBCT data as the reference standard.[6] Thus, the implant position as determined from CBCT is used to fabricate the template from arch scan data with greater precision than can be achieved by CBCT alone.[6,7]

Accurate coordination of CBCT data and scan data is essential for the fabrication of an accurate template.[8] Nonetheless, patients with multiple metal prostheses exhibit metal artifacts in CT data, which hinders the accurate coordination of CBCT and scan data and consequently introduces significant errors during the fabrication of the surgical template.[9,10]

The purpose of this article was to introduce a method of fabricating custom trays with landmark

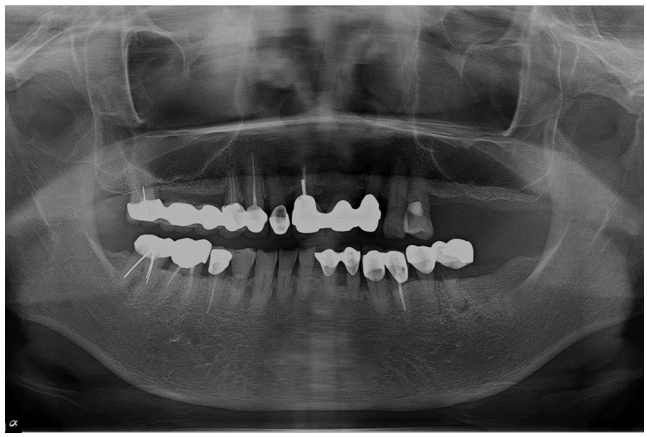

Figure 1. Panoramic radiograph before surgical implant placement. Patient had several metal prostheses.

Funding: This work was supported by the Advanced Technology Center (ATC) Program funded by the Ministry of Trade, Industry and Energy (MOTIE, Korea) (10077361, Integrated System for Dental Diagnosis, Treatment Simulation & PSI [Patient Specific Instrument] Design).

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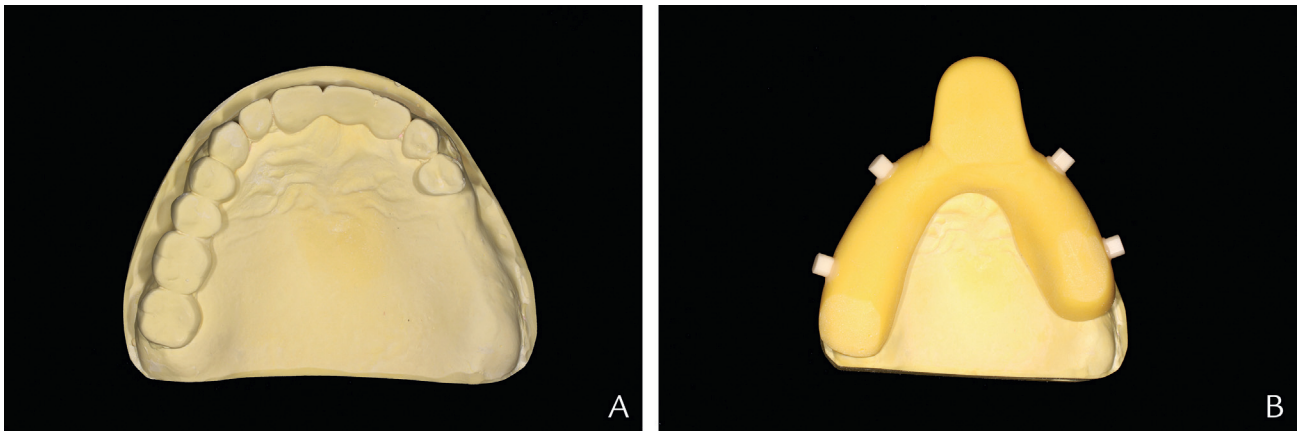

Figure 2. A, Diagnostic maxillary cast. B, Custom tray with landmarks for cone beam computed tomography imaging. Four alumina markers attached to tray extending to implant placement site.

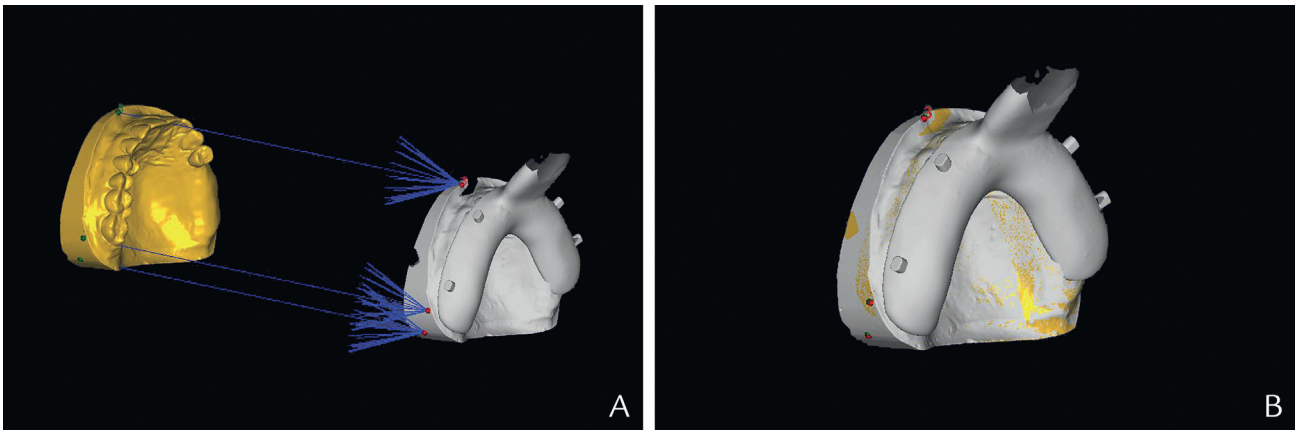

Figure 3. A, Three-dimensional alignment after scanning data of new stone cast and new stone cast with custom tray seated. B, Aligned data from 2 scans with common site.

structures to be used in the coordination of CBCT data and scan data in patients who have several metal prostheses; this method can also be used to fabricate the prostheses.

TECHNIQUE

1. For a patient with multiple metal restorations, pour a diagnostic stone cast from a preliminary impression (Fig. 1).
2. Fabricate a custom tray and use acrylic resin to attach 4 alumina cylinders (SGM5040; DIO Implant System) for use as landmark structures for coordination. Ensure the custom tray covers the implant placement sites (Fig. 2).
3. Fill the custom tray with elastomeric impression material (Identica Hybrid; Medit) and seat.
4. After the impression material has polymerized, make the CBCT image; remove the custom tray after the imaging is completed.
5. Pour a new stone cast for matching in the custom impression used for the CBCT imaging and add a base.
6. Scan the new stone cast with the custom tray without removing it from the impression. Scan the new stone cast alone after removing the cast from the impression material.
7. Align data from the 2 scans based on the common form of the cast base region and use these data for alignment with the CBCT data (Fig. 3).
8. Because direct coordination is not feasible because of the metal artifacts from the patient's CBCT data (Fig. 4A), first align the scan data from the custom tray with the CBCT scan data; use the alumina landmark structures for coordination (Fig. 4B).
9. Add the scan data from the new stone cast to the alignment. Because data from all 3 scans are aligned after step 7, CBCT data and the new stone cast data are also aligned (Fig. 4C).

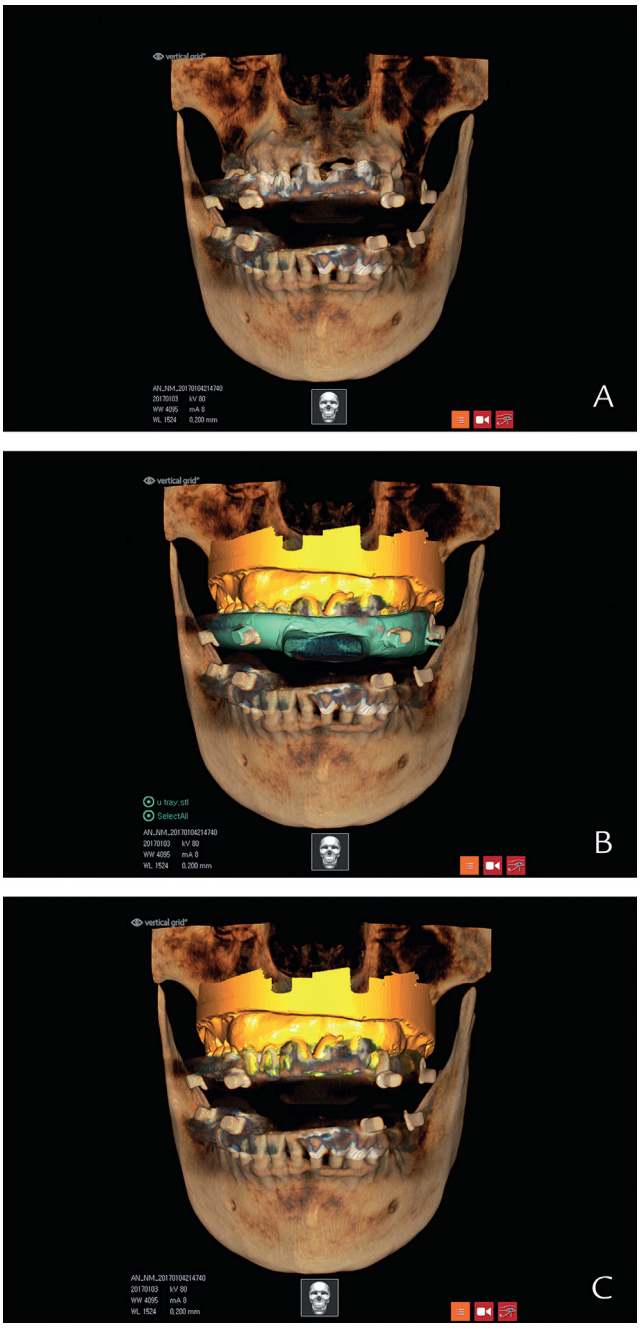

Figure 4. A, Metal artifacts from metal prostheses in CBCT image. B, Alignment of scan data of custom tray seated on new stone cast with CBCT data by using landmark structures for coordination. C, Alignment with CBCT data and new stone cast after loading. CBCT, cone beam computed tomography.

10. Design and fabricate the surgical template after planning the implant placement site by using software for guided implant surgery (Fig. 5).
11. Proceed with guided implant surgery by using the fabricated surgical template (Fig. 6).
12. Reuse the custom tray during fabrication of the prosthesis after implant placement to acquire an open-tray implant impression by opening the tray on the implant placement site (Figs. 7, 8).

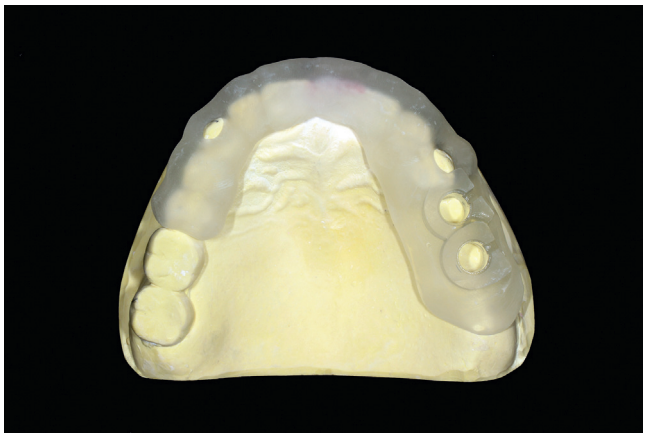

Figure 5. Surgical guide fabricated for implant surgery by process described.

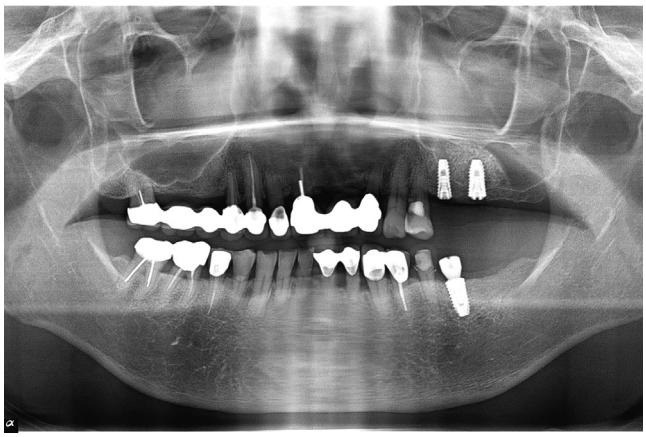

Figure 6. Panoramic radiograph after implant placement.

DISCUSSION

Patients with several metal prostheses typically exhibit metal artifacts; consequently, their CBCT data are inaccurate. Alignment using the conventional method of alignment of CBCT data and scan data from patient dentition, with the shape of the teeth for coordination, is therefore often impossible. Similarly, for edentulous patients, aligning CBCT data and oral scan data has been difficult. Thus, a double-scan technique, involving 2 separate CBCT scans (after applying a fiducial marker for coordination to a radiographic template) is an alternative approach. However, the double-scan technique involves higher costs because of the repeated CBCT scans and inaccurate seating of the surgical template, as guide fabrication is performed with only CBCT data.[7] The use of CBCT data alone could lead to inaccurate positioning of the implants.

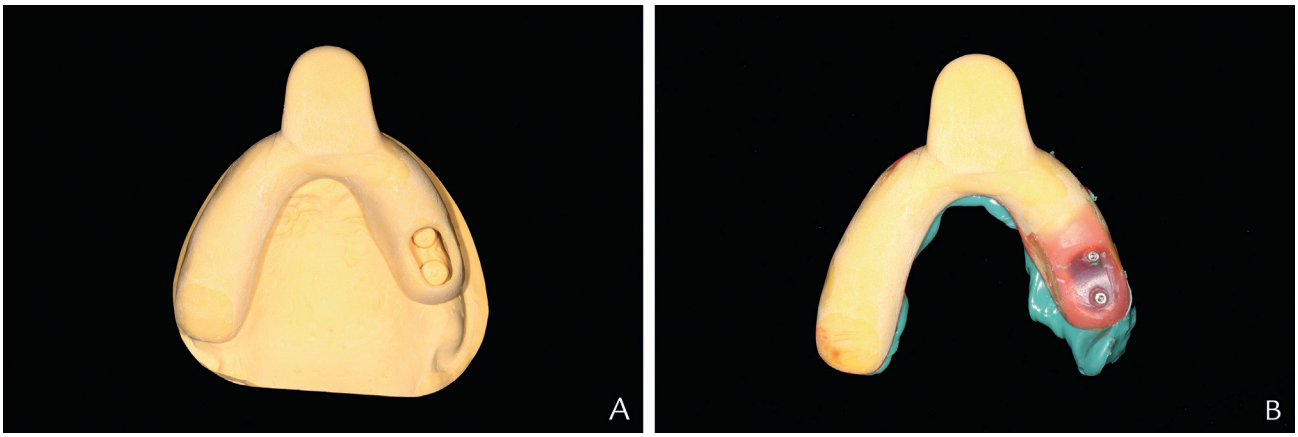

Figure 7. A, Modified tray for acquiring definitive impression of implants with custom tray fabricated to cover planned surgical implant placement sites. B, Definitive impression acquired at fixture level with open-tray technique.

Figure 8. Delivered implant-supported prosthesis. A, Occlusal side view. B, Buccal side view.

A recent study by Flügge et al[10] reported that the inaccuracy of guided implant surgery increased with the number of metal prostheses; accuracy differences depended on the segmentation of dentition in the CBCT data. During the planning process for conventional guided implant surgery, the segmentation of three-dimensional images is automatically performed with software and can be matched with data from the stone cast. However, as the number of metal prostheses increases, automatic segmentation becomes difficult, and metal artifacts obscure all important anatomic features.[10] Manual segmentation and data processing can be slightly more accurate, but this is a more specialized task and requires a great deal of time.[10]

In situations involving difficulty in registering CBCT data and stone cast data because of metal scattering, a marker has been used for orthognathic surgery.[11–13] Because brackets are attached to teeth before orthognathic surgery, the resulting metal artifacts make registration difficult when orthognathic surgery is planned in digital software.[14] A landmark such as titanium has been attached to the gingiva before CBCT scanning and impression making,[14,15] and a fiducial marker has been attached to an occlusion device on the maxillary occlusal surface before surgery.[9,11,12]

A dual-scan technique in which a radiopaque marker such as gutta percha is inserted into a radiographic template and the CBCT is made twice has been used for implant dentistry. This procedure has been used mainly for edentulous patients lacking a tooth landmark for registration.[3]

The procedure described here facilitates data alignment for planning guided implant surgery in patients with metal prostheses in their remaining dentition. This approach can prevent inaccurate coordination, diagnosis, and treatment because of the presence of metal prostheses; eventually, it provides for a more accurate implant placement. Furthermore, because the custom tray is fabricated to cover implant placement sites, it does not need to be refabricated for the definitive impression. Marker-based registration is a useful method, but the number and location of markers can affect the accuracy of

the registration. Investigation is needed regarding the accuracy of implant placement according to the number and location of attachment markers.

SUMMARY

A technique is presented that enables the smooth coordination of data and facilitates guided implant surgery by using a custom tray with landmarks in situations where coordination of CBCT data and scan data from patient dentition is complicated by the presence of metal artifacts. The fabricated custom tray allows data coordination and can be used for future fabrication of the prostheses.

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https://doi.org/10.1016/j.prosdent.2018.06.002