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DENTAL TECHNIQUE

CAD-CAM titanium preparation template for the socket-shield technique

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ABSTRACT

The socket-shield technique can be challenging and time-consuming. This article presents a digital approach to fabricating a computer-aided design and computer-aided manufacturing (CAD-CAM) titanium preparation template for the socket-shield technique. Preoperative cone beam computed tomography (CBCT) was used to map the remaining root, and the desired shape of buccal fragment of the root was determined as the socket shield. A CAD-CAM titanium preparation template was fabricated to facilitate root sectioning and the preparation procedure for forming an adequate socket shield. (J Prosthet Dent 2020;123:786-90)

Soft- and hard-tissue remodeling occurs immediately after tooth extraction, leading to alveolar ridge resorption.[1,2] The socket-shield technique was proposed by Hürzeler et al[3] in 2010 to preserve the alveolar ridge by retaining a buccal fragment of root. The technique includes immediate implant placement lingually.[3,4] The success of this technique is associated with the preservation of the buccal periodontium and the supracrestal attachment.[3] The technique can be modified to maintain the interimplant level of the hard and soft tissues.[5,6] The socket-shield technique can also preserve the alveolar bone in the pontic area for fixed dental prostheses after tooth extraction.[7,8] The tooth selected for the socket-shield technique should be carefully examined, and the root should be without any mobility, external or internal resorptions, or active periodontitis.[9,10] The clinical preparation of the socket shield should be carried out with great attention to detail, keeping the buccal fragment of the root stable and intact and preventing penetration into the bone or adjacent tooth.[10,11] The socket shield should also be prepared to a thickness of 0.5 to 1.5 mm,[12,13] and the coronal aspect of the socket shield should be trimmed to approximately the buccal bone crest.[3,9,10,12,14]

The root separation and socket shield preparation can be challenging and time-consuming. This technical report presents a digital approach to fabricating a CAD-CAM titanium preparation template to make the surgical procedure for the socket-shield technique more efficient and predictable.

TECHNIQUE

1. Obtain preoperative diagnostic data from the patient, including digital photographs, an intraoral scan in the standard tessellation language (STL) file format, and the cone beam computed tomography (CBCT) imaging in the Data Imaging and Communications in Medicine (DICOM) file format (Fig. 1).

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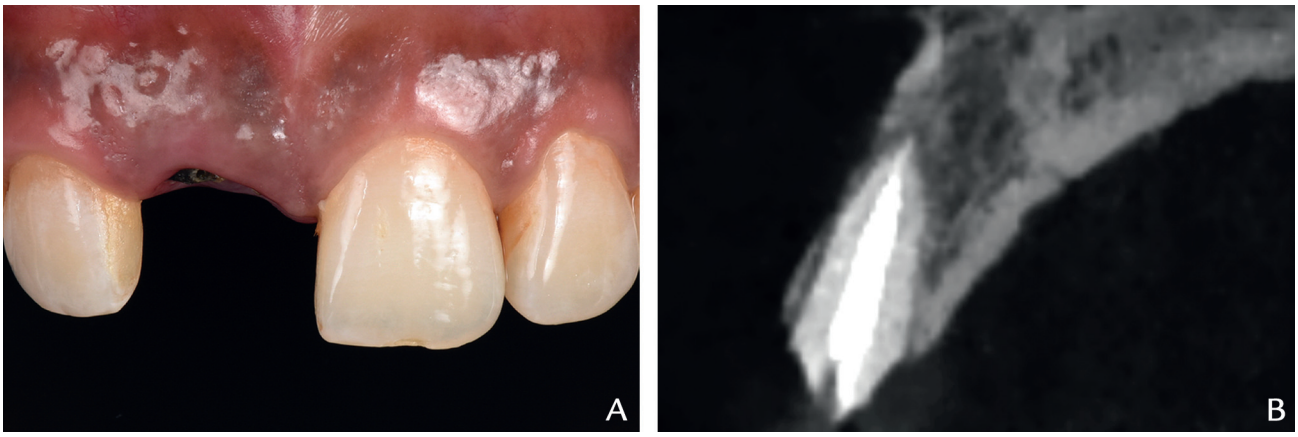

Figure 1. A, Preoperative condition of fractured maxillary right central incisor with remaining root in situ. B, Preoperative cone beam computed tomography imaging.

2. Import the DICOM and STL files into a 3D dental CAD software program (Segma Dental CAD; Segma). Complete a virtual diagnostic waxing and isolate the root from the surrounding anatomic structure (Fig. 2).
3. For immediate implant placement, determine the appropriate implant position based on the virtual diagnostic waxing and design the surgical template for the implant placement. Based on the planned implant position, determine the appropriate contour and thickness of the socket shield (Fig. 3).
4. Use the contour and boundaries of the socket shield to plan for the locations of the proximal and lingual guide planes. Design the proximal and lingual guide planes for the CAD-CAM preparation template in the CAD software program (Segma Dental CAD) and provide space between the desired contour of the socket shield and guide planes to account for the dimension of the tungsten carbide instrument needed during socket-shield preparation (Fig. 4). Based on the determined position of the proximal and lingual guide planes, design the CAD-CAM preparation template (Fig. 5). Incorporate seating verification windows in the design of the preparation template.
5. Subtract the segmented root from the diagnostic intraoral scan and export the new diagnostic cast and segmented root in STL format. Print the new diagnostic cast and segmented root by using a 3D printer (Perfactory Desktop Digital Dental Printer; EnvisionTEC) in photopolymerizing resin (E-Denstone Peach; EnvisionTEC) and fabricate the CAD-CAM preparation template by using a 5-axis mill (5X-200; Arum Europe GmbH) and titanium disk (Segma). Assemble the diagnostic cast and segmented root and position the preparation template on the diagnostic cast.

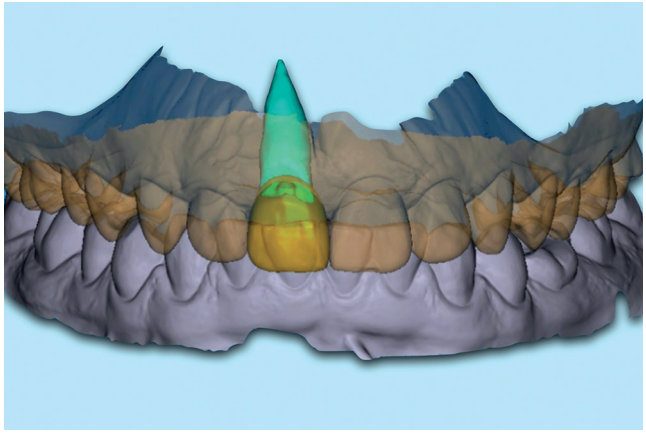

Figure 2. Digital diagnostic waxing and virtual reconstruction of remaining root.

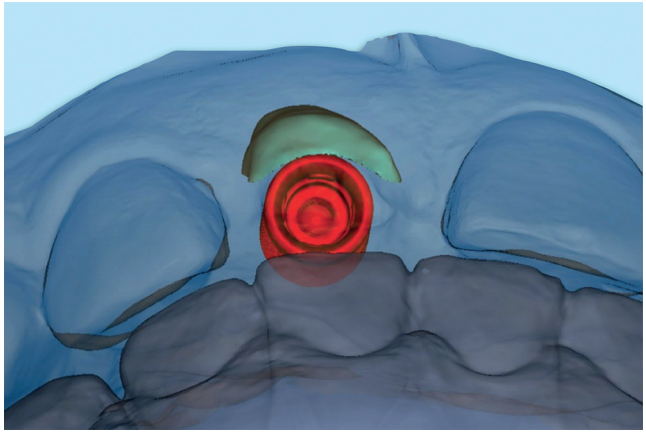

Figure 3. Planned implant position and desired contour and thickness of socket shield.

6. Select a tungsten carbide rotary instrument (Bone cutter H162SXL.314.014; Komet Dental) of sufficient length and mark depth indicators on the

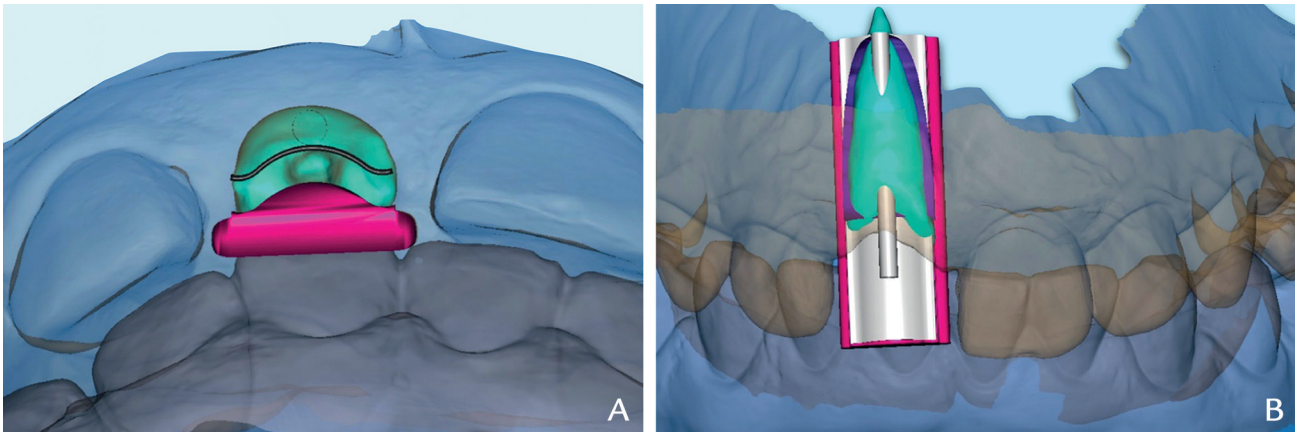

Figure 4. Design process of proximal and lingual guide planes for preparation template. A, *Teal* color indicates shape of remaining root, and *black* line indicates desired shape of socket shield. *Pink* color indicates contour of guide planes. Between *black* line and *pink* guide planes, space for tungsten carbide rotary instrument. B, Frontal view of socket shield and path of insertion for guide planes.

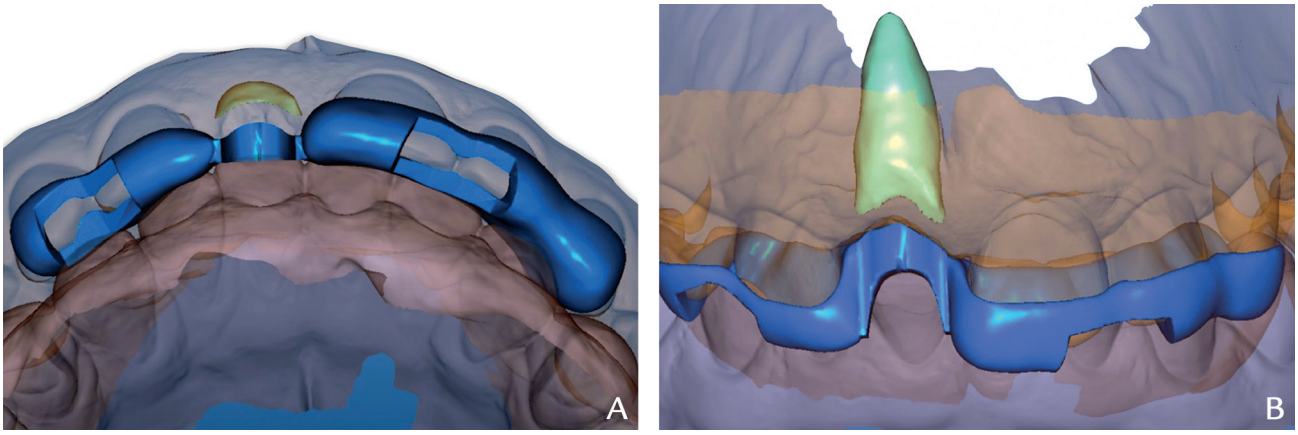

Figure 5. A, Incisal view of computer-aided design and computer-aided manufacturing socket-shield preparation template. Seating verification windows incorporated in template design. B, Frontal view of preparation template.

instrument to guide the preparation depth during the surgery (Fig. 6).

7. Proceed with the planned surgery and use the CAD-CAM titanium preparation template and tungsten carbide rotary instrument to section and prepare the buccal root fragment, forming an appropriate socket shield. Ensure the tungsten carbide rotary instrument contacts with and is parallel to the proximal and lingual guide planes in the preparation template (Fig. 7).
8. Upon completion of the socket-shield preparation, place the dental implant following the guidance of the surgical template (Fig. 8).

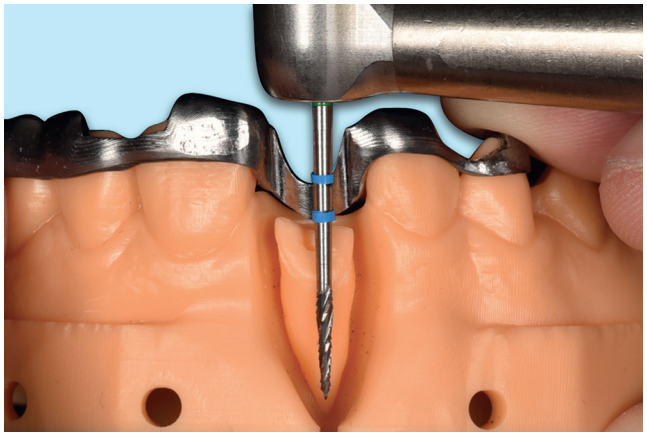

Figure 6. Printed diagnostic cast and segmented root. Mark depth indicators (*blue* lines) on tungsten carbide rotary instrument to guide preparation depth during surgery. One depth indicator represents location of upper margin of guide plane. Other depth indicator represents lower margin of guide plane.

DISCUSSION

This technique report presents a digital process for fabricating a CAD-CAM titanium preparation template for the socket-shield technique. In a retrospective study

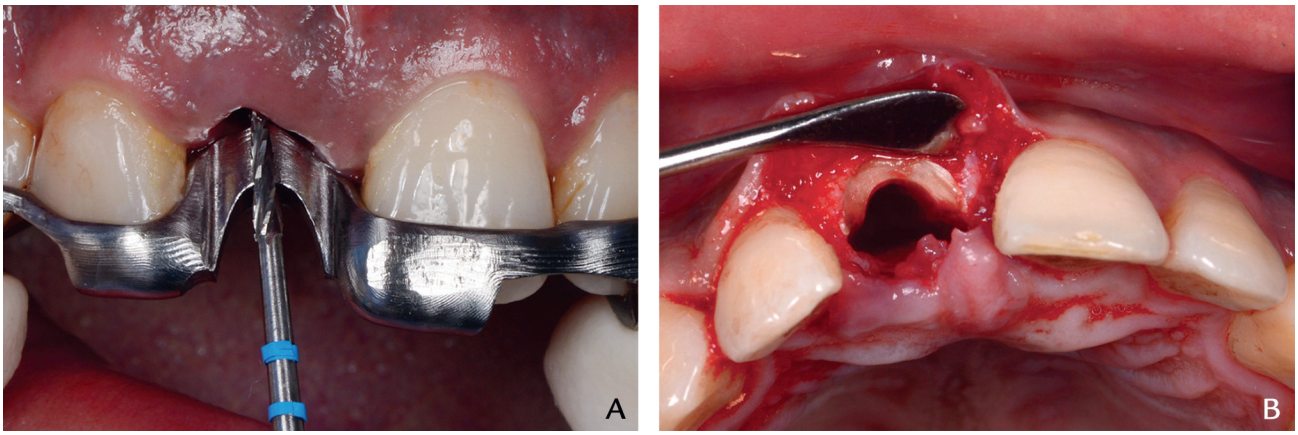

Figure 7. A, Sectioned root and prepared socket shield following guidance of preparation template. B, Occlusal view of prepared socket shield.

of 128 case series, the authors found that the most common complication resulted from improper socket-shield preparation, leading to exposure (perforation) of the socket shield.[11] When using the socket-shield technique without a preparation template, clinicians have to stop frequently to check the preparation depth and angulation and to verify the complete separation of the root while avoiding the penetration of the surrounding bone and adjacent teeth.[10] After separation and extraction of the palatal root fragment, the buccal root fragment has to be prepared to the desired thickness and shape to form an appropriate socket shield.[14] Using a CAD-CAM preparation template, the thickness and shape of the socket shield can be determined during preoperative planning, and the orientation and extension of the tungsten carbide rotary instrument can be properly guided by the preparation template during surgery. Seating verification windows are also incorporated in the template design, and clinicians should inspect the proper fit of the preparation template on the printed diagnostic cast and intraorally to ensure the accurate seating of the template and execution of the surgical plan. Another benefit of the present technique is using the concept of prosthetically driven surgical planning approach. With the use of a CAD-CAM preparation template, desired definitive prosthesis design (through diagnostic virtual waxing) can be planned in conjunction with the surgical planning of the socket shield.

Titanium was used to mill the preparation template, but cobalt-chromium (Co-Cr) alloy could be an alternative material. Furthermore, 3D metal printing technologies could also be considered for fabricating the desired preparation template. Although photopolymerizing resin is a convenient material for the fabrication of the surgical template by using a desktop stereolithography (SLA) 3D printer, it may not be suitable for the SS preparation template described in this report. Proximal and lingual guide planes on the SS preparation template are important to guide the tungsten carbide rotary instrument to section and prepare the buccal root fragment, but the photopolymerizing resin may not withstand the cutting force from the tungsten carbide instrument. Wear of a photopolymerizing resin surgical template can deform guide planes, leading to inaccurate execution of the surgical plan.

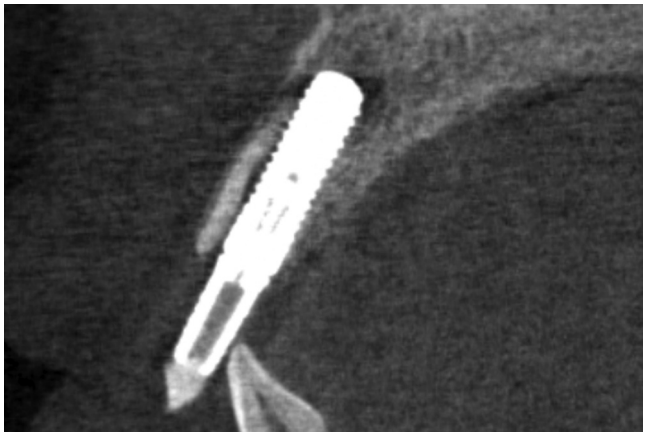

Figure 8. Postoperative cone beam computed tomography imaging of socket shield and implant.

Accurate and complete isolation of the remaining tooth or root in the CAD software program is essential in planning the socket shield, which requires high-resolution CBCT imaging with minimal artifact. Metal prostheses in the remaining tooth or root should be removed before the CBCT imaging to decrease artifact. If artifact cannot be eliminated and the complete isolation of the remaining tooth or root cannot be achieved from the DICOM files, the proposed technique is not applicable. In addition, a custom dental CAD software program (Segma Dental CAD; Segma) was used to design the preparation template. The development of new software programs would facilitate this technique.

SUMMARY

Root separation and preparation is challenging and time-consuming when using the socket-shield technique. The described CAD-CAM titanium preparation template can guide clinicians performing the technique and possibly improve surgical efficiency and safety through careful prosthetically driven surgical planning.

REFERENCES

1. Hansson S, Halldin A. Alveolar ridge resorption after tooth extraction: A consequence of a fundamental principle of bone physiology. J Dent Biomech 2012;3:1758736012456543.
2. Araujo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. an experimental study in the dog. J Clin Periodontol 2005;32:212-8.
3. Hürzeler MB, Zuhr O, Schupbach P, Rebele SF, Emmanouilidis N, Fickl S. The socket-shield technique: a proof-of-principle report. J Clin Periodontol 2010;37:855-62.
4. Bramanti E, Norcia A, Cicciu M, Matacena G, Cervino G, Troiano G, et al. Postextraction dental implant in the aesthetic zone, socket shield technique versus conventional protocol. J Craniofac Surg 2018;29:1037-41.
5. Kan JY, Rungcharassaeng K. Proximal socket shield for interimplant papilla preservation in the esthetic zone. Int J Periodontics Restorative Dent 2013;33:e24-31.
6. Cherel F, Etienne D. Papilla preservation between two implants: a modified socket-shield technique to maintain the scalloped anatomy? A case report. Quintessence Int 2014;45:23-30.
7. Gluckman H, Salama M, Du Toit J. Partial extraction therapies (PET) part 1: Maintaining alveolar ridge contour at pontic and immediate implant sites. Int J Periodontics Restorative Dent 2016;36:681-7.
8. Zhang Z, Dong Y, Yang J, Xu R, Deng F. Effect of socket-shield technique on alveolar ridge soft and hard tissue in dogs. J Clin Periodontol 2019;46:256-63.
9. Baumer D, Zuhr O, Rebele S, Hurzeler M. Socket shield technique for immediate implant placement - clinical, radiographic and volumetric data after 5 years. Clin Oral Implants Res 2017;28:1450-8.
10. Gluckman H, Salama M, Du Toit J. Partial extraction therapies (PET) part 2: Procedures and technical aspects. Int J Periodontics Restorative Dent 2017;37:377-85.
11. Gluckman H, Salama M, Du Toit J. A retrospective evaluation of 128 socket-shield cases in the esthetic zone and posterior sites: Partial extraction therapy with up to 4 years follow-up. Clin Implant Dent Relat Res 2018;20:122-9.
12. Tan Z, Kang J, Liu W, Wang H. The effect of the heights and thicknesses of the remaining root segments on buccal bone resorption in the socket-shield technique: An experimental study in dogs. Clin Implant Dent Relat Res 2018;20:352-9.
13. Calvo-Guirado JL, Troiano M, Lopez-Lopez PJ, Ramirez-Fernandez MP, de Val J, Marin JMG, et al. Different configuration of socket shield technique in peri-implant bone preservation: An experimental study in dog mandible. Ann Anat 2016;208:109-15.
14. Gluckman H, Nagy K, Du Toit J. Prosthetic management of implants placed with the socket-shield technique. J Prosthet Dent 2019;121:581-5.

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