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ORIGINAL ARTICLE

A three-dimensional printed assembled sleeveless guide system for fiber-post removal

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Abstract

This report describes a technique to develop a three-dimensional printed assembled sleeveless guide system to aid the fiber-post removal in a safe and efficient way. The surface and volume data of the dentition containing the targeted tooth were acquired with optical scanners and cone-beam computed tomography. The virtual path of the fiber-post removal was determined and integrated with a guide prototype with a cylindrical passage. The prototype data was split into two separate parts, combined with the matched pin and jack structures to facilitate the assembly. A guide tube was generated based on the axis of the cylindrical passage, split into three units, and combined with the previously processed data with connectors to form the finalized guide system. The adaptor for the head of handpiece was designed to facilitate the guidance. All the finalized data were printed with titanium alloy. The fiber-post of the upper right central incisor was successfully removed with the aid of this assembled sleeveless guide system that guides the handpiece rather than the rotary instrument.

KEYWORDS
3D printing, computer-aided design, fiber-post, guided technique

Fiber-posts are used to restore endodontically treated teeth.[1] However, removal of a fiber-post is needed at times to regain access to the root filled portions of an endodontically treated tooth as is the case of endodontic retreatment. Though several tools have been developed to facilitate post removal, such as a dental operating microscope, ultrasonic tips, and special post retrieval kits,[2–4] it is still a challenging task to remove the post without risking root damage.[5–7]

With the advent of digital dentistry, new technologies including three-dimensional (3D) data acquisition, and computer-aided design and computer-aided manufacturing (CAD-CAM) have been popularized in dental practice.[8] Guided implantology and endodontics have emerged to provide high levels of accuracy, safety, and efficiency.[9,10] Recently, a guided technique has also been used to remove fiber-posts.[11–15] These guide systems reported for fiber-post removal apply the traditional design with a sleeve to guide the rotary instrument. This design has several disadvantages. First, a cylinder-shape rotary instrument is required to match the sleeve. The rotary instrument with ideal shape, length, and diameter is not always available. Besides, the sleeve takes additional space, which restricts its application in the posterior region. Further, the traditional guide covers the field, which will impede irrigation and visibility during post removal. These limitations hinder the popularization of guided technique for fiber-post removal.

To solve these issues, a 3D-printed assembled sleeveless guide system that guides the head of handpiece rather than the rotary instrument was developed. This guide system consists of separate parts, and can be inserted from different directions and assembled as a whole intraorally. This technique

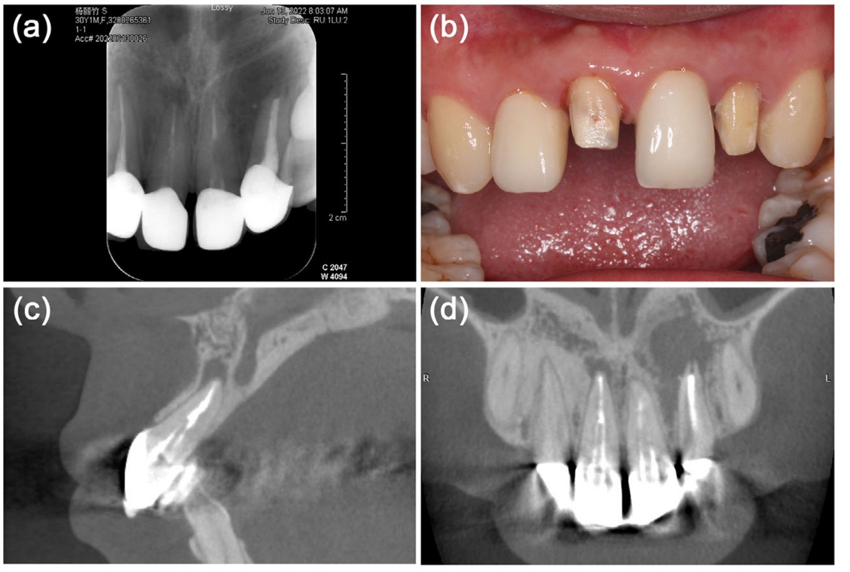

FIGURE 1 The upper right central incisor restored with fiber-post presenting apical periodontitis. (a) Apical radiograph. (b) Abutment after removing the full-crown. (c) Sagittal section in cone beam computed tomography (CBCT). (d) Coronal section in CBCT.

report describes the process to manufacture this sleeveless guide system, and the approach to remove a fiber-post with the aid of this guided technique.

TECHNIQUE

This technique was performed on a 30-year-old female patient whose upper right central incisor was restored with a fiber-post and all-ceramic crown. The central incisor presented with apical periodontitis (Fig 1a). The treatment plan of removing the crown as well as the fiber-post followed by endodontic retreatment was made after consulting the endodontic specialist. The following steps are performed after crown removal (Fig 1b).

1. Obtain cone-beam computed tomography (CBCT) images (3D Accuitomo; J. Morita Mfg. Corp, Fushimi-ku, Kyoto, Japan) of the tooth (Fig 1c and d). Export the data in digital imaging and communications in medicine (DICOM) file format.
2. Acquire the surface scans of the arch (TRIOS 3; 3Shape, Copenhagen, Denmark). Save the data in standard tessellation language (STL) file format.
3. Import the DICOM and STL file into an implant planning software (Implant Studio; 3Shape). Superimpose the two types of data (Fig 2a). Determine the virtual path and place a virtual fixation pin according to the 3D position of the fiber-post (Fig 2b). Design the periphery of the guide around the cervical part of the targeted tooth and three neighboring teeth on each side. Design the guide prototype (thickness: 1.5 mm) with a cylindrical passage for sleeve (Fig 2c). Save the data as an STL file.
4. Import the STL file of the dentition and guide prototype into an industrial CAD software (Geomagic Studio; 3D Systems, Rock Hill, SC). Design the guide tube as follows. Extract the axis feature of the cylindrical passage (Fig 3a). Establish a cylinder object (diameter: 13.85 mm) based on the axis. Form the guide tube by thickening the lateral surface of the cylinder (thickness: 1.5 mm). Reshape the bottom of tube by subtracting the prototype from the tube (Fig 3b). Determine the height of the guide tube based on the working length of the chosen rotary instrument (the total exposed length of the rotary instrument inserted into the handpiece). Ensure that the top of the tube is at least 5 mm longer than the base of the exposed rotary instrument at the initial drilling. Cut the tube into three parts by planes passing through the axis to form the inspection window and the passage for the handpiece (Fig 3c). Ensure the three parts diverge more than 180 degrees along the arc from the top view (Fig3d). Mark a depth reference on one tube part to indicate the position of the base of the exposed rotary instrument at the terminal drilling.
5. Split the prototype into two separate template parts with 1 mm width (Fig 4a). Remove the region over the targeted tooth by subtracting the cylinder for the guide tube from the prototype (Fig 4b). Combine the separate tube parts and template part on the same side. Add a connector where appropriate (Fig 4c). Establish two joined cylinders (diameter × height: 2 × 4.4 mm; 4 × 4 mm) to form the male pin structure (Fig 4d), and a hollow cylinder (diameter × height: inner, 2.2 × 4.4 mm; outer: 4 × 5.6 mm) to form the female jack structure (Fig 4e). Place the jack unit on each end of the guide, cut it into two parts, and combine them with each template part separately (Fig 4f and g). Save the data of the two separate guide parts and the pin unit as STL files (Fig 4h).
6. Design the adaptors for the required handpieces (Fig 5). Scan the head of the handpiece inserted with one cone-shaped rotary instrument (TRIOS 3) and import the data into Geomagic Studio. Extract the axis feature of the rotary instrument. Establish a cylinder object based on the axis (diameter: 13.70 mm; height: 1 mm higher than the head). Move the cylinder along the axis to the same

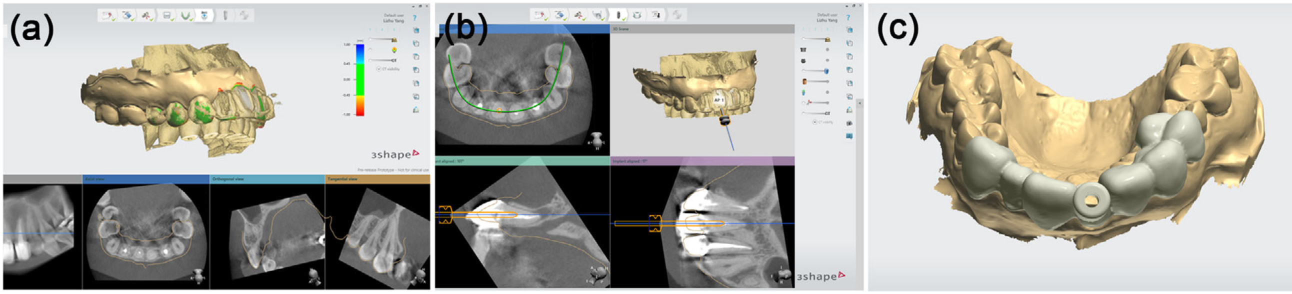

FIGURE 2 Design procedure of guide prototype. (a) Superimposed surface and volume data. (b) Placement of virtual fixation pin. (c) Designed guide prototype.

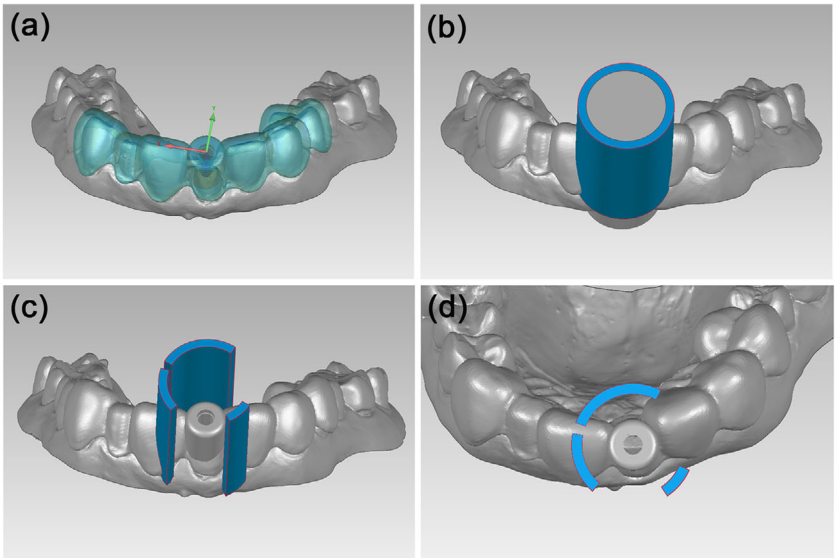

FIGURE 3 Design procedure of guide tube. (a) Axis feature of cylindrical passage. (b) Circular tube. (c) Lateral view of separate guide tube parts. (d) Top view of separate guide tube parts.

level with the head. Enlarge the handpiece by 0.05 mm. Subtract the cylinder by the enlarged handpiece. Remove the undercut areas that impede the insertion of handpiece from the top and form the passage for the neck of handpiece and the rotary instrument. Save the data as STL files.

7. Send these STL files to a metal 3D printer (M2; Concept Laser GmbH, Lichtenfels, Germany). Print the guide system with Titanium alloy (Titanium for Medicals, Optimal Material Technology, Chengdu, China).
8. Assemble the guide system and try-in on the cast. Check the fit, stability, and compatibility of the guide system (Fig 6).
9. Place the adaptor onto the handpiece. Assemble the guide system on the targeted dentition (Fig 7a). Use a tapered diamond bur (TF11; Mani, Utsunomiya, Tochigi, Japan) with working length 11 mm to remove the upper part of the fiber-post, then a tapered tungsten carbide rotary instrument (Reaccess Kit; RTD, Saint Egrève, France) with working length 21.5 mm for the lower part (Fig 7b). Perform visual inspection with dental operating microscope or probing examination for the contact with gutta-percha to confirm the removal of the post. For research purpose, this patient consented to a postoperative CBCT examination, and no additional root damage was found (Fig 7c and d).
10. Refer the patient for endodontic retreatment. Complete the definitive restoration of post and core crown after the endodontic concern has been treated (Fig 8).

DISCUSSION

The technical workflow of the data acquisition, CAD-CAM, and clinical application of this guide system is similar to that of a traditional post removal guide.[11–15] However, major differences exist in the data processing steps to develop the special configurations of this guide system, as described in this technique report. There are several advantages of this design compared with the traditional one. With this guide system, flexible rotary instrument use strategy can be adopted. For example, short rotary instruments can be used to remove the upper part of post, followed by long ones for the lower part. This, combined with the sleeveless design, can

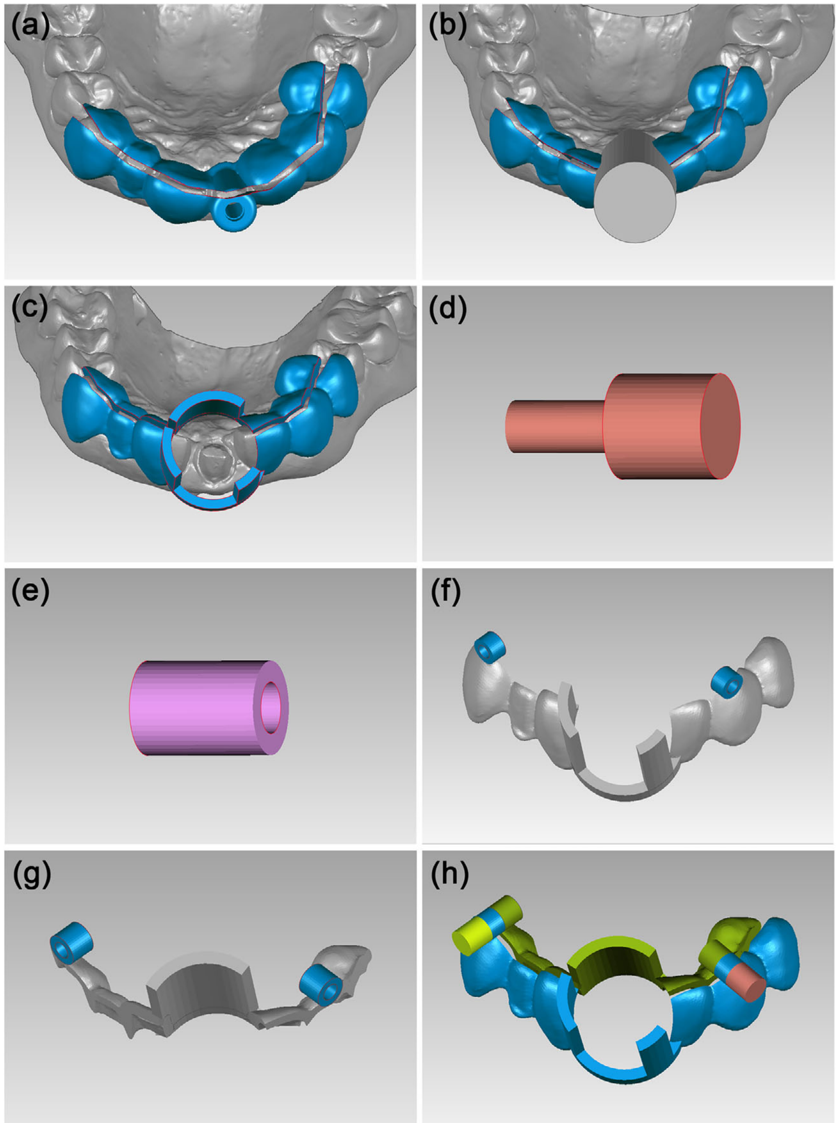

FIGURE 4 Design procedure of assembled guide. (a) Separate guide templates. (b) Removal of targeted area by the cylinder. (c) Combination of separate guide parts and templates with connector. (d) Male pin structure. (e) Female jack structure. (f) Placement of part of jack structure on one template part. (g) Placement of part of jack structure on the other template part. (h) Finalized assembled guide system.

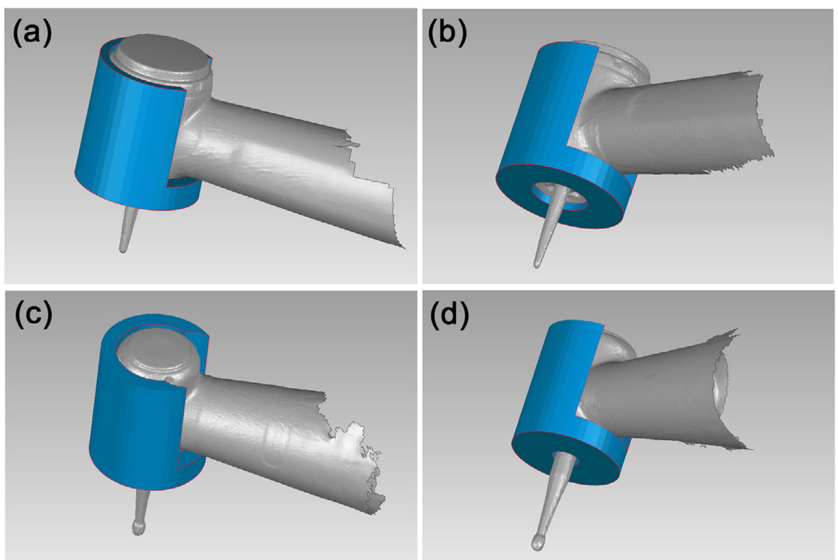

FIGURE 5 Designed adaptors. (a) Top side view of the adaptor of turbine handpiece. (b) Bottom side view of the adaptor of turbine handpiece. (c) Top side view of the adaptor of electric handpiece. (d) Bottom side view of the adaptor of electric handpiece.

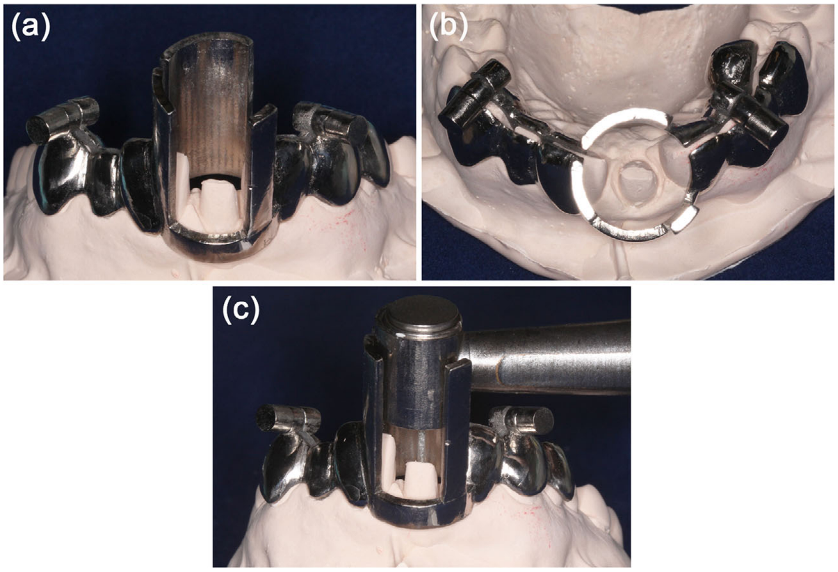

FIGURE 6 Printed guide system. (a) Lateral view of printed guide system inserted on the cast. (b) Top view of printed guide system inserted on the cast. (c) Evaluation of compatibility of guide system.

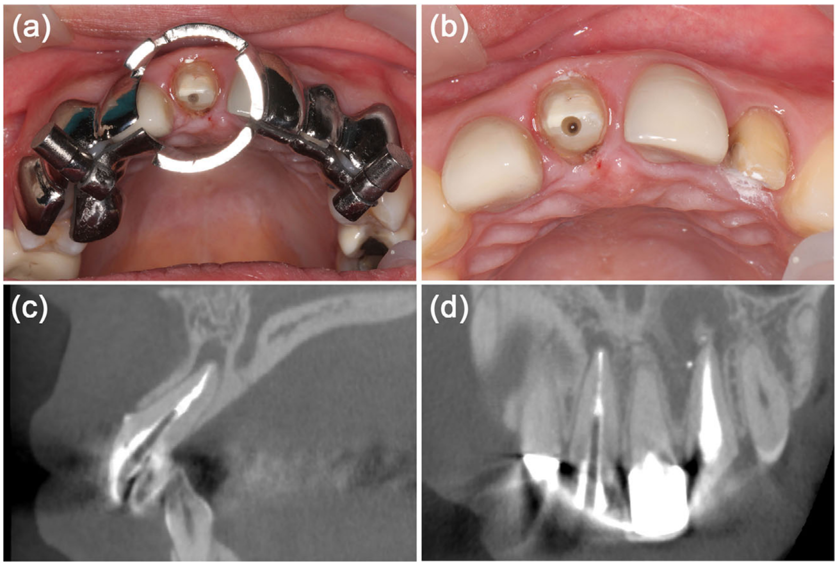

FIGURE 7 Fiber-post removal with guide system. (a) Intraoral insertion of guide system. (b) Abutment after removing fiber-post. (c) Sagittal section in cone beam computed tomography (CBCT) after operation. (d) Coronal section in CBCT after operation.

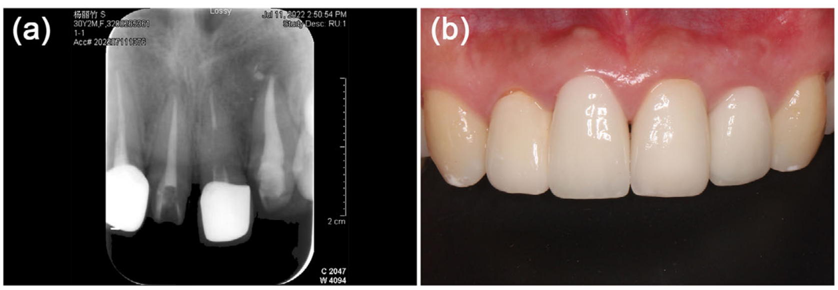

FIGURE 8 Definitive restoration of the upper right central incisor after root canal retreatment. (a) Apical radiograph after root canal retreatment. (b) Definitive all-ceramic crown.

facilitate the procedure, especially in the posterior regions where mouth opening may be limited (Fig 9). Also, cone-shaped rotary instruments can be used, which are safer than cylinder-shaped ones considering the anatomy of root canal system, but are not suitable for the traditional guide due to poor matching with the sleeve.

In addition, rotary instrument abrasion against the sleeve can be avoided. The operator has good visibility of the field to evaluate the deviation in real time by examining the alignment of the rotary instrument and the tube through the inspection window. This can further improve the operative safety.

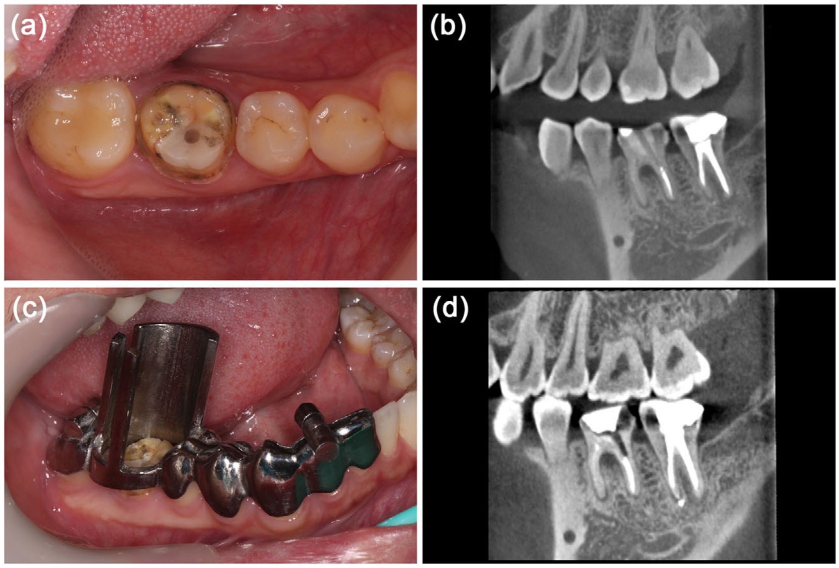

FIGURE 9 Another case for fiber-post removal in the mandibular right first molar with infection under the mesial root and root ramification. (a) Abutment restored with fiber-post and resin core. (b) Pre-operation cone-beam computed tomography (CBCT). (c) Application of guide system. (d) Post-operation CBCT showing that the post was successfully removed.

There are some tips for the clinical application. The position of the inspection window and the handpiece path should be determined considering the clinical presentation, and the height of the tube should be determined based on the working length of the rotary instruments to be used. The guide system is recommended to be fabricated from metal material, which presents with higher strength, smaller volume, better surface polishability and dimensional stability compared to light-polymerizing resin.[16] Rubber dam should be used after the removal of fiber-post, rather than during the application of the guide, as it may interfere with the insertion of the guide. The adaptors can be repeatedly used after sterilization as long as the internal diameter of the guide tubes remains the same, as well as the pins. This can reduce cost.

Some disadvantages of the guided technique for such cases remain, such as additional visits for the patient, and a learning curve for the clinician at the beginning. Another limitation is that additional industrial CAD software has to be used besides common dental CAD software. Access to these professional 3D design tools and the ability to use them are required.

SUMMARY

A 3D-printed assembled sleeveless guide system was developed which guides a handpiece rather than a rotary instrument. This guide system can aid in removal of fiber-posts in a safe and efficient manner.

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CONFLICT OF INTEREST

The authors deny any conflicts of interest in regards to this study.

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