CASE REPORT/CLINICAL TECHNIQUES

Guided Endodontics: Use of a Sleeveless Guide System on an Upper Premolar with Pulp Canal Obliteration and Apical Periodontitis

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ABSTRACT

Guided endodontics has been used for the treatment of anterior teeth with a successful outcome. This approach is not only limited to anterior teeth because it can also be used for the treatment of premolars and molars. However, in such cases, space may be a limitation because a long bur has to be used in addition to the guide being placed on top of the teeth. The aim of this case report was to present a novel guided endodontics technique using a sleeveless 3-dimensional–printed guide. This design can reduce vertical space, allowing an open view of the tooth and irrigation during drilling. A 46-year-old female patient consulted the endodontic department with intermittent pain around tooth #5. Tooth #5 presented pain upon percussion and responded negative to a cold test. The initial periapical radiograph revealed an apical radiolucency with pulp canal obliteration. Clinically, there was no sinus tract. The tooth was diagnosed with pulp necrosis and symptomatic apical periodontitis. Guided endodontic treatment was performed with a sleeveless 3-dimensional–printed guide and long neck carbide bur with a head diameter of 1 mm to drill a minimally invasive access cavity up to the root canal. A completely healed apical area of tooth #5 was visible after 1 year on periapical radiographs. This technique seems to be a promising alternative in comparison with the conventional guided endodontic guide design for the negotiation of pulp canal obliteration in cases in which vertical space is limited. *(J Endod 2021;47:133–139.)*

SIGNIFICANCE

We believe that this approach may provide an alternative to freehand treatment for the endodontic treatment of teeth presenting with PCO and reduce the risk of iatrogenic damage to the root. Additionally, the novelty of the guide can present an alternative in comparison with the conventional guided endodontic approach for the negotiation of PCO in cases in which vertical space is limited.

KEY WORDS

3-dimensional printing; cone-beam computed tomography; dental pulp calcification; guided endodontics; periapical periodontitis; root canal therapy

Endodontic treatment of teeth with pulp canal obliteration (PCO) is very challenging and may present a higher risk of failure[1–4]. PCO is usually associated with luxation injuries after dental trauma[2,4,5]; however, it may also occur as a pulpal response to carious lesions[6] or coronal restorations[7] and after vital pulp therapy procedures[8]. Additionally, the apposition of secondary dentin over time may also lead to a severe calcification of the root canal system in elderly patients[9,10]. Furthermore, PCO may arise as an adverse effect of orthodontic forces[11,12]. Root canal treatment is only indicated in cases in which the tooth has symptoms or radiographic signs of periapical disease. This can occur in 1%–27% of teeth with PCO[2,4,5].

In those cases, the use of cone-beam computed tomographic (CBCT) imaging could be beneficial because it is a technology that is widely used in contemporary endodontics. It can depict the tooth in all spatial planes in order to visualize its root canal anatomy and help with the assessment of PCO[13,14] as well as an additional aid during treatment[15].

Furthermore, CBCT imaging lays the foundation for 3-dimensional (3D) printing of access guides for guided endodontics[16]. Thanks to improvements in tomographic imaging techniques associated with virtual planning and 3D printing technologies, the concept of guided endodontics was introduced to aid in the access and treatment of calcified canals[17–19]. It is a promising technique offering a highly predictable outcome with a lower risk of iatrogenic damage and reduction in chairside time[16,20]. 减少医源性损伤；节省椅旁时间

Several cases using guides have been reported in the literature on anterior and posterior teeth with a successful outcome[19,21–25]. However, accessibility in posterior teeth with this technique is difficult

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because of limited space for the template and the drill[20]. Additionally, this technique might be a contraindication in patients with limited mouth opening[25].

去除套筒和将导轨移到骨嵴侧面解决垂直空间不足

A recent innovative guide design for guided implant placement has been used to solve the problem of the lack of vertical space[26–28]. It solves the issue by eliminating the sleeve and moving the guides (there are 2, and they are inserted directly on the handpiece through a dedicated adapter) lateral to the bone crest. This saves space and allows the clinician to work with shorter drills. As a consequence, it allows the clinician to work in the posterior areas, visibility is improved, and it allows for irrigation during drilling.

The aim of this case report was to present a novel guided endodontic technique using a sleeveless 3D-printed guide to gain access to obliterated root canals on an upper premolar on the basis of CBCT data.

CASE REPORT

A 46-year-old female patient, American Society of Anesthesiologists I, consulted the endodontic department at the University Hospitals of Leuven, KU Leuven, Leuven, Belgium, with intermittent pain around tooth #5. Clinically, tooth #4 and #5 presented a Miller type II recession. Tooth #5 presented pain upon percussion and responded negative to the cold test. The initial periapical radiograph revealed an apical radiolucency on tooth #5 with an obliterated root canal; clinically, there was no sinus tract (Fig. 1*A–D*). Tooth #5 was diagnosed with pulp necrosis and symptomatic apical periodontitis and scheduled for endodontic treatment.

Because of the degree of PCO, the location of the root canal was judged to be difficult and with a potentially high risk of iatrogenic damage to the root according to the endodontic case difficulty assessment guidelines from the American Association of Endodontists[29]. A CBCT scan was taken using the NewTom VGi evo (NewTom, Verona, Italy) operating at 110 kVp and 3.0 mA with a field of view of 5 × 5 cm and a voxel size 0.125 mm to assess the tooth's root canal anatomy. The CBCT image revealed a calcified root canal up to the middle of the root with an apical division (type V [1–2] according to Vertucci[30] or $^{1}14^{1-2}$ according to Ahmed et al's classification[31]) and an apical radiolucency of 32 mm^3; the buccal bone plate was preserved (Fig. 1). Additionally, an intraoral surface scan (Trios; 3Shape, Warren, NJ) from the upper jaw was taken, and treatment for this case was planned using a guided endodontic approach.

Both image data sets (Digital Imaging and Communications in Medicine images from the CBCT and the STL file from the intraoral surface scan) were imported into SMOP software (version 2.15.4; Swissmeda AG, Baar, Switzerland) and registered using the software's built-in tool. Then, a path for the bur was created maintaining straight-line access up to the root canal. The apical target point was measured from the occlusal surface of the tooth; for this case, it was 10 mm. Finally, a 3D guide was designed (2INGIS, Zaventem, Belgium) and printed using the Form 2 3D printer in Dental SG Resin (Formlabs, Somerville, MA) (Fig. 2*A–C*).

The guide is designed such that it does not use a sleeve to guide the bur. Instead, it uses guiding rails consisting of 2 cylinders (with an internal diameter of 2.05 mm) placed against each other on the sides of the tooth to guide the handpiece head. Additionally, a leg system or adapter (outer diameter = 2 mm, length = 13 mm) is firmly attached to the handpiece head. The adapter will fit on the rails and guide the handpiece during treatment. Also, a safety stop is added to the guiding rails to prevent the handpiece and, consequently, the bur from reaching beyond the apical target (Figs. 2 and 3*A–J*).

The 3D-printed guide was placed on the upper teeth. The open design of the guide allows for an immediate control of the fit and adaptation of the guide. After a satisfactory assessment of the fit and stability, treatment was initiated. Initially, a small cavity was drilled on the enamel using a diamond bur. Then, the guide was placed, and the access cavity was precisely drilled using a size 2 Munce Discovery bur (CJM Engineering, Santa Barbara, CA) with a head and shaft diameter of 1 mm, a working length of 16 mm, and a total length of 31 mm placed on a WS-75 L handpiece (W&H, Bürmoos, Austria) operating at a maximum of 10,000 rpm with a pumping movement. Every 2 mm of progression, the cavity was rinsed, and the head of the bur was cleaned. When the handpiece reached the safety stop, the apical target point was reached, and the tooth was immediately isolated and examined under a dental microscope.

After the glide path was achieved with a size 15 K-file (Dentsply Sirona Endodontics, Ballaigues, Switzerland), instrumentation of the canals was performed with WaveOne Gold files (Dentsply Sirona Endodontics). WaveOne Gold Medium (size 35, .06 taper) was selected as the final file, and apical patency was controlled during the whole procedure with the help of a size 10 K-file (Dentsply Sirona Endodontics). During treatment, the root canals were rinsed with 20 mL 5% sodium hypochlorite, and then a final irrigation protocol was applied using 17% EDTA and 5% sodium hypochlorite in combination with passive ultrasonic irrigation using a size 20 IrriSafe file (Satelec Acteon, Mérignac, France). The root canals were then dried using paper points and filled using a vertical condensation technique with warm gutta-percha and an epoxy sealer (TopSeal; Dentsply De Trey, Konstanz, Germany). The access cavity was then filled with composite, the restoration was polished, and occlusion was controlled. A periapical radiograph was taken after treatment, and the patient was scheduled for recall (Fig. 3).

The patient attended a recall appointment 1 year after root canal treatment. During the appointment, a follow-up periapical radiograph was taken that revealed a completely healed apical area (Fig. 3).

DISCUSSION

Root canal treatment in teeth with PCO is considered as being of high difficulty according to the endodontic case difficulty assessment guidelines from the American Association of Endodontists[29]. The operating times to localize the canals in such cases can vary from 15 minutes to 1 hour when performed by an endodontic specialist[10] wherein the likelihood of causing iatrogenic damage to the root or excessive loss of tooth structure is a risk. The use of a 3D-printed guide can help, not only by shortening the treatment time significantly but also by aiding in the localization of the root canal regardless of the experience of the operators. Moreover, there is significantly less substance loss when using a guide compared with traditional endodontic access[32]. As a result, the previously mentioned risks are reduced, and a better outcome can be achieved[16].

The concept of guided endodontics was first described by Krastl et al in 2016[19]. Since then, several guide designs have been developed in which drilling through a sleeve (metal or plastic) was a common feature[18,21,24,25,33,34]. Its accuracy seems to be reliable as reported in *in vitro* and *ex vivo* studies, with a mean angle deviation ranging from 1.6°–1.8°[20,22] and a mean deviation of less than 0.5 mm at the tip of the bur[20,22,35].

To our knowledge, this is the first case report on guided endodontics using a sleeveless guide. This system has already been used for guided implant placement. Schnutenhaus et al[28] reported a mean angular deviation of 2.8° and a mean apical deviation of

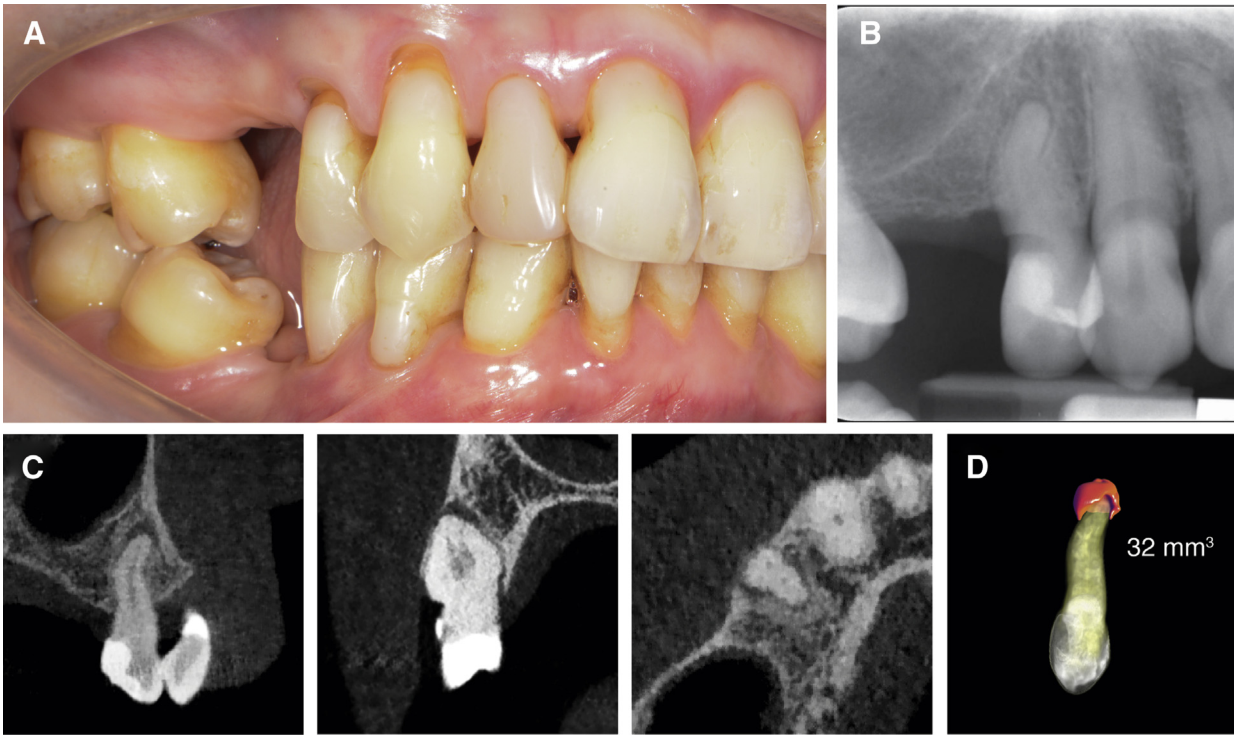

FIGURE 1 – Clinical and radiologic assessment of tooth #5. (*A*) Tooth #4 and #5 presented a Miller type II recession with an abfraction lesion. (*B*) A periapical radiograph revealed an apical radiolucency on tooth #5 with an obliterated root canal. (*C*) CBCT images from tooth #5 revealing a calcified root canal up to the middle of the root with an apical division (see the axial and coronal images). (*D*) An apical radiolucency of 32 mm^3 was measured.

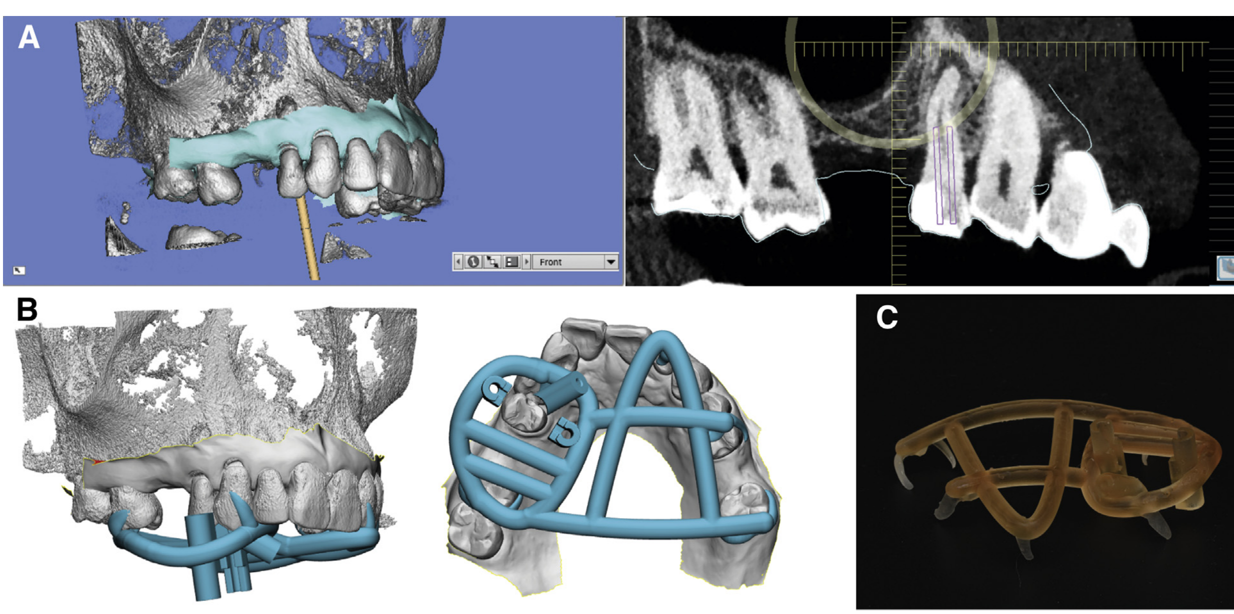

FIGURE 2 – The guide design. (*A*) Registration of Digital Imaging and Communications in Medicine images from the CBCT scans and the STL file from the intraoral surface scan; (*left*) the volumetric view and (*right*) the sagittal image showing in light blue the contour of the registered intraoral scan and in purple the planning of the access cavity and measurement of apical target point (10 mm). (*B*) The design of the 3D guide (2INGIS) with 5 occlusal anchor points and 2 guiding cylinders placed against each other on the sides of tooth #5 to guide the handpiece head. A third cylinder was designed for water cooling (this was not used during the procedure because water cooling was administered by the dental assistant). (*C*) The 3D-printed guide.

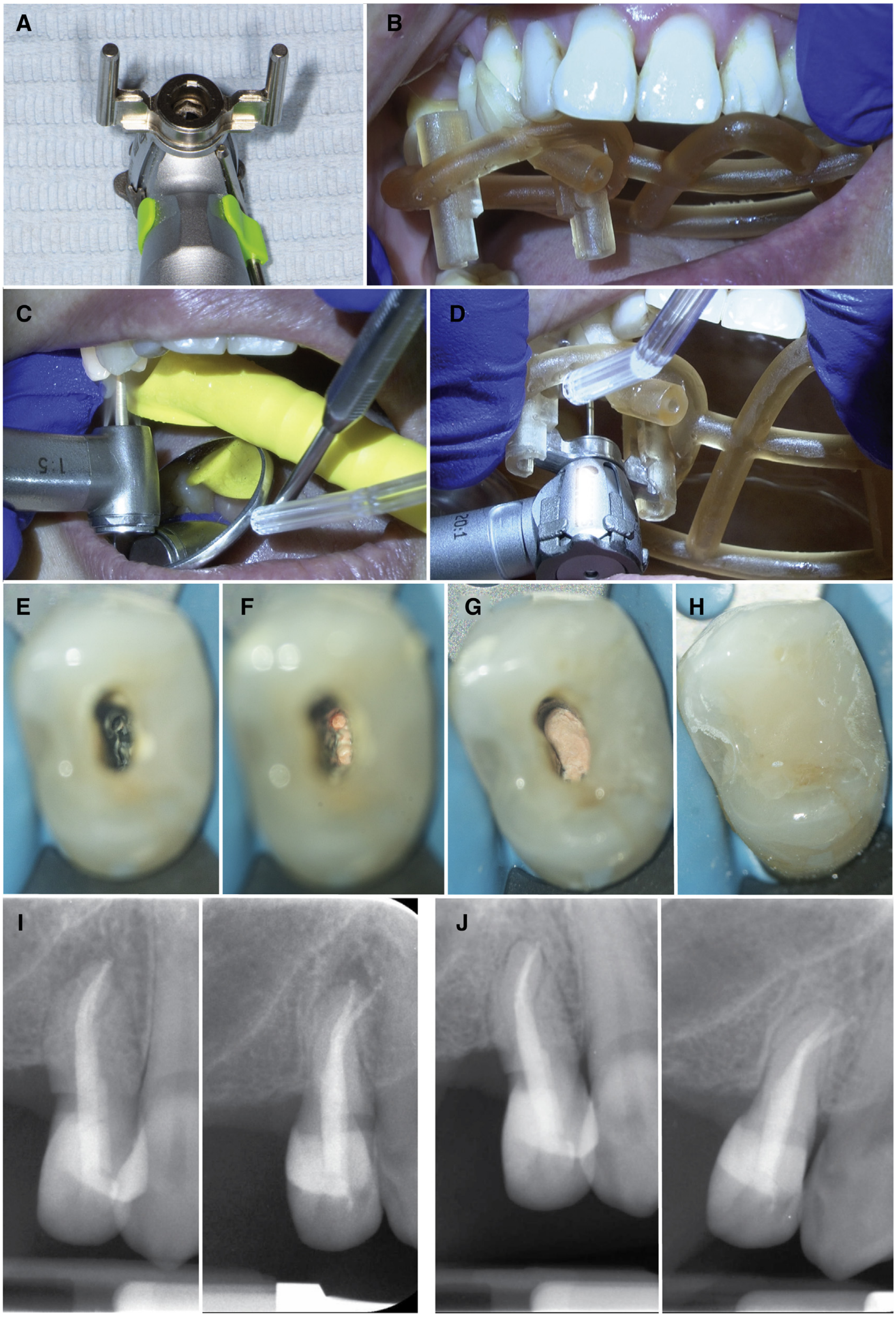

FIGURE 3 – The clinical case. (*A*) The handpiece head with an adapter firmly attached to allow guidance of the handpiece during treatment. (*B*) A frontal clinical photograph showing the fit of the guide in the mouth of the patient. (*C*) Initial drilling on the enamel using (*D*) a diamond bur to allow for the guided access cavity preparation using a Munce bur. When the apical target point was reached, the tooth was immediately isolated, and endodontic treatment was performed. (*E*) Apical division of the canal (coated with cement), (*F*) apical filling of the canals, and (*G*) final gutta-percha filling. (*H*) Composite restauration after polishing. (*I*) A periapical radiograph after treatment and (*J*) 1 year after root canal treatment revealing a completely healed apical area.

0.8 mm when placing 20 implants with this type of guide. These values show a higher precision for implant placement when compared with a sleeve-guided system[36]. Another 2 studies have also reported on successful implant placement using this technique. However, no deviation measurements were performed[26,27]. In the present case report, a minimally invasive access was achieved up to the middle of the root without any considerable deviation, and the canal was found.

This type of guide is designed such that it does not use a sleeve to guide the bur. Instead, it uses (1) guiding rails consisting of 2 cylinders placed against each other on the sides of the tooth to guide the handpiece head. (2) An adapter is firmly attached to the handpiece head. This adapter will fit on the rails and guide the handpiece during treatment. Once the adapter is inserted into the cylinders, the bur can only move through the drilling axis[26]. Additionally (3), a safety stop is added to the guiding rails to prevent the bur from reaching beyond the apical target.

A sleeve (metallic or plastic) has been used to guide the bur in all guided endodontic cases reported in the literature[16]. However, the use of a sleeve presents some intrinsic issues. By using a sleeve, it is necessary to use a dedicated bur, which will fit inside the sleeve and usually has a length of 34–37 mm[16]. Additionally, the sleeve has to be positioned above the tooth to be treated. This sleeve will have a minimum length of 5 mm as has been shown for guided implant placement; a shorter sleeve will present a risk for major deviations[37]. If the sleeve alone will need at least 5 mm of space above the tooth and a special long bur is needed, accessibility in posterior teeth with this technique will be difficult because of the limited space[20,25]. In the present case report, a first upper premolar was treated without difficulty regarding the vertical space available. Because the design allows removal of the sleeve and, consequently, eliminates the need for a dedicated bur, shorter burs can be used in more posterior teeth when space becomes scarcer.

Moreover, a sleeveless guide will eliminate the additional cost of a sleeve and a specially dedicated bur, resulting in a low-cost guide. The adapter for the handpiece will only have to be acquired once and can be reused. sleeveless的优点：费用低；视野好

Visibility is another issue when using a sleeve because it directly blocks the clinician's vision. Furthermore, there is no water cooling. The bur fits snug into the sleeve, and there is no space to cool it properly while working. The open design of the sleeveless guide allows for a direct view of the operation field; the bur is free, and water cooling can be optimal.

Supporting the guide selectively by anchor points reduces the negative consequences that scanning errors may have. Moreover, because of the open design, the clinician can control directly the optimal fit of the guide in the mouth[27,38]. This design represents an advantage to a full-coverage guide. In such cases, a single scanning error or a printing imperfection can result in the instability of the guide[39–41]. Additionally, this design does not allow the control of the fit on the occlusal contacts, and it requires powerful 3D printers to reduce potential printing errors that may affect the final stability of the guide[38].

One drawback when using the current guide is that a full mouth isolation is needed to ensure its stability. Although possible, this could be uncomfortable for some patients. In the present case report, rubber dam isolation was placed after drilling the access cavity. Also, despite the fact that the handpiece is guided by an adapter, some clinical training is recommended, as with any new technique, to avoid errors.

Furthermore, it needs to be acknowledged that extra time is needed for the planning and fabrication of the guide. Although it may seem in the beginning to be time-consuming, chairside operating times and excessive loss of tooth structure are reduced as well as the risk of iatrogenic damage[16].

It should also be noted that guided endodontics is limited to straight canals[19,35]. The drill used is straight and not deformable and should therefore only be used in the straight portion of the canal and not beyond the curvature[21,25]. However, because calcifications would initially begin in the coronal third and extend apically, this technique can be applied in most cases. Yet, in cases in which the curvature would prevent safe access to the target region, apical surgery should be indicated[19,25,42].

Even with the clinical success reported in this case report and the advantages of the current approach to guided endodontics, it should be noted that there are still insufficient data on the accuracy of the present system, except from 1 study on guided implant placement[28]. Further studies are needed to measure the accuracy of the sleeveless guide system.

CONCLUSION

By using a sleeveless 3D-printed guide, a minimally invasive access was achieved up to the middle of the root in a maxillary first upper premolar with PCO and apical periodontitis. This type of guide seems to be a safe and accurate alternative to the conventional guide design for the treatment of PCO in posterior teeth because of the gain in vertical space. Additionally, there is an open view of the tooth that allows for irrigation during drilling, and there is the possibility to use any bur during treatment. Nevertheless, more studies are needed to assess its accuracy.

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The authors deny any conflicts of interest related to this study.

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