CASE REPORT/CLINICAL TECHNIQUES

Limitations and Management of Static-guided Endodontics Failure

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ABSTRACT

Endodontic treatment in severely calcified canals is always a challenging task because it can result in accidents such as deviations or perforations. Recently, guided endodontics has become an alternative approach for pulp canal calcification, facilitating the location of root canals more predictably through the combined use of cone-beam computed tomographic imaging, oral scanning, and endodontic access guides. Although several reports have shown that guided endodontics is safer, faster and can be performed without an operating microscope and by less experienced operators, the technique has limitations, and iatrogenesis may occur. This article describes the limitations of static-guided endodontics and possible causes of failures. In the present case, not fixing the guide to the bone and inaccuracies generated by manually performing mesh merger software led to root perforation. Endodontic microsurgery was effective in resolving this case and should be considered the treatment of choice when guided endodontics cannot be used safely or when it fails. *(J Endod 2022;48:273–279.)*

KEY WORDS

Dental trauma; endodontic microsurgery; endodontics; guided endodontics; pulp canal obliteration

SIGNIFICANCE

Although several reports have shown that guided endodontics is safer, faster and can be performed without the aid of an operating microscope and by less experienced operators, the technique has limitations, and iatrogenesis may occur.

Pulp canal obliteration (PCO), also known as pulp canal calcification or calcific metamorphosis, is associated with dental trauma[1], vital pulp therapy[2], caries and restorations[3], and physiological changes in elderly patients[4,5], causing a significant reduction in root canal space due to the apposition of secondary dentin over time along the canal walls.

Endodontic treatment in severely calcified canals in which the tooth has symptoms or radiographic signs of periapical disease is always challenging, and deviations from the original path should be avoided because they can result in perforations[6,7]. Incomplete instrumentation, bacterial persistence, and debris may result in endodontic failure[8]. According to the American Association of Endodontists, teeth with PCO are considered a high level of difficulty[9].

Nowadays, the use of modern technology, such as magnification and illumination with a dental operating microscope[10], ultrasonic tips[11], cone beam-computed tomographic (CBCT) imaging[12], and guided endodontic access, has increased the precision involved in planning and performing the treatment of calcified canals as well as allowed practitioners to overcome some of these challenges[13].

Guided endodontics is an alternative solution for teeth with the canal partially or entirely obliterated[13,14]. The advantages of 3-dimensional (3D) planning and the creation of guided models for locating the root canal system outweigh the high cost of the technique[15]. Special software (coDiagnostix; Dental Wings Inc, Montreal, Canada) aligned with CBCT and 3D digital scanning facilitates virtual planning to access a cavity in the canal. Subsequently, a 3D model can be produced to guide the drill in the calcified root canal[16].

The virtual planning and guided access procedure for calcified root canals can preserve the dental structure and prevent accidents such as deviations and perforations, leading to an improvement in long-term prognoses[17]. Procedural errors might negatively impact endodontic treatment success and contribute to infections in inaccessible apical areas. In such circumstances, surgical intervention is required[18,19]. The present case report aimed to describe the limitations and management of a static-guided endodontics failure in a severely calcified root canal.

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CASE REPORT

A 38-year-old male patient was referred to a postgraduate educational institution for endodontic treatment of the upper left central incisor. The patient had no history of medication or systemic diseases. It was reported that there was a history of trauma involving tooth 9 a couple of years ago, resulting in a yellowish coloration. A previous attempt to locate the canal by another professional was unsuccessful. Periodontal probing depths were within normal limits. The tooth did not respond to thermal (cold) or electric tests, and both percussion and palpation elicited normal responses. High-resolution CBCT imaging was performed using the following settings: a 0.2-mm voxel size, 14-bit gray scale, 26.9-second x-ray exposure, 120 kV, and 37 mA (iCAT; Imaging Sciences International, Hatfield, PA). CBCT (Fig. 1) and radiographic examination (Fig. 2*C*) revealed severe PCO and a suggestive image of the periapical lesion, confirming the diagnosis of previous initiated therapy with asymptomatic apical periodontitis.

After the treatment planning options were presented and discussed with the patient, guided endodontics was chosen as the most appropriate treatment approach. The patient fully agreed with the proposed treatment and signed the informed consent form.

An intraoral scan was performed, aligned, and processed using software with the CBCT images previously performed (Fig. 1). Two guides were made for endodontic access to the root canal: the first guide was intended for access to the middle-cervical third and the second to the apical third. The tooth presented 23 mm of total length; nevertheless, merely 4 mm of the visible canal was found in the CBCT image. A virtual copy of a drill with a diameter of 1.3 mm and a length of 20 mm (Neodent Drill for Tempimplants, Ref: 103179; JJGC Ind e Comercio de Materiais Dentarios SA, Curitiba, Brazil) was superimposed on the scans in a position that allowed access to the root canal system through the palatal surface of the tooth, as recommended by Tavares et al[13]. The drill position was verified in virtually 3 dimensions in a depth of 19.00 mm. Subsequently, the 3D model was sent to a 3D printer.

An intraoral exam revealed a yellowish appearance previous attempt to access the root canal, and crown inclination toward the buccal surface (Fig. 2*A*, *B*, and *D*). Local anesthesia was achieved with 2% lidocaine with epinephrine 1:100,000 (Nova DFL, Rio de Janeiro, Brazil), and a conventional opening access was initiated with a high-speed spherical diamond burr (1014; Komet, Rock Hill, SC). The adjustment of the guides was verified in the mouth. The drill was attached to an X-Mart Plus endodontic motor (Dentsply Maillefer, Ballaigues, Switzerland) with a torque of 4 N and 950 rpm. Once the first guide was adapted, penetration started with a 1.3-mm drill to the middle third of the root canal under abundant irrigation with saline solution (Fig. 2*E*). Subsequently, the second guide was adapted to finalize access to the apical third. After access to the root canal was reached, a rubber dam was placed, and exploration was performed using a #8 K-file (Dentsply Maillefer).

After reaching the estimated working length, a #15 K-file (Dentsply Maillefer) was introduced into the canal, and the working length was confirmed using the apex locator (Romi Apex A15; Romidan, São Paulo, Brazil). The tooth was instrumented with the Logic NiTi rotary system until size 30.05 (Easy Equipamentos Odontológicas, Belo Horizonte, MG, Brazil) and irrigated with 2.5% sodium hypochlorite and 17% EDTA using a 30-G needle (NaviTip; Ultradent, South Jordan, UT).

During the master gutta-percha radiograph, it was possible to observe a deviation in the path of the canal with consequent perforation in the apical region (Fig. 2*F*). The canal was dried with sterile paper points (Dentsply Maillefer) and filled with gutta-percha (Odous de Deus, Belo Horizonte, MG, Brazil) and bioceramic cement (BioC Sealer; Angelus, Londrina, Panará, Brazil) using the warm vertical condensation technique. The tooth was restored with Filtek Z350 XT (3M Oral Care, St Paul, MN). For all procedures, a range of 3× to 16× magnification was used with a surgical microscope (DF Vasconcelos, Valença, Rio de Janeiro, Brazil). The patient was informed about the root canal deviation. After careful explanation of the possible surgical treatment options, the patient agreed to undergo endodontic microsurgery.

Endodontic Microsurgery

Local anesthesia was achieved using 2% lidocaine with epinephrine 1:100,000 (Nova DFL, Rio de Janeiro, Brazil). A horizontal submarginal incision using a no. 67 microblade (Swann-Morton, Sheffield, England) was performed within the attached gingiva followed by 2 vertical reliefs (Fig. 3*A*), and a full-thickness mucoperiosteal flap was reflected. The osteotomy was performed with a tungsten carbide bur in slow-speed (size 6, Komet) under copious saline solution irrigation. The periapical lesion was completed enucleated (Fig. 3*B*) followed by 3 mm of a root-end resection using an ultrasonic tip (Blade Sonic; Helse Ultrasonic, Ocoee, FL) under copious saline solution irrigation (Fig. 3*C*).

The anatomic canal was located with the aid of a surgical microscope (DF Vasconcelos, Valença, Rio de Janeiro, Brazil) using 16× magnification and a microprobe (Kit Camargo; Millennium, Sao Caetano do Sul, SP, Brazil). Retropreparation was performed with an ultrasonic tip (Dental Trinks, São Paulo, Brazil) under copious saline solution irrigation up to a limit of 3 mm (Fig. 3*D*). Retrofilling was performed with bioceramic cement phosphate-buffered saline (CIMMO, Pouso Alegre, MG, Brazil) (Fig. 3*E*). A heterologous bone graft was performed with lyophilized bovine bone (Lumina Bone; Criteria Biomaterials, São Paulo, SP, Brazil) (Fig. 3*F*). The graft region was covered with a collagen membrane (Lumina Coat, Criteria Biomaterials). The flap was repositioned and sutured with Vicryl 6.0 (Ethicon, Cincinnati, OH). Preoperative and postoperative radiography showed how endodontic microsurgery effectively resolved this case (Fig. 4*A* and *B*).

The patient was reassessed after 7 days for suture removal and later for a 6-month and 2-year follow-up. The patient reported no symptoms or discomfort. The radiographic and CBCT examinations showed complete bone repair (Fig. 4*C* and *D*).

DISCUSSION

It has been reported that guided endodontics is practical and safe, optimizes the time taken to access severely calcified canals, eliminates the need for the operating microscope, and can be performed by less experienced operators[15,17,20]. The guided access procedure and virtual planning can significantly reduce access cavity size, preserve the tooth structure, and avoid accidents such as deviations or perforations[21].

Although the literature shows high levels of success achieved with guided endodontics[10], there is a lack of information regarding safety and limitations. Practitioners must be aware that possible failures may occur, and precautions should be taken to avoid iatrogenesis[22].

Over the last 4 years, our team has gained experience in guided endodontics[13,23,24]; this method can be a general solution for most cases. On the other hand, there are limitations, and in specific circumstances, guided endodontics is not recommended. Patients with a limited mouth opening might have this technique as a counterindication. Patient underuse of aligners can modify the teeth position and make it impossible to use the guide. In those situations, the patient must stop using the aligner after oral scanning and CBCT imaging

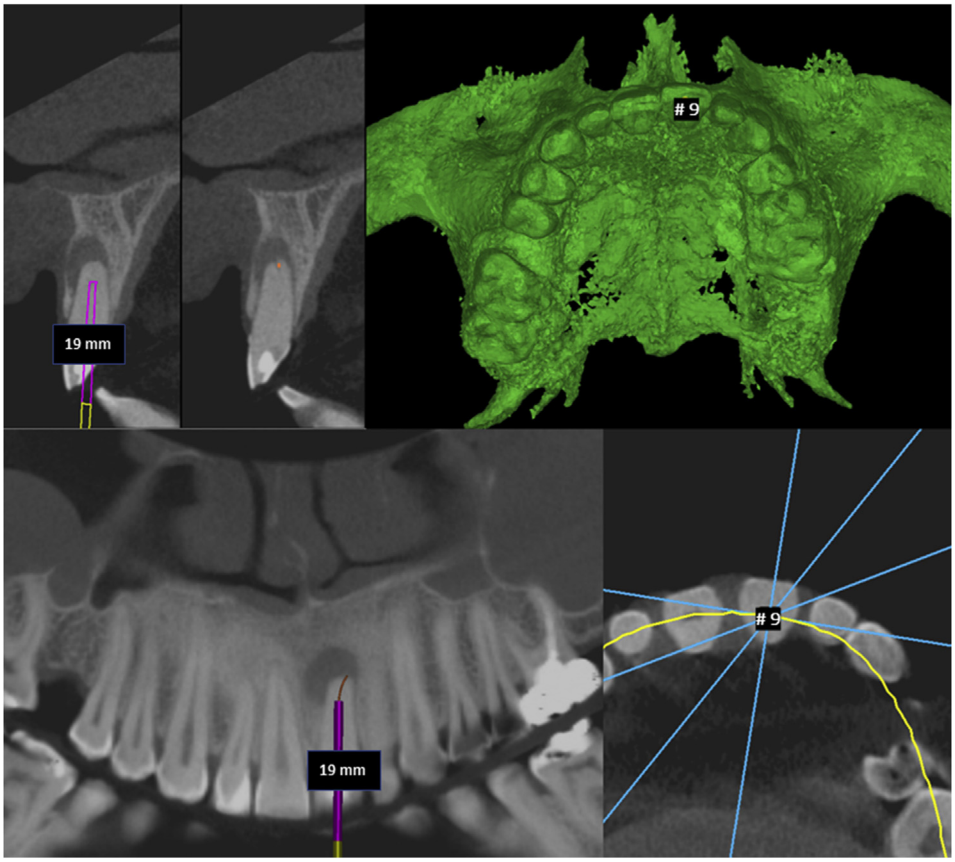

FIGURE 1 – A CBCT image of the upper left central incisor presenting severe PCO associated with a periapical lesion. In the virtual planning of guided endodontics, the drill position was verified in virtually 3 dimensions in a depth of 19.00 mm until the apparent image of the root canal space could be reached.

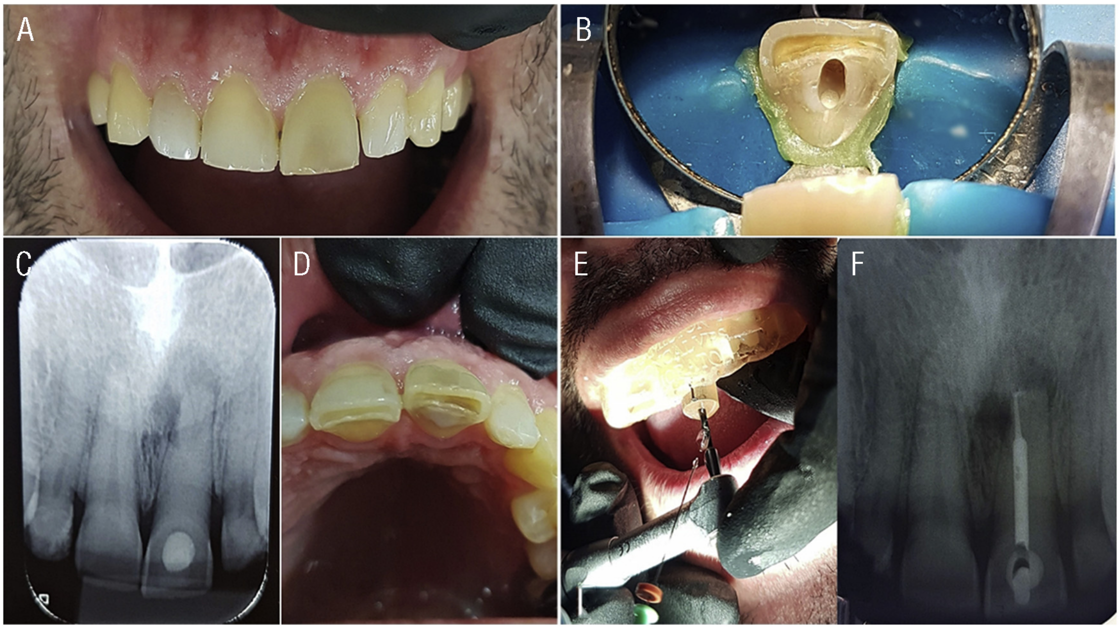

FIGURE 2 – (*A*) The upper left central incisor with a yellowish appearance. (*B*) The palatal view of the previous attempt to access the root canal. (*C*) The preoperative radiograph of tooth 9 showing PCO. (*D*) The palatal view. Note the crown inclination toward the buccal surface. (*E*) Guided endodontics being performed. (*F*) The postoperative radiograph showing root canal deviation and failure of guided endodontic therapy.

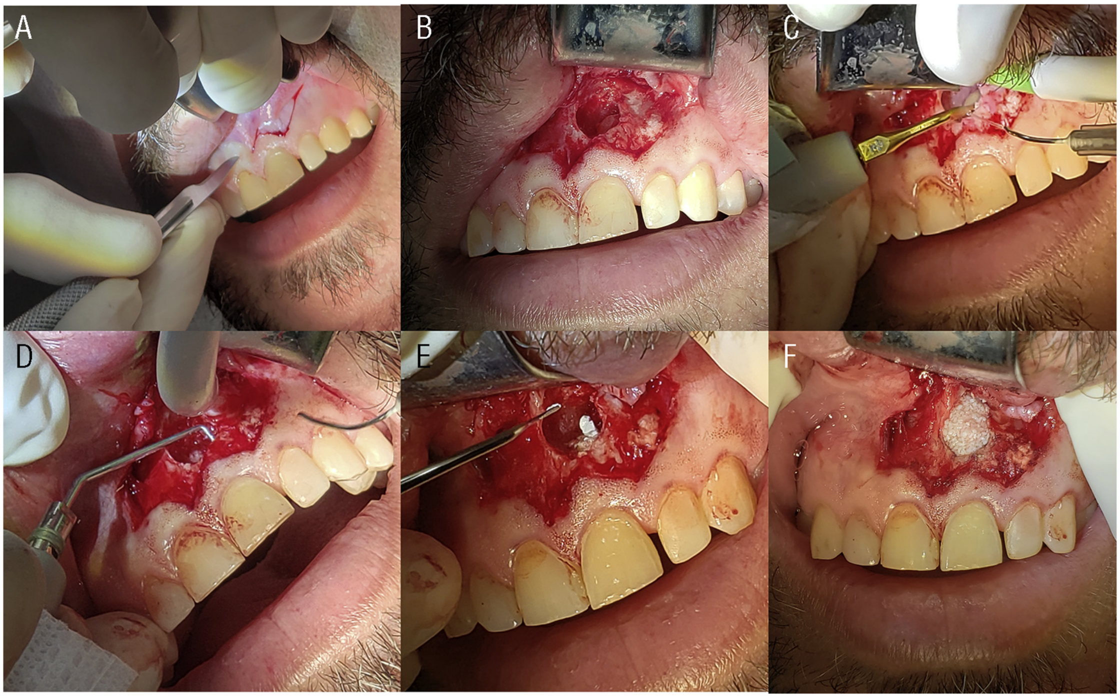

FIGURE 3 – (*A*) A horizontal submarginal incision with the maintenance of the attached gingiva with 2 vertical reliefs. (*B*) A clinical view after osteotomy and enucleation of the periapical lesion. (C) Root-end resection using an ultrasonic tip under copious saline solution irrigation. (*D*) Retropreparation performed with an ultrasonic tip under copious saline solution irrigation. (*E*) Retrofilling was performed with bioceramic cement phosphate-buffered saline. (*F*) The surgical cavity filled with a heterologous bone graft with lyophilized bovine bone.

until guided endodontic treatment is performed. Furthermore, new restorations after treatment planning must be avoided to maintain the original teeth configuration.

The evolution of intraoral scanning has provided benefits because it allows for greater accuracy in the models required for 3D planning[23]. However, the professional must be mindful when performing this step and 3D virtual planning and printing the guide. Any distortion or error in these steps will compromise the results of the technique. Nevertheless, the quality of these steps will be verified in a crucial moment when testing the fit of the prototyped guide in the mouth. If the adaption is not perfect, it is necessary to repeat the planning and printing. A good practice that can be adopted in the design of the guide is to perform windows in the template to permit the visualization of the perfect fit in the teeth and avoid any errors[13].

A well-adapted prototyped guide will fit the teeth very precisely. If a gap is observed between the guide and the teeth, the adaptation was not perfectly executed. Likewise, the guide must not show any tipping movement. Fixing the guide to the bone with the aid of screws can be virtually planned to prevent movement of the guide during access. In the present case, this step was not followed; a lack of complete guide stability and design inaccuracies potentially led to the iatrogenic incident.

A small field of view CBCT scan should be performed according to the correct protocol. Thus, it is essential to move the lip away for an accurate technique of obtaining images. The complete arc must be scanned. In the case of maxillary teeth, the palate must be included in the scan to better match the image meshes with the 3D file of the computed tomographic scan and the guide-making software.

The printing of the guides is also a critical factor. It must be calibrated correctly. It is imperative to use the original and manufacturer-specified entries with regular changes. After the printing process, in the posttreatment of the guide, washing and curing will be performed, which are fundamental for the dimensional stabilization of the guide.

The guide washer, where the drill will be inserted, must have a length of 8 mm for better precision of the drill. Washers with shorter lengths will enable instability of the cutter used. Therefore, when planning the case, the professional must keep in mind that the active part of the instrument must be subtracted from the 8 mm of the washer. If the root canal is not visible up to this length in the CBCT imaging during digital planning, there will be a limitation of the technique. In the present case, the drill used was 20 mm, and the root canal was only observed beyond the 12 mm that provided a safety margin for the procedure.

Regarding the difference in diameter of the drill and the root canal space, the diameter of the drill used in guided endodontics ranges from 0.85–1.3 mm, whereas the diameter of calcified root canals is eventually reduced compared with those of noncalcified teeth[1,25]. This means that the clinician must be aware and cautious when achieving the virtual position of the root canal space; #8 or #10 K-files can be precurved and used to negotiate the patent canal after copious irrigation to remove debris caused by the drill. The use of the operating microscope is crucial to check the cleanliness and locate the canal. If the location of the root canal is unsuccessful, 1 alternative is to take a new CBCT scan to verify its position.

In severe calcifications up to the apical third, as in the present case, it is necessary to plan and print 2 templates. Depending on the software used, the guides are designed differently, which increases the chance of errors. The software with the best mesh matching features uses artificial intelligence technology. However, the software used in the present case, the mesh merger, was still

FIGURE 4 – (*A*) Radiography after guided endodontics. (*B*) Postoperative radiography after endodontic microsurgery. (*C*) The 6-month follow-up. (*D*) CBCT imaging at the 2-year follow-up.

performed manually, which could have compromised the planning and may be the justification for the deviation of the canal.

As demonstrated by Choi et al[26], an accuracy error in the CBCT settings, low-quality images, section thickness >1 mm, and an incorrect threshold value can compromise the guided endodontic planning and lead to deviations.

When a complete absence of root canal space is observed in the CBCT image, the chances of failure rise. Virtually, the professional will plan the position of the burr in contact with the visible lumen of the root canal. In some circumstances, the calcification process is so severe that this may not be easily detectable. In those cases, the operator must avoid inserting the instrument beyond the limits of the 3D planning, and other strategies must be conducted to improve root canal disinfection[24,27,28].

Apical surgery should be considered the treatment of choice in the case of PCO in which a straight line to the patent canal cannot be achieved by the burr with guided endodontics in severely curved canals in order to remove unreachable infected areas and seal the root canal[27,28]. Over the last 20 years, modern endodontic microsurgery has improved the prognosis of complex cases and iatrogenic root perforation[29].

CONCLUSIONS AND CLINICAL IMPLICATIONS

The use of guided endodontics is claimed to be safe, straightforward, time-saving and can be performed without the aid of an operating microscope and by less experienced operators; however, it still presents limitations. The present case report describes the limitations, possible causes, and management of an unsuccessful case of severe obliteration in which guided endodontics was used. Endodontic microsurgery effectively resolved this case and should be considered the treatment of choice when guided endodontics cannot be used safely or fails.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Warley Luciano Fonseca Tavares: Conceptualization, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Natália de Oliveira Murta Pedrosa:** Resources, Writing – original draft, Writing – review & editing, Visualization. **Raphael Alves Moreira:** Validation, Formal analysis, Writing – review & editing, Project administration. **Tiago Braga:** Formal analysis, Data curation, Visualization, Writing – review & editing. **Vinícius de Carvalho Machado:** Software, Data curation. **Antônio Paulino Ribeiro Sobrinho:** Methodology, Formal analysis, Investigation, Resources, Data curation. **Rodrigo Rodrigues Amaral:** Conceptualization, Investigation, Writing – review & editing, Supervision, Project administration.

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

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