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Guided Endodontic Technique in Mandibular Incisors with Pulp Canal Obliteration: A Case Report

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The American Association of Endodontics classifies the management of pulp canal obliteration (PCO) cases as a high-risk difficulty. This classification indicates an increased likelihood of procedural errors. However, advancements in dental technology have simplified the endodontic treatment of calcified teeth. Guided endodontics uses cone-beam computed tomography (CBCT) and a three-dimensional (3D) printer to create a patient-specific guide, enhancing accuracy and predictability in complex cases. A healthy 60-year-old male was referred by a prosthodontist for root canal treatment on teeth #23, #24, and #25. Periapical radiographic examination revealed partial PCO in all teeth. After choosing guided endodontics treatment, CBCT imaging and intraoral 3D scanning were utilized to design a patient-specific endodontic guide. After verifying the stability of the endo-guide, access cavities were prepared using a Munce Discovery bur. Following the negotiation of the canals, the working length was determined. Root canal treatment was performed using rotary files up to size 25/0.04% and sodium hypochlorite irrigation. The obturation was completed using the warm condensation technique. Although PCO was present, no complications occurred during treatment. The teeth remained completely asymptomatic and functional, demonstrating the success of the treatment. Guided endodontics can be a practical and predictable approach for managing PCO in mandibular incisors. This technique provides accurate canal location, reduces procedural errors, and preserves tooth structure. Despite concerns about cost, radiation exposure, and challenges with anatomical variations, it represents a promising advancement in endodontic treatment.

Keywords: Cone-beam Computed Tomography; Dental Pulp Calcification; Endodontics; Minimally Invasive Surgical Procedures; Three-dimensional Printing

Introduction

Anterior mandibular teeth are retained longest, which is essential for treatments like overdenture or removable partial denture [1, 2]. In the case of the need for root canal treatment (RCT) for anterior teeth, the presence of pulp canal obliteration (PCO) makes negotiating and endodontic treatment of these teeth challenging even for experienced practitioners [3-6]. Complications such as perforation, instrument fracture, or treatment failure are prevalent in teeth with PCO [7, 8]. The prevalence of PCO in anterior teeth was reported to be 4.7% [9]. The prevalence of this phenomenon due to dental trauma varies between 16-27% [10]. Patients over 60 years old, because of the aging process and teeth wear, are more susceptible to PCO [9, 11]. Approximately 11% of the patients older than 60 presented with a tooth with PCO [9]. Factors such as trauma, carious lesions, orthodontic forces, and aging may cause PCO [6, 12-14]. The clinical presentation, which involves yellowish discoloration of the tooth with reduced or null responses to pulp vitality tests, makes diagnosis and treatment planning difficult [5].

According to the American Association of Endodontics (AAE), the negotiation of PCO cases is classified as moderate to high-risk [7]. Advances in dental technology have simplified the endodontic treatment of teeth with PCO. Three-dimensional printing revolutionized dentistry by manufacturing accurate and customized dental appliances, such as maxillofacial prostheses, crowns, bridges, aligners, and surgical guides [15]. Guided endodontics is currently an option for the treatment of

Figure 1. *A*) Pre-treatment radiographs of the patient; *B*) Clinical view

calcified canals with higher accuracy [16, 17]. By the combination of cone-beam computed tomography (CBCT) and computer-aided design (CAD), clinicians generate patient-specific guides that allow an accurate drill path through calcified regions [4]. Three dimensional (3D) printed guides enhance the precision of canal location, minimize the risks of procedural errors, and enhance the general success of treatment [18-20]. Recent studies show significant success in managing calcified anterior mandibular incisors with the aid of guided endodontics [3, 5, 21, 22]. However, there is still a need for further clinical studies to evaluate this procedure in various clinical situations. The present case report depicts the management of calcified anterior mandibular teeth using an endo-guide and converting complex cases into a predictable and successful treatment.

Case presentation

A healthy 60-year-old male patient was referred by a prosthodontist for root canal treatment of teeth #23, #24, and #25 to place a fixed prosthesis. The patient reported no pain. Teeth did not respond to the electrical pulp test (EPT; Gentle Pulse, Parkell, New York, USA) and cold (ROEKO Endo-Frost, Coltene, Langenau, Germany) and warm thermal tests. Teeth were not sensitive to percussion and palpation. The probing depths were normal.

After taking a periapical radiograph, the anterior mandibular teeth showed a partial canal obliteration in the coronal third of the root and PDL widening with no apparent periapical lesion (Figure 1). According to the radiographic evidence and clinical tests, pulp necrosis was considered for all teeth. According to the AAE classification of endodontic difficulty, the difficulty level of treating these cases was considered high. Therefore, CBCT was requested to assess the degree of canal calcification, location, and the number of canals [23]. The CBCT image was obtained using ProMax 3D MAX (Planmeca OY, Helsinki, Finland).

Due to the difficulty of the treatment, endo-guide treatment was offered to the patient, and his consent was acquired. Since there was no periapical pathology in the teeth, and the treatment method involved using an endo-guide after obtaining CBCT scans, the prognosis for treatment was deemed favorable despite the presence of PCO in all teeth.

An intra-oral 3D scan was obtained using Omnicam AF (Dentsply-Sirona, York, PA, USA) to design a unique endo-guide. The intraoral scan 3D stereolithography file (STL file) and CBCT file were imported into the dental system version 3 software (3Shape, Copenhagen, Denmark). During the planning phase, a virtual drill that matched with size 1 Munce Discovery bur (CJM Engineering, Santa Barbara, CA, USA) was used to determine the position and direction of the drilling path (designed by Seyed Mahdi Mohammadi). The position of the drill was confirmed in a different plan (Figures 2A-2F). Finally, a 3D guide printed with resin (PowerResins SG, Singapore) was printed using a Sonic 4K 3D Printer (Phrozen Technology, Hsinchu,Taiwan) (Figure 2G).

An alginate impression was taken, and a plaster model was prepared to evaluate the fitting and accuracy of the printed guide. Before the clinical procedure, the guide was tested, and a pilot hole was created using a diamond bur to facilitate drill placement through the guide (Figures 3A, 3B). The teeth were anesthetized with buccal infiltration using 4% Articaine with 1:100,000 Epinephrine (Septodont, Saint Maur des-Fossès Cedex, France). Then, access cavities were prepared with the Munce Discovery bur, and the guide was intermittently removed. After isolation with the rubber dam (Figure 3C), the canals were negotiated with a C-Pilot #10 file (VDW Endodontic Synergy, Munich, Germany). After reaching patency in all canals, the working length was determined using an apex locator (Propex IQ; Dentsply Sirona, Ballaigues, Switzerland) and confirmed with radiography (Figure 3D). The canals were shaped up to size 25/0.04 in the apical region using rotary files (Hero 642; Micro Mega, Besançon, France). Throughout the procedure, the canals were irrigated with 25 mL of 5% sodium hypochlorite [24, 25] (Cerkamed, Stalowa Wola, Poland) and received a final rinse with 3 mL of 17% EDTA (Cerkamed, Stalowa Wola, Poland). The canals were dried with paper points (Meta Dental, Cheoungju City, Korea). Finally, the root canals were obturated with gutta-percha size 25/0.04 (Dentsply Maillefer, Ballaigues, Switzerland) using the warm vertical condensation technique with AH-Plus sealer (Dentsply Maillefer, Ballaigues, Switzerland) (Figure 3E). Coltosol F temporary filling material (Coltene, Altstätten, Switzerland) was placed in the access cavities, and the patient was referred to the prosthodontist for receiving the final restoration.

At the two-year follow-up, radiographic and clinical evaluations indicated that the teeth remained asymptomatic and functional (Figure 3F).

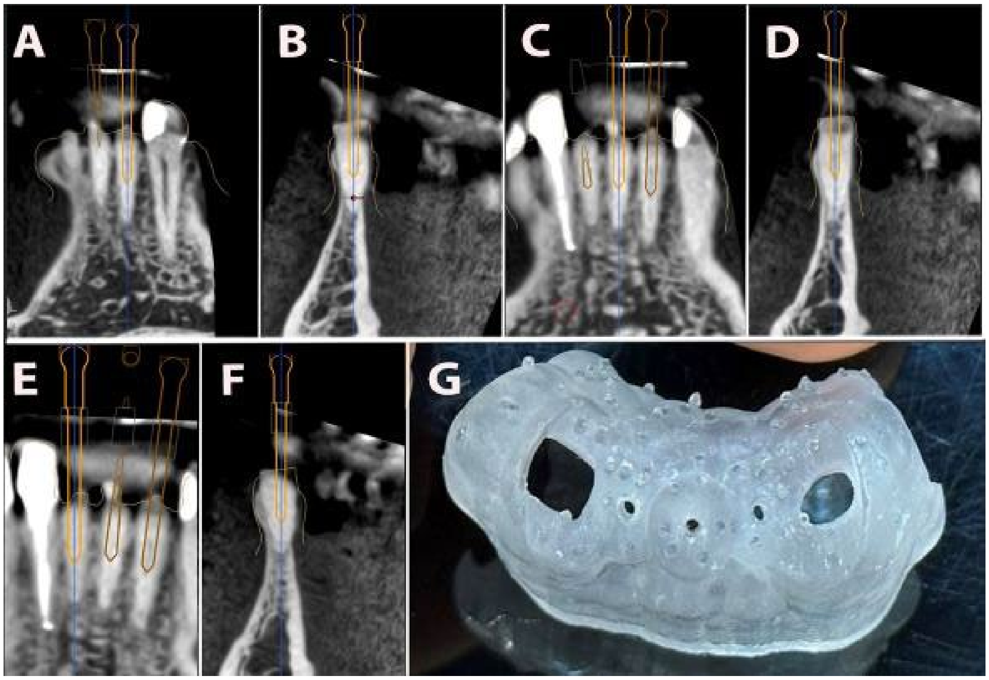

Figure 2. *A-F*) Digital work-flow of preparing the drills' guide; *G*) The printed endo-guide

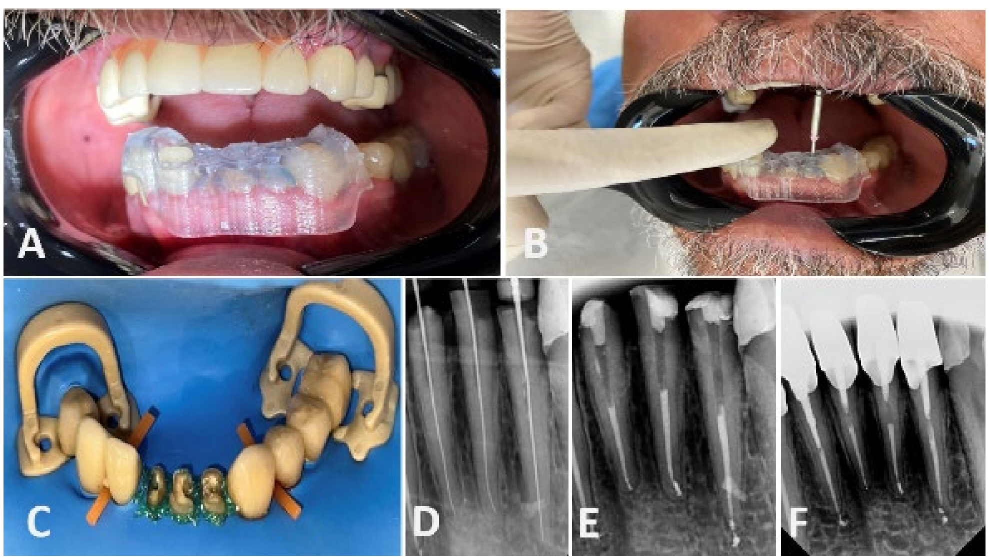

Figure 3. *A*, *B*) Trying the endo-guide fit and preparing the pilot hole; *C*) Isolating the teeth; *D*) Determining the working length; *E*) Final obturation and preparation of the post space; *F*) Periapical radiograph after two-year follow-up: the teeth were asymptomatic

Discussion

This case report demonstrates the procedure for managing calcified anterior mandibular teeth with an endodontic guide. Compared to the conventional method, this method decreases the rate of excessive tooth loss and root fracture, impacts the prognosis of endodontic treatment, and is also not influenced by the experience of the operator [3, 8]. Recent studies have reported an 80% reduction in dental tissue loss, a 48% reduction in treatment duration, and a 100% improvement in canal detection when using guided endodontics over conventional techniques [8]. By incorporating guided endodontics, this case reduced procedural risks, enhanced accuracy, and preserved significantly more tooth structure than conventional methods.

A 3D printed endodontics guide may or may not have a sleeve. Sleeveless guides use guiding rails, which consist of two cylinders positioned adjacent to each other on the sides of the tooth and are used to direct the handpiece head during the procedure [26]. Removing the sleeve reduces the required vertical space, making it suitable for cases with limited mouth openings or posterior regions with restricted interocclusal spaces [27-29]. In this case, sleeves were added to the endodontic guide due to adequate vertical space and vision.

The 3D navigation guide is divided into static and dynamic navigation. Static navigation systems use pre-operative CBCT and optical scans to design a virtual drill path, which is then used to create a template with 3D printing. In contrast, dynamic navigation systems convert the virtual drill path into a real-time drill path using navigation software, providing real-time guidance during the procedure [30]. In this case report static navigation (SN) was used, which reduces the excessive loss of tooth structure and chair-side operating times, but in disadvantages, using SN in posterior teeth requires the fabrication of several templates to allow straight access to individual root canals and also greatly relies on the surgical template's design and manufacturing process [31]. While this case effectively used static guided endodontics, future advancements in dynamic navigation could provide real-time precision, further improving the accuracy and adaptability of guided access techniques in endodontic therapy.

Several software programs are used nowadays for designing and planning static endo-guides. However, in this study, due to the lack of specific software for endodontics, an implant software was used to fabricate a 3D printed guide, similar to many studies [5, 6]. Merging both Standard Tessellation Language (STL) and Digital Imaging and Communications in Medicine (DICOM) files helps improve the guide's accuracy and fitness [32]. Artificial intelligence can be used without radiological-guided surgery software for CBCT augmentation to plan implants in an authentic 3D environment, which may replace conventional software [33]. The accuracy of surgical guides may be influenced by fabrication technology, especially in surface areas contacting the mucosa, axial precision of sleeves' housings, and linear deviations of their center points [34]. Endodontic guides made with additive manufacturing techniques may present volumetric errors due to approximated contours that can result in a loose fit of the guide and teeth. In contrast, milling has shown statistically significantly better accuracy than 3D printing [34, 35].

In the current study, the teeth did not respond to any electric pulp or thermal test, leading to a diagnosis of non-vitality. However, in cases of pulp canal obliteration, traditional pulp sensibility tests, such as EPT and temperature-based methods (cold or heat tests), often provide unreliable results [36]. This is primarily because these tests depend on neural responses, which may be diminished or absent in calcified canals despite the presence of viable pulp tissue. Pulse oximetry (PO) and laser Doppler flowmetry (LDF) are non-invasive techniques used to assess blood flow in microvascular systems. These methods have been utilized to diagnose pulp vitality [37]. Studies revealed greater accuracy of the LDF method in compromised situations, such as incomplete pulp innervations and dental trauma, compared to traditional techniques [37, 38]. Therefore, clinicians should interpret negative responses from sensibility tests in calcified teeth with caution and consider adjunctive diagnostic tools.

The accuracy of a scanner can be influenced by many factors, such as operator experience, type of scanner, scanning pattern, and size of scan [39]. Mangano *et al.* [40] reported a precision of 43.2 µm and a trueness of 38.1 µm for the Omnicam AF scanner in the partial prosthesis scanning.

Since the first case report of guided endodontics by Krastl *et al.* [41], various modifications have been added to endodontic guides, making them applicable in challenging clinical situations. Zargar *et al.* [42] successfully managed a maxillary central incisor with a history of trauma, presenting PCO and rarefaction in the periapical area using an endodontic guide. After 18 months of follow-up, the tooth remained asymptomatic, and the lesion had healed. Santiago *et al.* [43] used an endodontic guide for a patient with limited mouth opening in a mandibular molar presenting calcification. Fixation pins were used to overcome the risk of displacement in the posterior region and improve stability. MahjourianQomi *et al.* [5] effectively managed the mandibular anterior teeth with total PCO using an endo-guide, which was designed and manufactured similarly to what is described in this case report. A 6-month follow-up shows successful treatment outcomes. Ishak *et al.* [4] had to complete the access cavity without using an endo-guide because of calcification in the canal's middle third and the sleeve's limitations that prevented further drilling. Buchgreitz *et al.* [26] have modified a custom-fabricated guide into a composite-based access cavity guide. They have eliminated the metal sleeve and are using an intracoronal guide instead. This innovation overcomes the limitations posed by reduced interocclusal spaces while using an endo-guide in posterior regions. Braga Diniz *et al.* [44] used a method similar to what is described in this case report to manage maxillary incisors with PCO and previous iatrogenic deviation using guided endodontic.

Despite the advantages of using 3D-printed endo-guides and the present case's success, it has some drawbacks, including higher radiation dose and high initial cost due to performing an initial CBCT radiograph. This technique cannot be used in emergencies [21]. Furthermore, it is limited to canals with anatomic variation, like C-shaped canals [45]. Therefore, case selection is crucial to assess the cost-benefit of using endo-guides.

Conclusion

This case report presents the successful management outcome of mandibular incisors with PCO using an endodontic guide technique. With the integration of CBCT imaging, intraoral scanning, and 3D-printed guides, the procedure was accurate, and no complications occurred.

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Conflict of interest
None.

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Authors' contributions
Conceptualization: SN; Methodology: SN/EL; Formal Analysis and Investigation: SN/EL; Writing-Original draft preparation: EL; Writing-review and editing: SN/EL; Supervision: SN. All authors read and approved the final manuscript.

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