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CASE REPORT

Microguided Endodontics: a method to achieve minimally invasive access cavity preparation and root canal location in mandibular incisors using a novel computer-guided technique

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Abstract

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Aim To present a novel miniaturized and minimally invasive treatment approach for root canal localization in mandibular incisors with pulp canal calcification and apical periodontitis.

Summary A 51-year-old male patient presented with pain from his mandibular incisors. The patient had a history of severe dental trauma over 30 years ago. Both mandibular central incisors (teeth 31, 41) were tender to percussion and had a yellowish discoloration. They did not respond to thermal and electrical sensitivity tests. Two periapical radiographs from different projections revealed severe pulp canal calcifications and signs of periapical periodontitis. To facilitate the 'Microguided Endodontics' technique, a CBCT and an intra-oral surface scan were aligned using special software. This allowed the virtual planning of optimal access cavities up to the apical third of the root. In this technique, a 3D-printed template guides a customized drill to the orifice of the root canal. After negotiation of the root canals, conventional root canal treatment was performed. This case report demonstrates that minimally invasive and apically extended access cavities are feasible in mandibular incisors with this technique.

Key learning points

- The 'Microguided Endodontics' technique is a safe and minimally invasive method for root canal location and prevention of technical failures in anterior teeth with pulp canal calcification.

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Introduction

Pulp canal calcification is usually associated with luxation injuries after dental trauma (Andreasen *et al.* 1987, Oginni *et al.* 2009). However, it may also occur as a pulpal response to carious lesions (Sayegh & Reed 1968), coronal restorations (Fleig *et al.* 2017) and after vital pulp therapy procedures (Agamy *et al.* 2004). Additionally, the apposition of secondary dentine over time may also lead to a severe calcification of the root canal system in elderly patients (Johnstone & Parashos 2015, Kiefner *et al.* 2017). Further, pulp canal calcification may arise as an adverse effect of orthodontic forces, which have been shown to interfere with pulpal blood supply (Delivanis & Sauer 1982, Brodin *et al.* 1996).

There is consensus that root canal treatment is only indicated in cases of irreversible pulpitis or apical periodontitis, which are encountered in 1% to 27% of teeth with pulp canal calcification (Holcomb & Gregory 1967, Andreasen 1970, Stalhane & Hedegard 1975, Jacobsen & Kerekes 1977, Andreasen *et al.* 1987, Robertson *et al.* 1996, Oginni *et al.* 2009, McCabe & Dummer 2012). The literature regarding treatment of these teeth is scarce. Searching for calcified root canals is challenging and associated with an increased technical failure rate and a reduced prognosis (Cvek *et al.* 1982, American Association of Endodontists 2006).

Recently, a new method was introduced for treatment of calcified teeth and periapical pathosis called 'Guided Endodontics' (Krastl *et al.* 2016, Zehnder *et al.* 2016). With the help of special software (coDiagnostix™, Dental Wings Inc., Montreal, Canada), alignment with a CBCT and surface scan allows virtual planning of an ideal access cavity. Subsequently, a template can be produced by means of a 3D printer. This template guides a minimally invasive drill to the calcified root canal.

An *ex vivo* study illustrated the high accuracy of this technique (Zehnder *et al.* 2016), which already has been successfully used on patients (Krastl *et al.* 2016). The drills used had a diameter of 1.5 mm and are unsuitable for the treatment of smaller-sized mandibular incisors. Thus, instruments were miniaturized to facilitate Microguided Endodontics in teeth with thin roots, such as mandibular incisors.

The aim of this case report was to describe the preparation of minimally invasive access cavities for root canal localization in mandibular incisors with pulp canal calcification and apical periodontitis using the 'Microguided Endodontics' technique.

Case report

A 51-year-old male patient presented with pain from his mandibular incisors. The patient had a history of a severe dental trauma more than 30 years ago.

Both mandibular central incisors were tender to percussion, had a yellowish discoloration (Fig. 1) and did not respond to thermal and electrical sensitivity tests. Two periapical radiographs at different projections revealed severe pulp canal calcification on both central incisors in contrast to the lateral incisors (Fig. 2). Tooth 41 had radiologic signs of apical periodontitis, whilst the periapical health of tooth 31 was less clear. In accordance with the guidelines of the European Society of Endodontology (2014), a CBCT scan with a limited field of view and high resolution was performed (Accuitomo

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80; J. Morita Mfg. Corp., Irvine, CA, USA) to clarify apical pathosis of tooth 31 and to allow a detailed view of the potentially complex anatomy of both teeth. The CBCT images confirmed the presence of apical periodontitis and severe pulp canal calcification in both teeth (Fig. 3). Root canals were visible 4 mm from the apex. Due to this complex anatomy, it was decided to perform treatment with the 'Guided Endodontics' technique (Zehnder *et al.* 2016) utilizing specially designed miniaturized burs (diameter = 0.85 mm). Therefore, an intra-oral surface scan was performed (iTero, Align Technology Inc., San Jose, CA, USA; Fig. 4). Data from both scans (CBCT and surface scan) were processed with coDiagnostix™ software (Dental Wings Inc., Montreal, Canada), which was designed for guided implantology purposes. After alignment of both scans by the software, a virtual copy of the drill (Gebr. Brasseler GmbH & Co. KG, Lemgo, Germany) was superimposed with its tip touching the visible part of the calcified root

Figure 1 Yellowish discoloration of both mandibular central incisors.

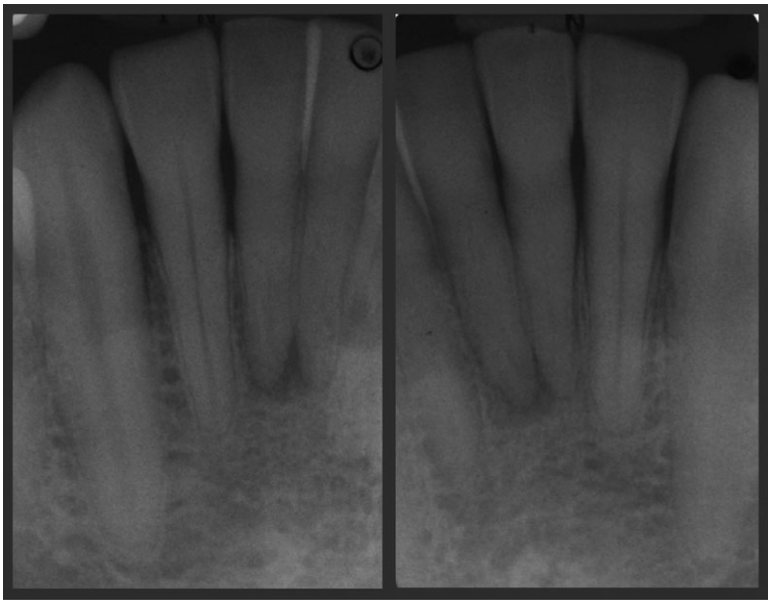

Figure 2 Radiographic images of teeth 31 and 41.

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canals in both teeth (= apical target points) (Fig. 5). The correct position of the virtual drill was checked three dimensionally.

An inbuilt software tool allowed the design of a template needed for guidance of the drill (Fig. 6). The template was exported as a surface-tessellation-language (stl-) file and was produced by a 3D printer (Objet Eden 260 V, Material: MED610, Stratasys Ltd., Minneapolis, MN, USA).

The correct fit of the template with implemented specially made sleeves (steco-system-technik GmbH & Co. KG, Hamburg, Germany) was checked on the patient (Fig. 7). A mark indicating the position of the access point was placed through the template to remove the enamel in a minimally invasive way until dentine was exposed. The rotational speed was set to 10 000 rpm, and the Microguided Endodontics drill was used to gain access to the apical third of the roots by pumping movements (Fig. 8). The apical target points were reached in both teeth when the end of the shaft of the bur touched the sleeves. Preparation of these apically extended access cavities took approximately ten minutes. Figure 9 shows the minimally invasive access cavity. Conventional root canal treatment followed. Root canals were irrigated with 1% sodium hypochlorite and instrumented with a reciprocating file (R25, VDW, Munich, Germany). Passive ultrasonic irrigation was performed, and a calcium hydroxide dressing (Ultracal XS, Ultradent Products Inc, South Jordan, UT, USA) was placed after drying the root canals, followed by a temporary filling (Cavit™, 3 M ESPE). Both teeth had no tenderness to percussion after 2 weeks, and the root filling was performed with vertically condensed gutta-percha and an epoxy sealer (AH Plus, De Trey, Konstanz, Germany).

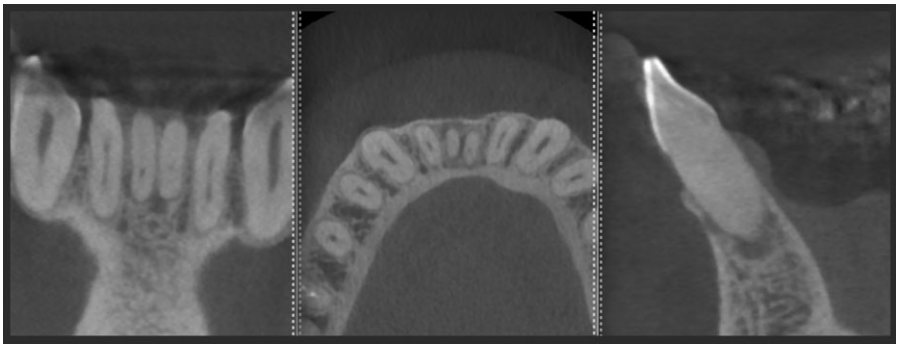

Figure 3 CBCT scan of the mandibular anterior teeth.

Figure 4 Surface tessellation language- (stl-) data of an intra-oral surface scan of the mandibular teeth.

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Figure 10 shows the radiographs taken during root canal treatment. The access cavity was cleaned and filled with a composite resin (Filtek Supreme XTE, 3 M ESPE, Seefeld, Germany) and a multistep bonding agent (Optibond FL, Kerr, Orange, CA, USA).

Discussion

This is the first case report describing the treatment of mandibular incisors with pulp canal calcification and apical periodontitis using the Microguided Endodontics technique.

The technique was successful in both teeth, and it allowed adequate root canal treatment without significant removal of coronal or radicular tooth structure. Conventional root canal treatment would have been associated with a high risk of perforation or at least overpreparation of the thin roots. In this context, it has been demonstrated that any alteration of the natural geometry of the root leads to significant changes in tooth rigidity (Lang *et al.* 2006).

Two *ex vivo* studies have already shown the high success rate of the Guided Endodontics technique with a low deviation of angle (1.59–1.8°) for all 3D-aspects at the tip of the bur (0.12–0.47 mm) (Zehnder *et al.* 2016, Connert *et al.* 2017). The first study was performed on maxillary teeth using a bur of 1.5 mm diameter, which is not

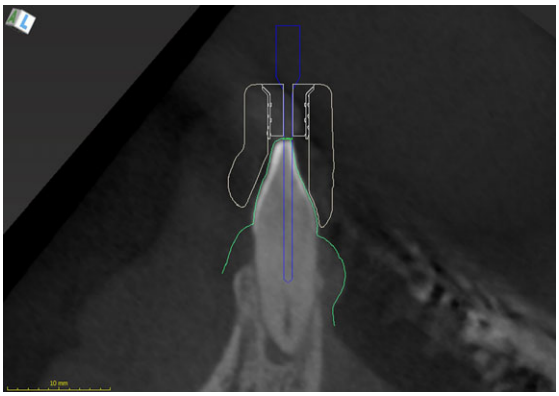

Figure 5 Virtual planning of minimally invasive access cavity. The virtual copy of the drill is placed in such a way that the tip touches the radiographically visible part of the calcified root canal.

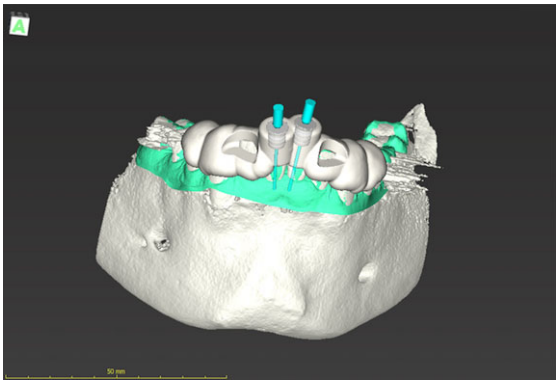

Figure 6 Design of the template for guidance purposes.

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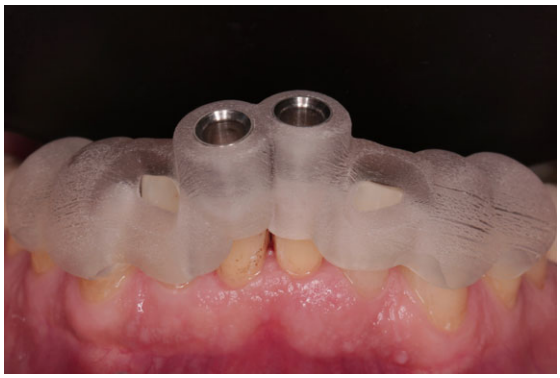

Figure 7 Well-fitting template in the correct position.

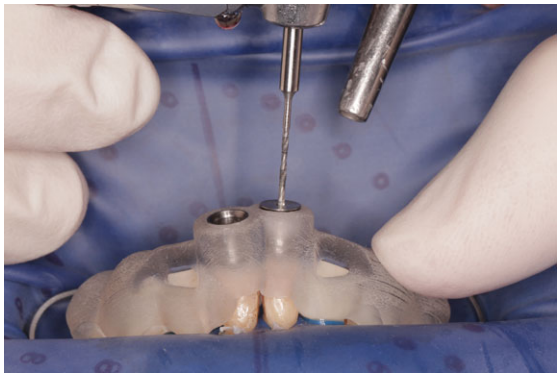

Figure 8 Access is gained to the calcified root canal using the 'Guided Endodontics' technique.

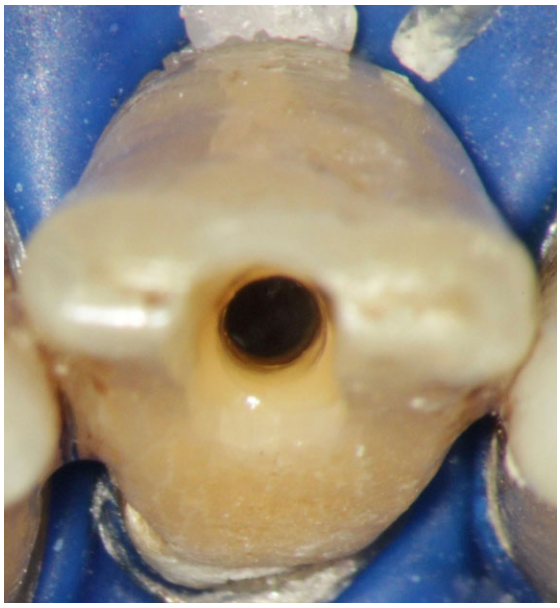

Figure 9 Minimally invasive access cavity possible with this technique.

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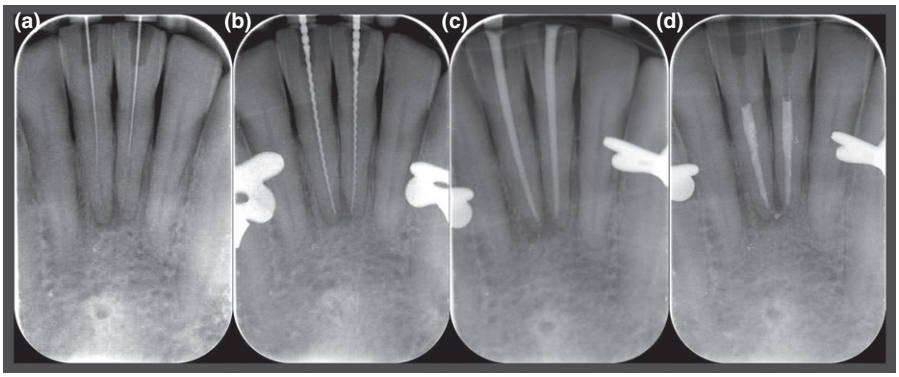

Figure 10 Radiographs taken during root canal treatment. (a) After finalization of Guided Endodontics for orientation purposes, (b) length measurement, (c) masterpoints, (d) final filling with removal of coronal segment of root filling.

suitable for the treatment of mandibular incisors. Therefore, the instruments used were decreased in diameter to 0.85 mm.

Although the planning of Microguided Endodontics seems to be very time-consuming, the chair-time during treatment is minimal. The additional costs for CBCT and the template may be justified by the reduction of the likelihood of iatrogenic errors such as perforation, thereby increasing the chance of tooth retention. The costs for an implant would be higher if conventional treatment with technical failure led to tooth extraction (Zitzmann *et al.* 2009).

There are shortcomings associated with this technique. Due to the space needed for the template and the bur, treatment might not be feasible in the posterior region. Additionally, Microguided Endodontics can only be used for teeth with straight roots or in the straight part of curved roots. Further, the preparation bur may induce microcracks in the dentine. In contrast to post-space preparation, which uses comparable burs and rotational speeds, the contact area with the canal wall is increased because no root canal filling is present. Thus, forces generated, particularly at the tip of the bur, are increased and might lead to crack formation (Capar *et al.* 2015). Likewise, the temperatures generated on the root surface during drilling represent a potential insult to the periodontal ligament and the adjacent bone (Saunders & Saunders 1989). Hussey *et al.* (1997) found a higher increase in temperature when burs with a larger diameter were used. Thus, reducing the diameter of the Microguided Endodontics bur from 1.5 mm to 0.85 mm might have a positive effect in terms of less heat generation on the root surface. Certainly, the long-term clinical effects of guided endodontic procedures on crack formation and temperature increase in the root warrant further investigations.

Another drawback of this technique is the increased radiation dose, which is associated with CBCT. Although a small field of view is sufficient for this purpose and newer CBCT devices can have a radiation dose of only 5 μSv, there is still a large range of radiation dose with different devices (Ludlow *et al.* 2015). Therefore, every CBCT scan has to be carefully justified. In this case with a complex anatomy due to the severe pulp canal calcification, the use of CBCT might be indicated (European Society of Endodontology 2014) regardless of whether a guided or a conventional approach is used for root canal location.

Although conventional treatment is associated with a high failure rate (Cvek *et al.* 1982), a recent study showed that the root canal treatment of teeth with pulp canal calcification is feasible, if it is performed by a specialist in endodontics and with the help of an operating microscope (Kiefner *et al.* 2017). However, there is no information

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regarding the quantitative substance loss of conventional root canal treatment. This aspect needs further investigations for both treatment approaches (conventional and Guided Endodontics).

A considerable technical effort is also needed for Microguided Endodontics, but CBCT and intra-oral scanners are becoming increasingly popular amongst dentists. Due to this rapidly proceeding trend, the combination of these data sets for different reasons, for example implantology, may become standard in the future. Thus, it is likely, that Microguided Endodontics may also be established in clinical practices.

Conclusion

Preparation of minimally invasive access cavities to the apical third of the root in mandibular incisors is feasible with the presented Microguided Endodontics technique using miniaturized instruments.

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Conflict of interest

All authors report grants from Swiss Society for Endodontology during the conduct of the study.

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