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Microguided endodontics: A case report of a maxillary lateral incisor with pulp canal obliteration and apical periodontitis

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Abstract

Aim To describe a minimally invasive method to create a 3D printed guide to gain access to obliterated root canals on the basis of CBCT data.

Summary A 85-year-old female ASA III was referred for root canal treatment of tooth 22. Clinically there were no complains, no percussion pain or sinus tract. Radiologically the tooth had an obliterated canal with an apical radiolucency. The tooth was diagnosed with asymptomatic apical periodontitis. Microguided Endodontic treatment was performed with the help of a 3D printed guide. The root canal was localized initially with the aid of the 3D printed guide using a round carbide bur with a head diameter of 0.8 mm. Then, the canal was shaped and cleaned using mechanical rotary files under copious irrigation with 5% NaOCl, 17% EDTA and passive ultrasonic activation. A completely healed apical area of tooth 22 was visible after 6 months on periapical radiographs and small field of view CBCT.

Key learning points

- Using the Microguided Endodontics concept, a minimal invasive access was achieved up to the middle of the root, in a maxillary lateral incisor with pulp canal obliteration and apical periodontitis.
- This technique is a valuable tool for the negotiation of pulp canal obliteration, reducing chair time and risk of iatrogenic damage to the root.

Introduction

Pulp canal obliteration (PCO) or calcific metamorphosis is a process associated with injury to the pulp and it is characterized by the deposition of hard tissue within the root canal space (Langeland et al. 1971). Clinically, these teeth are associated with a yellow discoloration due to a decrease in tissue transparency (Langeland et al. 1971, West 1997). Moreover, the response to thermal and electric pulp tests can be diminished or even absent, which can hamper diagnosis (Holcomb & Gregory 1967, Oginni et al. 2009).

The PCO process can present as a result of tooth trauma (McCabe & Dummer 2012), caries, tooth surface loss or operative procedures such as pulp capping, pulpotomy and rarely orthodontic treatment (Langeland et al. 1971). On the other hand, in elderly patients, a lifelong apposition of secondary or tertiary dentine, can result in a severe PCO (Kiefner et al. 2017). In such cases, root canal treatment should only be initiated if the tooth has symptoms or radiographic signs of periapical disease (McCabe & Dummer 2012).

During root canal treatment, localizing root canals that have PCO can be a difficult and time-consuming task. Kiefner et. al. (2017) found that the time needed to localize root canals with PCO in elderly patients can range from 15 minutes up to 1 hour. These patients may also have different comorbidities such as Parkinson's disease or chronic back pain (Allen & Whitworth 2004). They often have difficulties or pain, while trying to keep the mouth wide open for a long period of time. They may also complain about discomfort on the dentist's chair due to chronic back pain (Kiefner et al. 2017).

Cone Beam Computed Tomography (CBCT) is a reliable, non-invasive imaging and measuring tool that can depict the tooth in all spatial planes to explore root canal anatomy and can aid on the assessment of PCO (Michetti et al. 2010, Patel et al. 2015). Most often, radiation doses are reasonably low (Pauwels et al. 2012). This may help the clinician to establish a customized strategy to approach the root canal prior to treatment with potential benefit of reducing treatment time.

Another approach for the treatment of PCO is the recently introduced concept of "Guided Endodontics" (Krastl et al. 2016, van der Meer et al. 2016, Connert et al. 2018). In this method, a digital impression of the patient's jaw is taken and registered to the data from the CBCT. Then, a path for the bur is created up to the location of the root canal on the CBCT. Finally, a guide for the bur being used during treatment is designed by means of a Computer Aided Design (CAD) software and printed using a 3D printer. By using a 3D

printed guide, the chances of iatrogenic damage to the root are reduced and the likelihood of finding the root canal is high, while also reducing treatment time (Buchgreitz et al. 2016, Krastl et al. 2016, van der Meer et al. 2016, Zehnder et al. 2016, Connert et al. 2017, 2018).

The aim of this case report was to describe a minimally invasive method to create a 3D printed guide to gain access to obliterated root canals on the basis of CBCT data.

Case report

An 85-year-old female, ASA III, was referred to the Endodontic Department at the University Hospitals of Leuven, KU Leuven, Belgium, for root canal treatment of tooth 22. The patient consulted initially the department of Maxillo-Facial Surgery, from the same hospital, for information on how to replace her missing teeth. A panoramic radiograph was taken upon examination (kVp: 72, mA: 11, using the Dürer VistaPano, Dürer Dental, Bietigheim-Bissingen, Germany) revealing an apical radiolucency on tooth 22 with an obliterated root canal (Fig 1.). Clinically there were no complaints, no percussion pain or sinus tract. The tooth was diagnosed with asymptomatic apical periodontitis. A CBCT was taken, using the NewTom VGi evo (NewTom, Verona, Italy) operating at 110 kVp, 3.0 mA with a FOV of 10 x 10 cm and voxel size 0.2 mm, to assess the tooth's root canal anatomy and for implant planning reasons. The CBCT revealed a calcified root canal up to the apical third of the root and an apical radiolucency of 39.8 mm³, the buccal bone plate was preserved (Fig. 2).

Due to the difficulty and potentially high risk of iatrogenic damage to the root while searching for the root canal, a 3D-printed guide was designed to aid with the access cavity. An alginate impression was taken first to obtain the study model of the patient's maxillary teeth. Then, the plaster cast was scanned with a high resolution optical scanner (Activity 885, SmartOptics, Bochum, Germany) with an accuracy of 4 µm as provided by the manufacturer.

Both image datasets (DICOM images from the CBCT and the scanned images of the plaster cast) were imported into Mimics Medical software 19.0 (Materialise, Leuven, Belgium) and registered initially using point-based registration which was then refined by surface based registration. A path for the bur was created maintaining a straight-line access up to the root canal. Finally, a guide for the bur was designed using 3-matic medical software 11.0 (Materialise) (Fig. 3) and 3D printed in biocompatible material (MED 610) using the Objet Connex 350 3D printer (Stratasys, Eden Prairie, MN, USA). The guide had a cylindrical corridor with a diameter of 1 mm and 7 mm long to guide the bur. Additionally, 2 lines that followed the path of the bur externally were drawn to allow visual guidance during the treatment.

The 3D guide was placed on the teeth and treatment was initiated using a size 1 Muncie Discovery bur (CJM Engineering, Santa Barbara, CA, USA). This bur is a round carbide bur with a head diameter of 0.8 mm and a variable shaft diameter of 0.7 – 1 mm, with a total length of 34 mm. Due to the absence of teeth distally from tooth 22, it was not possible to place dental dam isolation initially without compromising the correct position of the guide.

A small mark was placed through the guide on the tooth surface and a small cavity was drilled on the enamel using a diamond bur allowing the Muncie bur to drill on dentine tissue only. A cavity was then precisely drilled using a Green S-Max M15L handpiece (NSK, Tochigi, Japan) operating at a maximum of 10.000 rpm using a pumping movement. The cavity was rinsed, and the head of the bur was cleaned every 2 mm of progression. When the apical target point was reached, the tooth was examined under the dental microscope. Upon location of the root canal, the tooth was isolated, and root canal treatment performed. ProTaper Next (Dentsply Sirona Endodontics, Ballaigues, Switzerland) files were used to instrument the root canal. ProTaper Next X3 (size 30, .07 taper) was selected as final file, apical patency was controlled during the whole procedure with the help of a size 10 K-File

(Dentsply Sirona Endodontics). During treatment, the root canal was rinsed with 20 mL of 5% NaOCl, then a final irrigation protocol was applied using 17% EDTA and 5% NaOCl in combination with passive ultrasonic irrigation using a size 20 IrriSafe (Satelec Acteon, Mérignac, France). The root canal was then dried using paper points and filled using a vertical condensation technique with warm gutta-percha and an epoxy sealer (TopSeal sealer, Dentsply De Trey, Konstanz, Germany). The access cavity was then filled with composite, the restoration was polished, with occlusion and placement of the removable prosthesis controlled. A periapical radiograph was taken after treatment and the patient was scheduled for recall (Fig. 4).

The patient attended a recall appointment 6 months after root canal treatment. During the appointment, a follow-up periapical radiograph was taken that revealed a completely healed apical area (Fig. 4). A small field of view CBCT (NewTom VGi evo; NewTom, Verona, Italy. Operating at 110 kVp, 3.0 mA, FOV of 5 x 5 cm and voxel size 0.15 mm) was then taken to truly assess the success of the treatment. The CBCT image revealed a completely healed apical area around tooth 22 after 6 months (Fig. 5).

Discussion

In recent times, dentistry has experienced an era of digitalization. From the introduction of digital radiography, to computer-aided implant dentistry, CBCT, CAD/CAM intra-oral scanners and most recently, the introduction of 3D printers specially designed for use in dentistry. The concept of Guided Endodontics is feasible now and is being used increasingly by clinicians. It has been shown that it is a very diverse technique that can be applied successfully for the treatment of PCO (Krastl et al. 2016, van der Meer et al. 2016, Connert et al. 2018, Shi et al. 2018), dens evaginatus (Mena-Alvarez et al. 2017) and even during apicoectomy (Strbac et al. 2017, Ahn et al. 2018).

The concept of guided endodontics was first described by Krastl et al. (2016) who introduced the term “Guided Endodontics” and used it on a clinical case of a maxillary central incisor with PCO and apical periodontitis. Later, van der Meer et al. (2016) used this method for the treatment of maxillary anterior teeth with PCO on three patients.

This is the first case describing a microguided endodontic technique on maxillary incisors. The concept of microguided endodontics was described by Connert et al. (2017a) who used this technique on mandibular central incisors. They used a small diameter bur (0.85 mm) in contrast to the bigger sizes that have been used in the past, ranging from 1 to 1.5 mm (Krastl et al. 2016, van der Meer et al. 2016, Mena-Alvarez et al. 2017) hence the name “microguided endodontics”. In the present case, a small diameter size bur (0.8 mm) was used because of the smaller root size of the lateral incisor, to achieve a minimally invasive treatment while maintaining as much of the root’s rigidity as possible (Lang et al. 2006).

It is important to consider that the longer a tooth remains functional, the greater the risk of negative effects to the pulp tissue such as caries, multiple restoration procedures or prolonged exposure to periodontal pathogens, which can lead to PCO or even pulp necrosis (Kiefner et al. 2017). Likewise, a lifelong apposition of secondary or tertiary dentine, can result in a severe PCO, as shown in the present case (Foreman & Soames 1988).

Root canal treatment of such cases should only be initiated if the tooth presents symptoms or radiographic signs of periapical disease (McCabe & Dummer 2012). This type of treatment is considered as being of high difficulty according to the Endodontic Case Difficulty Assessment Guidelines from the American Association of Endodontist (AAE) (American Association of Endodontists 2005). In such cases, achieving a predictable treatment outcome will be challenging for even the most experienced practitioner. Additionally, the time that it takes for an endodontic specialist with the aim of an operating

microscope to localize obliterated root canals can vary considerably, ranging from 15 min to 1 hour (Kiefner et al. 2017). With the help of a 3D printed guide, it can range from 9 to 208 seconds, as reported by Connert et al. (2017b) in a laboratory study.

A limited field of view CBCT, should be considered as the imaging modality of choice in such cases for intra-appointment identification and localization of calcified root canals, as recommended by the AAE and the AAOMR (American Academy of Oral and Maxillofacial Radiology) (Fayad et al. 2015). In this case, a larger FOV was needed in the beginning of the treatment for implant planning reasons. Additionally, CBCT can also be used to objectively quantify bone healing by measuring the volumetric defect changes over time. This approach is more accurate than the previously used qualitative healing assessments by means of a periapical index (Liang et al. 2011, Patel et al. 2012b, Fernandez et al. 2013, Metska et al. 2013, van der Borden et al. 2013, Liang et al. 2014). Furthermore, CBCT has a greater diagnostic accuracy than periapical radiographs for the detection of periapical lesions when compared to histologic findings (de Paula-Silva et al. 2009). This could be due to the difficulty of detection of apical periodontitis due to anatomical noise or superimposition of cortical bone in the intra-oral image. These limitations could lead to overestimation of the success rate, as stated by several authors (Wu et al. 2009, Patel et al. 2012a, Fernandez et al. 2013, van der Borden et al. 2013). Therefore, after achieving complete healing on the periapical radiograph, a small field of view CBCT was taken to truly assess the healing of the lesion and periapical bone. The follow-up CBCT scan confirmed that the initial lesion of almost 40 mm³ had completely healed in a period of 6 months. However, the absence of signs on intraoral radiographs together with the absence of symptoms should be enough to classify the apical lesion as “healed” or (at least) “healing”.

During the planning of this case, the time used for the design and fabrication of the guide was somewhat long as for any learning phase. However, this was compensated with a significant reduction in treatment time. Additionally, the likelihood of causing iatrogenic damage to the root or excessive loss of tooth structure was also reduced. Furthermore, once a protocol can be established, the planning time can be further reduced. Another advantage was that the use of a guide facilitated localization of the root canal and thus root canal treatment. This due to the possibility to preoperatively visualize the root canal location and design the navigation in detail without having to mentally transfer the planning to the clinical situation (van der Meer et al. 2016). Moreover, due to the use of a guide, the final preparation shape did not exceed the size of the last file used, resulting in a minimally invasive treatment.

One of the limitations of this case was that multiple teeth must be isolated at once to support the guide and ensure its stability. On the present case, there were no teeth available distally from tooth 22, because of that, the access cavity had to be prepared first without rubber dam isolation. This issue should be considered in future designs of the guide. Another disadvantage as mentioned by van der Meer et al. (2016) was that the guide restricted the visualization of the treatment, despite its transparent nature. The intermittent removal of the guide may be needed to ensure that the proper path is still being followed.

A 3D-printed guide without a metal sleeve was used during this case in contrast to other studies (Krastl et al. 2016, van der Meer et al. 2016, Zehnder et al. 2016, Connert et al. 2017, 2018). Instead, the guide had a cylindrical corridor for the bur (1 mm diameter and 7 mm length). However, a slight burn on the plastic corridor after the drilling occurred. This was negligible and did not interfere with the procedure during this case. Nonetheless, placing a metal sleeve for the protection of the plastic guide should be considered in the future.

Additionally, a commercially available bur was used instead of a specially adapted bur (Buchgreitz et al. 2016, Connert et al. 2017, 2018). This bur has a variable shaft diameter which goes from 0.7 to 1 mm at 9 mm length from the head of the bur. This is why two additional lines were drawn externally on the guide to ensure visual guidance during initial drilling. After a couple of millimeters the bur was fully guided by the corridor on the guide.

Conclusion

Using the Microguided Endodontics concept, a minimally invasive access was achieved up to the middle of the root, in a maxillary lateral incisor with pulp canal obliteration and apical periodontitis. This technique may be a valuable tool for the negotiation of pulp canal obliteration, reducing chair time and risk of iatrogenic damage to the root.

Conflict of Interest statement

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Figure Legends

Figure 1 Panoramic radiograph of the patient. Tooth 22 is highlighted. Lower right; a close-up view of tooth 22 which presents a PCO with an apical radiolucency.

Figure 2 (a.) CBCT sagittal views of tooth 22; a root canal with PCO can be seen up to the middle of the root together with an apical radiolucency. (b.) 3D volume rendering and segmentation of the apical radiolucency with a volume of 39.8 mm³.

Figure 3 The DICOM images and the images scanned from the plaster cast are imported into Mimics Medical 19.0 software (Materialise, Leuven, Belgium). (a.) The cast is registered to the maxilla via point-based registration. (b.) A path for the bur is defined. (c.) The 3D guide is design in 3-matic software (version Medical 11.0; Materialise, Leuven, Belgium).

Figure 4 (a, b) Clinical views of tooth 22. (c.) The 3D guide is placed on the teeth and treatment is initiated using size 1 Muncie Discovery bur (Ø 0.8mm). (d.) A cavity is precisely drilled up to halfway of the root length and the root canal is found. (e. – i.) The tooth is then isolated, and the root canal treatment is performed. (j.) Periapical x-ray after treatment and (k.) 6-month control.

Figure 5 (a.) Left: 3D volume rendering and segmentation of the apical radiolucency with a volume of 39.8 mm³. Right: sagittal view of tooth 22. (b.) Left: 3D volume rendering, Right: sagittal view of tooth 22, after 6 months. A completely healed apical area is visible on the CBCT around tooth 22, and a perfect alignment of the root canal preparation trajectory.







