Minimally invasive endodontics using a new single-file rotary system – Part 2

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Introduction

Reduced fracture resistance of root canal treated teeth remains a great concern when evaluating the long-term success of endodontic treatment. In fact, structural integrity is one of the main factors impacting the longevity of endodontically treated teeth (Reeh, Messer and Douglas, 1989). Knowledge of root canal morphology, chemomechanical preparation techniques and cavity designs is also important when evaluating the long-term success of root canal treatment (Mauger, Schindler and Walker, 1998, Willershausen, Kasaj, Röhrig et al., 2008).

Access cavities and canal preparations should promote direct access into the root canal system without compromising the conservation of tooth structure (Willershausen, Kasaj, Röhrig et al., 2008). Pericervical dentine and the structural integrity thereof is described in the literature as a key factor in determining the long-term prognosis of endodontically treated teeth, with specific reference to fracture resistance (Tang, Wu and Smales, 2010). The preservation of hard tissue has been shown to significantly reduce stress concentrations, especially in the cervical region, and to increase the resistance to fracture in endodontically treated teeth (Zhang, Liu, She et al., 2019). The term "pericervical dentine", as described by Clark and Khademi in 2010, refers to the 4mm coronal to the crestal bone and 6mm apical of the crestal bone (Clark and Khademi, 2010). Although the loss of tooth structure is not solely responsible for reduced fracture resistance in endodontically treated teeth, clinicians should adapt a minimally invasive approach when performing endodontic treatment and deciding on a choice of preparation instruments in order to preserve dentine adequately.

This article reviews the use of the TruNatomy system (Dentsply Sirona) in conventional root canal treatment and illustrates the use of the instruments in complex and challenging endodontic cases.

Case Report 1 – Conventional root canal treatment

A main goal of root canal treatment is the elimination of peri-apical inflammation (Berutti, Negro, Lendini et al., 2004). It is well established that ingress of micro-organisms is the cause of pulpal and consequentially periapical disease (Kakehashi, Stanley and Fitzgerald, 1965). Biomechanical cleaning and shaping in order to facilitate irrigation, disinfection and ultimately canal obturation are crucial elements in eliminating apical periodontitis (Berutti, Negro, Lendini et al., 2004).

Preservation of the original canal anatomy and position and size of the apical foramen are also important when performing contemporary root canal treatment (Schilder, 1974). Van der Vyver et al. describe some of the benefits and design features of a novel system, TruNatomy, in a recent paper (Van der Vyver, Vorster and Peters, 2019). The TruNatomy preparation system was designed specifically with

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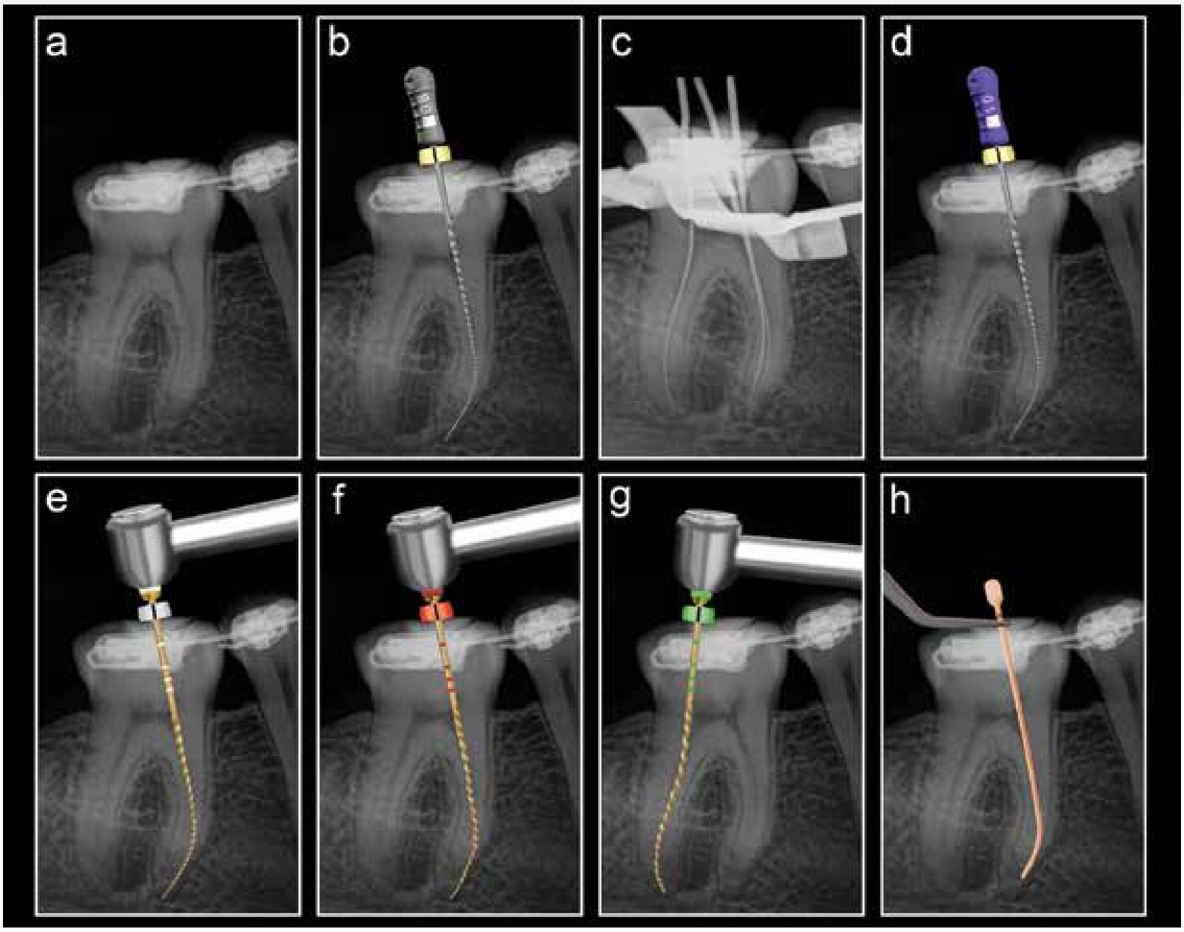

Figure 1. (a) Pre-operative peri-apical radiograph of mandibular first molar; (b) Canals were located and negotiated to patency with a size 08 K-File; (c) Working length was determined with an electronic apex locator and confirmed radiographically; (d) Reproducible micro glide paths were prepared with a 10 K-File; (e) Glide paths were expanded using the TruNatomy Glider; (f) Mesial root canals systems were prepared with a TruNatomy Prime instrument; (g) Distal root canal system was prepared with a TruNatomy Medium instrument; (h) 17% EDTA was activated using the manual dynamic agitation technique with a gutta percha point

dentine preservation and the overall strategy of minimally invasive endodontics in mind.

The patient, a 27-year-old female, reported severe pain on her mandibular first molar after orthodontic treatment (Figure 1a). A diagnosis of irreversible pulpitis with an acute apical periodontitis was made after clinical examination. The tooth was anaesthetised and an access cavity prepared. Three root canal systems were located and the canals negotiated to patency with a size 08 K-File (Figure 1b). Working length was determined with the Propex IQ apex locator (Dentsply Sirona) and confirmed radiographically (Figure 1c). A reproducible micro glide path was prepared with size 08 and 10 K-Files (Figure 1d) and verified before the glide path was expanded using the TruNatomy Glider (Figure 1e). The root canal systems were prepared with the TruNatomy Prime instrument (Figure 1f). It was noted that the Prime instrument passively progressed to full working length in the distal root canal system, and it was decided to complete canal preparation with the TruNatomy Medium instrument (Figure 1g).

The irrigation protocol that the authors recommend is to remove the smear layer with 17% EDTA solution by activating it with either (1) the EDDY irrigating tip driven by a sonic air scaler or (2) using the manual dynamic agitation technique where the tip of a matching gutta percha point is trimmed 1.5mm and pumped 30–40 times up and down in the root canal system (Figure 1h). This is followed with 20–40ml of warmed 3.5% sodium hypochlorite dispensed continuously into the pulp chamber, while activating the solution with the EDDY irrigating tip driven by a sonic air scaler (Figure 1i). A

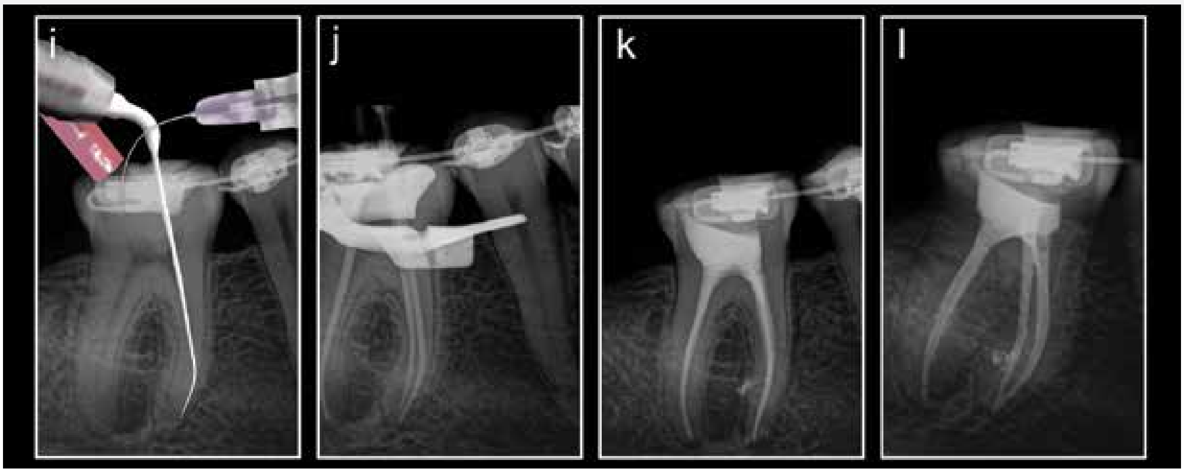

Figure 1. (i) Heated 3.5% sodium hypochlorite was dispensed continuously into the pulp chamber, and activated with the EDDY irrigating tip driven by a sonic air scaler. A suction tip was held next to the tooth to collect the excess spray and overflow from the pulp chamber; (j) Fit of TruNatomy gutta percha points confirmed radiographically; (k) Postoperative peri-apical radiograph after root canal obturation (parallel view). Note the maximum preservation of pericervical dentine; (l) Postoperative peri-apical radiograph after root canal obturation (mesial angulated view). Note the obturation of a midroot lateral canal

suction tip is held next to the tooth to collect the excess spray and overflow from the pulp chamber.

TruNatomy Prime gutta percha points were fitted in the mesial root canals and a TruNatomy Medium cone in the distal root canal, and the fit confirmed radiographically (Figure 1j). The root canal systems were dried with matching TruNatomy paper points. The root canal systems were obturated (Figures 1k and l) with the TruNatomy gutta percha points and Pulp Canal Sealer (Kerr), using warm vertical condensation with the Gutta Smart Obturation System (Dentsply Sirona).

Case Report 2 – Root canal treatment with unusual anatomy (Radix Entomolaris)

The number of roots in the mandibular first molar teeth may vary; Carabelli et al. was the first to report on mandibular first molars with supernumerary roots. The third root was located on the disto-lingual side and was called radix entomolaris (RE) (Carabelli, Carabellivon, Lunkaszprie et al., 1844). In very rare cases, the mandibular first molar can also present with an additional root on the mesio-buccal side, known as radix paramolaris (Calberson, De Moor and Deroose, 2007, Sperber and Moreau, 1998).

The presence of RE in the mandibular first molar is more frequently associated with certain ethnic groups. In populations with Mongoloid traits (for example Chinese, Inuit and Native Americans) the frequency can range from 5–30% (Turner, 1971, Curzon and Curzon, 1971, Yew and Chan, 1993, Reichart and Metah, 1981, Walker, 1985, Curzon, 1973). However, in Eurasian and Indian populations it is less than 5% and in African populations less than 3% (Ferraz and Pécora, 1992). RE can be found on first, second and third mandibular molar teeth, occurring least frequently on second molars (Visser, 1948). Studies have also reported a bilateral occurrence with a frequency of 50–67% (Steelman, 1986).

According to Calberson, De Moor and Deroose (2007) the etiology behind the formation is still unclear, but it could be related to external factors during odontogenesis. Racial genetic factors can also influence profound expression of a particular gene, which can result in the more pronounced phenotypic manifestation.

The coronal third of the disto-lingual root of RE can be fixed partially or completely to the distal root. Based on the curvature in a buccal-lingual orientation, the separate RE variants can be classified into three types according to De Moor, Deroose and Calberson (2004). Type I refers to a straight root/root canal. Type II refers to an initially curved entrance, which continues as a straight root/root canal. Type III refers to an initial curve in the coronal third of the root canal and a second curve beginning in the middle and continuing to the apical third.

The patient, a 45-year-old male, presented with pain and discomfort in his mandibular left first molar, previously restored with a direct pulp-capping procedure and a composite resin restoration. A pre-operative radiograph revealed evidence

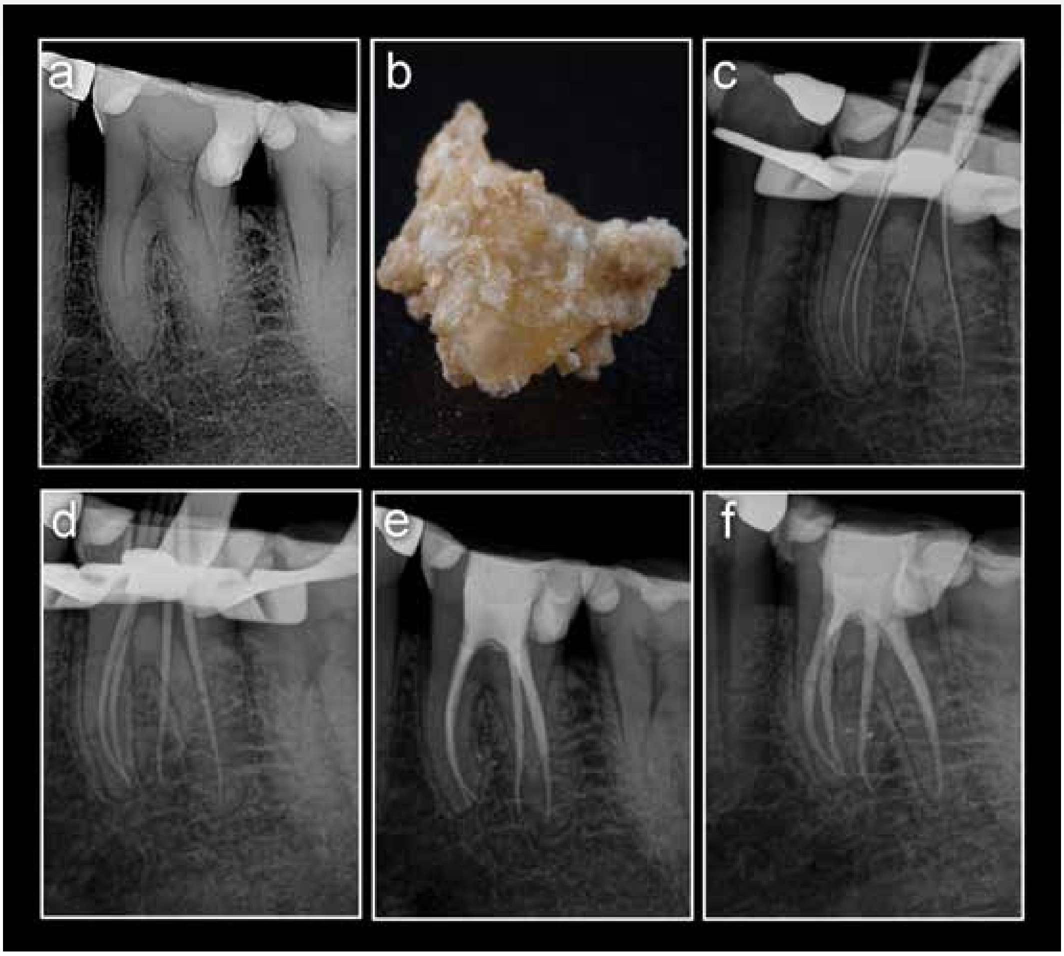

Figure 2. (a) Pre-operative peri-apical radiograph of a mandibular left first molar, previously restored with a direct pulp capping procedure and a composite resin restoration. Note the evidence of a large pulp stone in the pulp chamber as well as unusual root morphology; (b) Large pulp stone removed with a Start-X no. 3 ultrasonic tip; (c) Peri-apical radiograph confirming working length. Note the presence of an additional disto-buccal root; (d) Fit of TruNatomy gutta percha points confirmed radiographically; (e) Postoperative peri-apical radiograph after root canal obturation (parallel view). Note the maximum preservation of pericervical dentine; (f) Postoperative peri-apical radiograph after root canal obturation (mesial angulated view)

of a large pulp stone in the pulp chamber as well as unusual root morphology (Figure 2a). The tooth was accessed and the pulp stone (Figure 2b) removed with a Start-X no. 3 ultrasonic tip (Dentsply Sirona). Four root canal orifices were located and enlarged with the TruNatomy Orifice Modifier (Dentsply Sirona).

The canals were negotiated with size 08 C+ and K-Files to patency and a length determination was made with an electronic apex locator (Propex IQ Apex Locator, Dentsply Sirona) and confirmed radiographically (Figure 2c). The peri-apical radiograph also confirmed the presence of an additional disto-buccal root, and a diagnosis of Radix Entomolaris Type I was made.

Reproducible glide paths were prepared with hand files and the TruNatomy Glider (Dentsply Sirona). Root canal preparation was completed using the TruNatomy Prime instrument.

The root canal systems were irrigated with the modified EDDY technique and dried with paper points. Four Prime TruNatomy gutta percha points were placed and the fit confirmed radiographically (Figure 2d). The canals were obturated using the gutta percha points and Pulp Canal Sealer (Kerr) using the continuous wave of condensation technique with the Gutta Smart Obturation System (Dentsply Sirona). Figures 2e and 2f show the postoperative obturation results.

Management of fractured instruments and canal preparation

A serious clinical complication of endodontic therapy is the fracture of an endodontic instrument. Even with highly skilled operators, the incidence of fracture is about 5% for NiTi instruments (Parashos and Messer, 2006). Leaving the fractured fragment in situ, bypassing the fragment or removing it are the options available to the clinician.

Leaving the fragment in situ involves incorporating the fragment into the final obturation (Saunders, Eleazer, Zhang et al., 2004). This can be risky in cases with apical lesions as the chance of healing may be reduced, (Sjögren, Hägglund, Sundqvist et al., 1990, de Chevigny, Dao, Basrani et al., 2008), but in selected vital cases or cases where chemical disinfection was complete before fracture of the instrument, the prognosis is considered favourable and this treatment option can be considered (Parashos and Messer, 2006, Torabinejad and Lemon, 2002).

Bypassing the instrument with small hand files between the fragment and the root canal is another option. Although it is a time-consuming and labour-intensive exercise, full working length negotiation can be achieved. The fragment is left in situ to form an integrated part of the final obturation (Saunders, Eleazer, Zhang et al., 2004).

The last option is to remove the fractured fragment. This procedure can be a very challenging exercise (Frota, Aguiar, Aragão et al., 2016) and proper vision, illumination and magnification play a crucial role (Gencoglu and Helvacioglu, 2009). According to Hulsmann (1994) there is no standard method for removing fractured instruments and a number of approaches can be followed.

Case Report 3 – Bypass of a fractured instrument

A 45-year-old female presented with a fractured file in the mesio-buccal root canal of her mandibular right second molar (Figure 3a). It was a fragment of approximately 7mm, located in the apical third of the root canal system. After an unsuccessful attempt by her general dentist to remove the fractured instrument with ultrasonic instruments, she was referred for further management.

At the time of treatment it was decided to attempt to bypass the file for the following reasons: (1) examination of a CBCT scan revealed that the fragment was located beyond the maximum curvature of the root canal system; (2) under high microscope magnification the coronal aspect of the fractured fragment was not visible even after coronal enlargement of the root canal system by her general dentist.

A size 08 C+ and 08 K-File were precurved and used alternately to bypass the fractured fragment (Figure 3b). The new glide path next to the fractured instrument was carefully enlarged with a size 10 K-File, followed by a size 12 Profinder (Dentsply Sirona) and a ProGlider (Dentsply Sirona) rotary glide path instrument used in a manual motion.

Canal preparation was completed with the TruNatomy Prime file in the mesial root canal systems and the TruNatomy Medium file in the distal root canal system. The fit of two Prime and one Medium TruNatomy gutta percha cones was verified radiographically (Figure 3c) before the canals were obturated with AH Plus root canal cement (Dentsply Sirona) using the Gutta Smart Obturation System (Dentsply Sirona) (Figure 3d).

Case Report 4 – Removal of a fractured instrument

A 58-year-old male presented with a history of a fractured instrument in the mesio-buccal root canal of his mandibular left first molar. A peri-apical radiograph confirmed a fractured

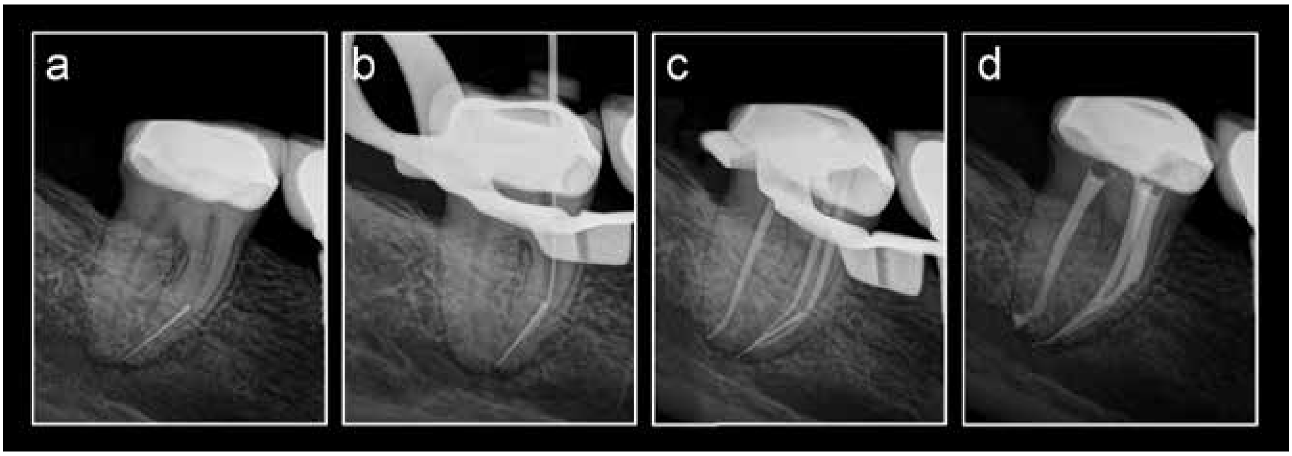

Figure 3 (a) Pre-operative peri-apical radiograph of a mandibular right second molar with a fractured instrument in the mesio-buccal root canal system; (b) Fractured file bypassed with a size 08 K-File; (c) TruNatomy Prime gutta percha points fitted after preparation with the TruNatomy Prime and Medium files; (d) Postoperative peri-apical radiograph after obturation file located in the midroot region (Figure 4a). A sagittal view of a CBCT confirmed the location, but demonstrated that the fragment was located at the point of maximum curvature of the root canal system (Figure 4b). The mesio-lingual and mesio- and disto-buccal root canal systems were patent and could be negotiated to full working length (Figure 4c). It was decided to use the EndoCowboy (Köhrer Medical Engineering) (Figure 4d) to attempt removal of the fractured instrument.

Figure 4e depicts the coronal aspect of fractured fragment in the mesio-buccal root canal system under 12X magnification. A size 15 Endosonare file (Dentsply Sirona) mounted on a U-File holder (Endo Kit E12, NSK) driven

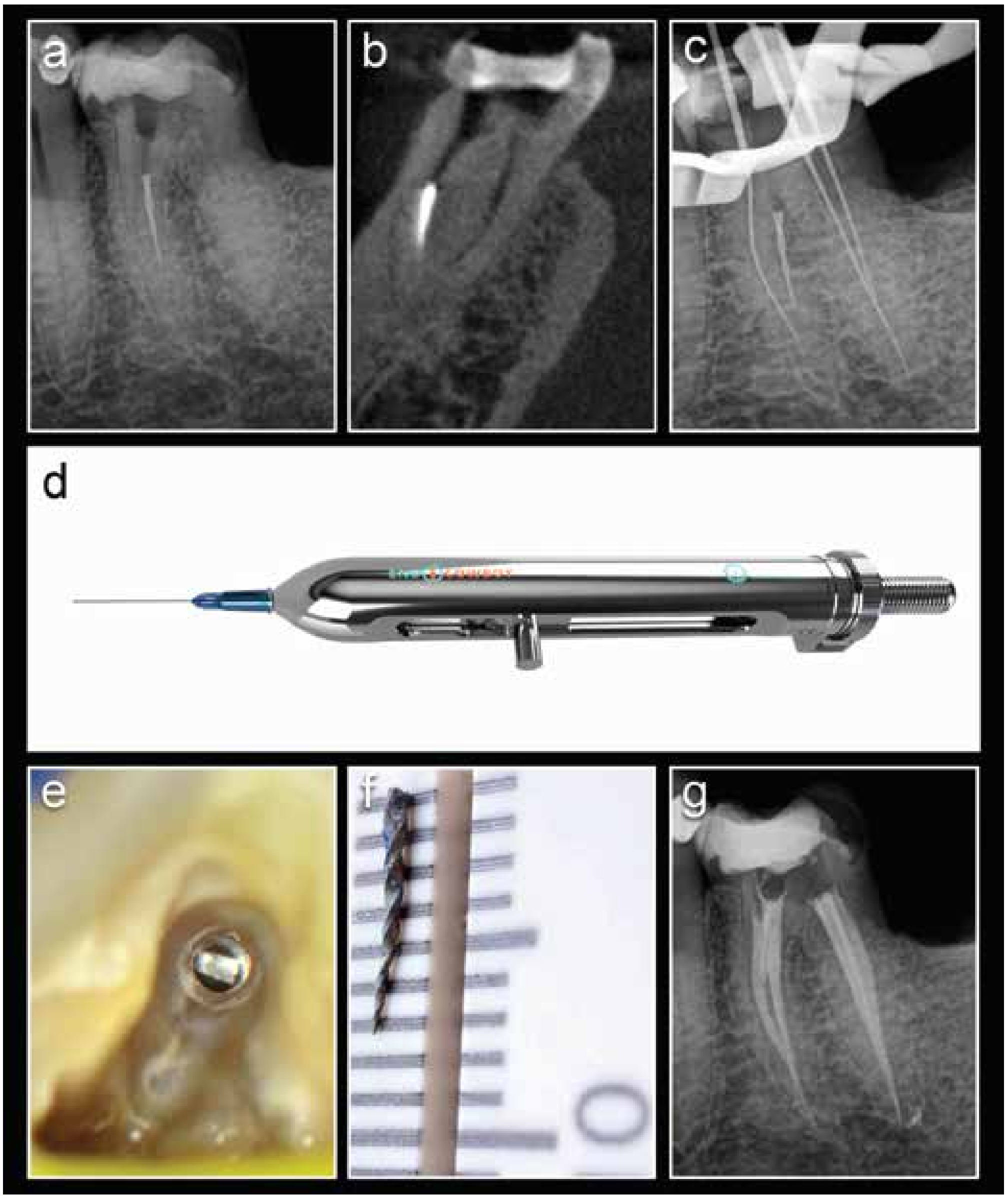

Figure 4: (a) Peri-apical radiograph showing a fractured instrument in the midroot area of the mesio-buccal root canal of a mandibular left first molar; (b) Sagittal view of a CBCT confirmed that the fragment was located at the point of maximum curvature of the root canal system; (c) Length determination peri-apical radiograph confirming that the mesio-lingual and mesio- and disto-buccal root canal systems were patent and could be negotiated to full working length; (d) EndoCowboy (Köhrer Medical Engineering), preloaded with the standard 0.12mm wire in a 0.5mm cannula; (e) Coronal aspect of the fractured fragment in the mesio-buccal root canal system under 12X magnification; (f) Extracted fractured fragment measuring 6mm on a ruler; (g) Postoperative peri-apical radiograph after root canal preparation and obturation of all the root canal systems

by a Satelec P-5 ultrasonic scaler (Satelec) was used to trough around and to expose the coronal aspect of the fragment. The EndoCowboy, preloaded with the standard 0.12mm wire in a 0.5mm cannula, was introduced into the root canal, the preformed lasso was positioned around the separated instrument, the lasso closed and the fractured fragment (Figure 3f) extracted from the root canal using a pulling action. Figure 3g shows the final obturation result after treatment of all the root canal systems.

Case Report 5 – Orthograde endodontic retreatment

Orthograde endodontic retreatment of previously treated teeth is a fairly common clinical procedure and is usually attempted before surgical endondontics, especially in teeth restored without posts (Gorni and Gagliani, 2004).
Salehrabi and Rotstein (2010) evaluated the outcome of orthograde endodontic retreatment of 4744 teeth over a period of five years. The results of the study indicated that 89% of the teeth were retained in the oral cavity five years after endodontic retreatment; only 4% of the teeth required apical surgery within two years of completion of the orthograde retreatment, and only 11% of the teeth were extracted over the five-year period.

The patient, a 49-year-old female, presented with discomfort in her maxillary left first molar, which had previously had root canal treatment. Radiographic examination revealed that all three obturated root canal systems was treated short of full working length (Figure 5a). After access cavity preparation, the previous gutta percha was removed from the canals using Endosolv E (Septodont) and a size 15 Hedstrom file. Under magnification, a second mesio-buccal root canal system was detected before all the root canal systems were negotiated to full working length using size 08 C+ and K-Files (Figure 5b). Reproducible micro glide paths were established using a size 10 K-File and enlarged with a TruNatomy Glider (Dentsply Sirona). The root canal systems were prepared to working length with the TruNatomy Prime file followed by the TruNatomy Medium file. TruNatomy medium gutta percha points were placed and the fit confirmed radiographically (Figure c). Figure 5d depicts the final result after obturation.

Case Report 6 – S-shaped root canals

The extent of root canal curvature is one of the most important variables that determine the difficulty of root canal shaping procedures. The curvature in the root canals varies depending on the location or severity; it may be apical or gradual or S-shaped (Ruddle, 2001). In clinical conditions, when two curves are present in the same root canal trajectory, this is called an "S-shaped" canal (Machado, Chaniottis, Vera et al., 2014). S-shaped canals are found most often in maxillary lateral incisors, maxillary canines, maxillary second premolars and mandibular second molars (Gutmann and Lovdahl, 2010, Michetti, Maret, Mallet et al., 2010).

These S-shaped root canal systems often pose clinical challenges during root canal instrumentation, disinfection and obturation (Sakkir,Thaha,Nair et al., 2014). Common causes of failure in these canal systems are primarily related to procedural errors such as ledges, fractured instruments,

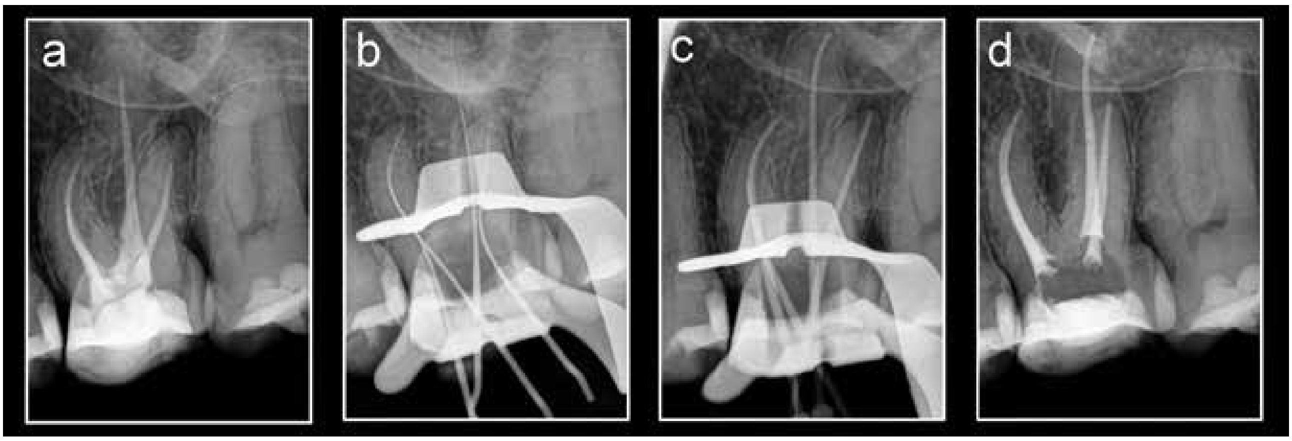

Figure 5. (a) Preoperative peri-apical radiograph of maxillary left first molar with previous root canal treatment. Note that all three obturated root canal systems were treated short of full working length; (b) Length determination peri-apical radiograph; (C) Conefit peri-apical radiograph; (d) Postoperative peri-apical radiograph after obturation

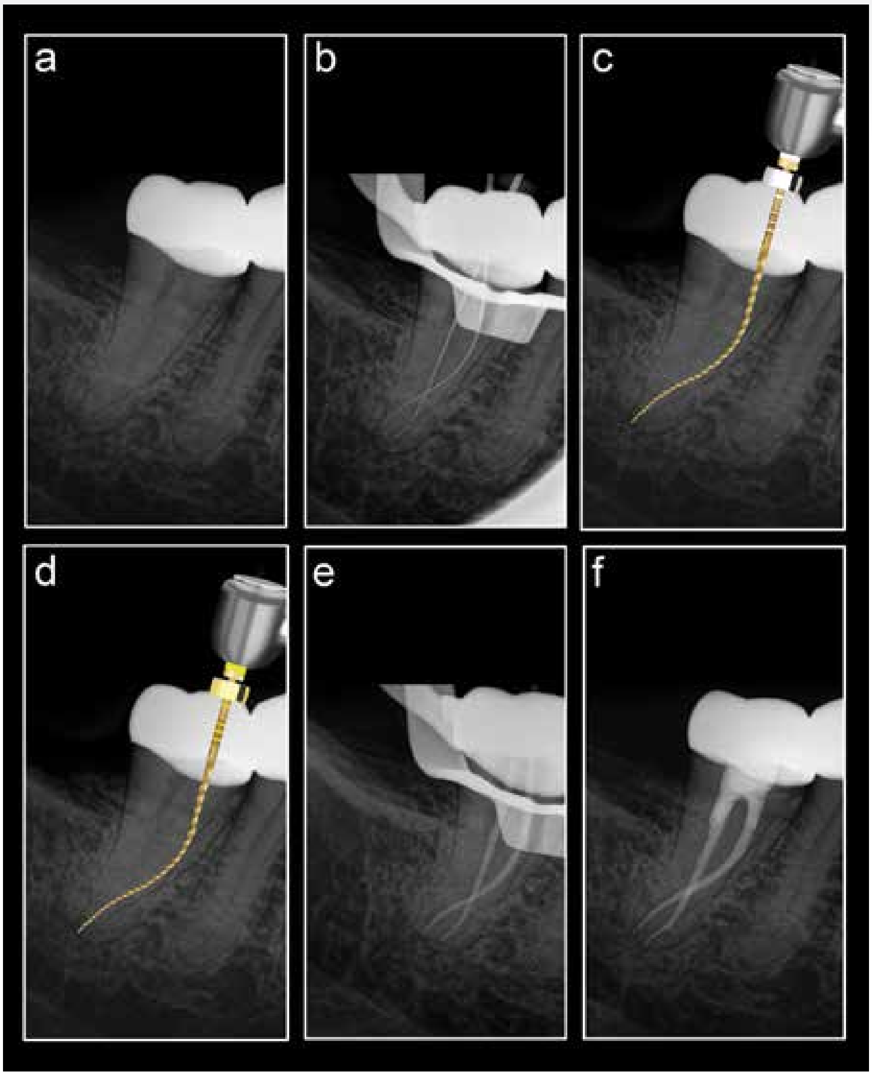

Figure 6. (a) Pre-operative peri-apical radiograph of non-vital mandibular right second molar; (b) Length determination peri-apical radiograph; (C) Glide path enlargement with the TruNatomy Glider; (d) Root canal preparation with the TruNatomy Small file; (e) Conefit peri-apical radiograph; (d) Postoperative peri-apical radiograph after obturation

canal blockages and canal transportation (Hamasha,Al-Khateeb and Darwazeh, 2002). Root canal preparation of S-shaped canal systems depends on the flexibility of the instruments, the technique of biomechanical preparation, the location of the apical foramen and the presence of calcification in the root canal system (Ye and Gao, 2012). In general, problems can occur primarily in four distinct anatomical situations during root canal preparation with rotary instruments: i) canals that join as they traverse from the orifice to the apical foramen; ii) S-shaped canals; iii) canals with abrupt deviations coronally, usually 2–4mm below the canal orifice; iv) canals with sudden deviations, usually 90 degrees or more in the apical one-third of the root (Gutmann and Lovdahl, 2010).

The patient, a 58-year-old female, presented with a symptomatic non-vital mandibular second molar (Figure 6a). The patient reported that the tooth had been crowned approximately two years before but had never felt comfortable. After access cavity preparation and examination of a pre-operative CBCT scan, only two root canal systems were located. It was very difficult to negotiate the S-shaped canals with pre-curved size 08 C+ and K-Files and it took several attempts to achieve patency and to determine working length (Figure 6b). A

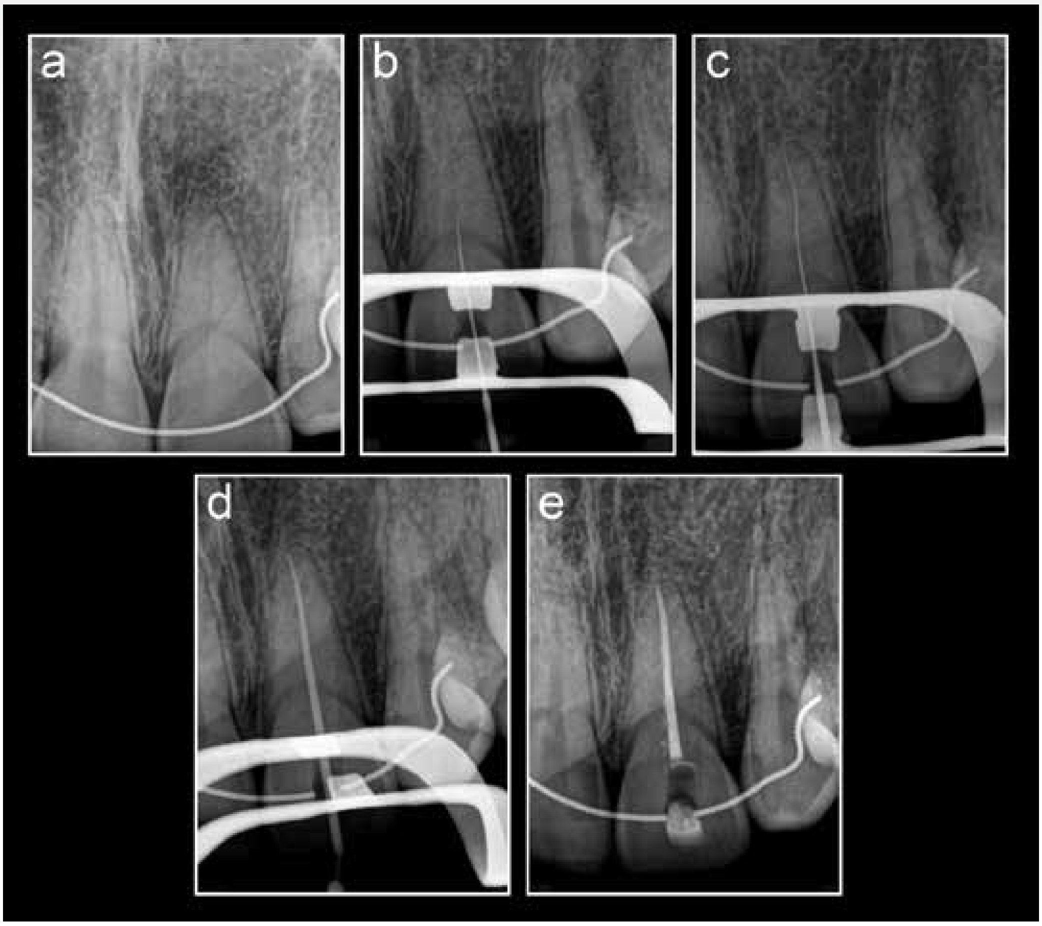

Figure 7. (a) Pre-operative peri-apical radiograph of maxillary left central incisor with obliterated root canal system; (b) Coronal aspect of the root canal negotiated with a 08 C+ File; (c) Length determination peri-apical radiograph; (d) Conefit peri-apical radiograph confirming the fit of a TruNatomy Prime gutta percha point; (e) Postoperative peri-apical radiograph after root canal obturation

reproducible micro glide path was prepared in both root canal systems using a size 10 K-File before the glide paths were carefully enlarged with a TruNatomy Glider (Dentsply Sirona) (Figure 6c). Several cutting cycles were made with the TruNatomy Glider, followed by irrigation, recapitulation and re-irrigation before the TruNatomy glider reached full working length. Taking into account the difficulty of canal negotiation, glide path preparation and the S-shape of the root canals, it was decided to only enlarge the root canal systems with the TruNatomy Small file (Figure 6d). After irrigation, TruNatomy Small gutta percha points were placed and the fit confirmed radiographically (Figure 6e). Figure 6f depicts the final result after obturation using the Gutta Smart Obturation Sytem (Dentsply Sirona) to perform warm vertical condensation.

Case Report 7 – Calcific Metamorphosis

Calcific metamorphosis (CM) or pulp canal obliteration (Andreasen, Andreasen and Andersson, 2013) is a common occurrence following concussion and subluxation injuries (Oginni, Adekoya-Sofowora and Kolawole, 2009). Although the exact mechanism by which the canal is obliterated is unknown, it is believed to be related to neurovascular damage and deposition of hard tissue within the canal (Yaacob and Hamid, 1985, Robertson, 1998). This calcification of the pulp canal space results in a loss of translucency and leaves the crown with a yellow discolouration (Patterson and Mitchell, 1965). CM can be clinically detected as early as three months after injury, but in most cases remains undetected for up to a year after trauma (Andreasen, 1970, Rock and Grundy, 1981, Torneck, 1990).

Most teeth showing canal obliteration are asymptomatic (McCabe and Dummer, 2012, Robertson et al., 1996, Oginni, Adekoya-Sofowora and Kolawole, 2009) including the absence of sensitivity to percussion (Malhotra and Mala, 2013). CM is therefore often an incidental finding during clinical or radiographic investigations (Oginni, Adekoya-Sofowora and Kolawole, 2009, McCabe and Dummer, 2012). Asymptomatic teeth presenting with CM do not initially require treatment other than annual follow-ups (McCabe and Dummer, 2012, Oginni, Adekoya-Sofowora and Kolawole, 2009), but the pulp status within partially obliterated canals may eventually lead to apical pathology requiring treatment (Malhotra and Mala, 2013, de Cleen, 2002, Feiglin, 1996, Gopikrishna, Parameswaran and Kandaswamy, 2004, Amir, Gutmann and E Witherspoon, 2001).

The absence of a root canal on conventional radiographs does not necessarily mean the total absence of a canal (McCabe and Dummer, 2012, Patterson and Mitchell, 1965, Schindler and Gullickson, 1988, Torneck, 1990). Histologic evaluation of pulp canals, radiographically diagnosed as being obliterated, almost always confirms the existence of a narrow pulp canal with pulpal tissue (Feiglin, 1996, Abbott and Yu, 2007, Amir, Gutmann and Witherspoon, 2001, Malhotra and Mala, 2013). "Canal mineralisation" has therefore been suggested as a more accurate term than canal obliteration (Malhotra and Mala, 2013, Abbott and Yu, 2007, Levin, Law, Holland et al., 2009).

The patient, a 27-year-old female, presented with percussion sensitivity on her maxillary left central incisor. A peri-apical radiograph and CBCT scan revealed that the canal was almost completely obliterated. After access cavity preparation, the darker dentine discoloration of the pulp floor was followed with small long-shank burrs (Dentsply Sirona) and a Start.X no. 3 ultrasonic tip (Dentsply Sirona) until a very calcified canal orifice was located. The coronal aspect of the canal was negotiated with a 08 C+ File followed by a 08 K-File. This sequence was repeated until canal patency and full working length were achieved. A size 10 K-File was used to create a reproducible micro glide path before the macro glide path was completed using the TruNatomy Glider in 8–12 back-stroke brushing motions. Canal preparation was done with the TruNatomy Prime file followed by canal irrigation with EDTA and sodium hypochlorite. The root canal system was obturated with a TruNatomy Prime gutta percha point (Dentsply Sirona), AH Plus Root Canal Sealer (Dentsply Sirona) and the Gutta Smart Obturation System (Dentsply Sirona).

Conclusion

Endodontic treatment, even in routine cases is often challenging and indeed stressful (Dahlström, Lindwall, Rystedt et al., 2017). More challenging and complex cases may be seen as not predictable even in expert hands. The presented case studies illustrate how clinicians can approach a variety of challenging endodontic scenarios using the TruNatomy endodontic shaping system. It is evident from each case that the TruNatomy system not only preserves dentine, ensuring minimally invasive root canal preparation, but is also a versatile system with many clinical benefits and advantages when used in these challenging cases.

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