Negotiation of an S-curved root canal using an EDM machined CM instrument: A case report

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Introduction

During root canal treatment, the shaping sequence plays a vital role in the endodontic procedure and can ultimately determine the outcome. Historically, shaping of root canals was done with stainless steel files, but in the early 1980's nickel- titanium provided the revolutionary turn-around in the shaping procedure.[1] The introduction of nickel titanium provided substantial benefits which include protecting the original canal shape and reducing iatrogenic errors during cleaning and shaping (zipping, ledges and perforations).[2] In modern times, numerous rotary file innovations have been introduced to the endodontic market and rotary file systems differ in their designs from one system to the other. The different approaches in designs are an effort to eliminate procedural errors. However, the management of curved canals remains a huge challenge for any instrument even in the hands of the experienced clinician.[3]

Recently, an innovative endodontic instrument design has been introduced. It is manufactured using controlled-memory (CM) nickel-titanium wire and the Electric Discharge Machining (EDM) manufacturing process. Controlled memory can be defined as the process where the shape memory of the nickel-titanium alloy is removed by a special thermomechanical process.[4] The EDM procedure is a process where there is no contact between the work piece and manufacturing apparatus and only a pulsating electric current removes parts of the alloy. The metal alloy is immersed in a dielectric medium which allows electric discharge flow between an electrode and the metal alloy. Melting and evaporation of the alloy occur in a controlled and repeatable way.[5,6] The end result is an extremely flexible endodontic file where areas of the surface are superficially removed leaving a surface with evenly distributed craters (Figure 1).[7]

The following case report presents a detailed approach on the use of the HyFlex EDM rotary endodontic system in the negotiation of a tooth with challenging anatomy.

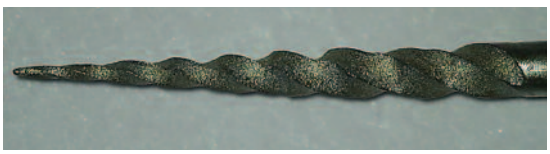

Figure 1: The EDM manufacturing process creating the "sand paper" appearance of the file

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Case Report

Visit 1

A 26 year old female patient was referred to the Department of Operative Dentistry at Sefako Makgatho Health Sciences University for endodontic treatment on her upper right second molar. Emergency root canal treatment was performed on a previous visit. The patient presented with an uncomplicated medical history and the patient reported no further symptoms on the treated tooth after the initial visit. A pre-operative radiograph revealed the upper right second molar with challenging anatomy, narrowing of the root canal spaces and an apical radiolucency on the apex of the mesial root (Figure 2).

The tooth was anaesthetized, the temporary restoration was removed and straight line access was achieved. A rubber dam was placed, the orifices of the mesio-buccal, distal and palatal canals were located, but sclerotic tooth structure covered the pulp floor and location of a potential second mesio-buccal canal (MB2). Sclerotic tooth structure was carefully removed with a long shank slow round carbide bur (Komet Dental, Brasseler, Germany) (Figure 3) and ultrasonics (Start-X number 3, Dentsply Sirona Endodontics) (Figure 4) under magnification using the Dental Operating Microscope (Carl Zeiss, Oberkochen, Germany), but no orifice(s) was detected after careful investigation of the pulp floor map (Figure 5).

The remaining canals were scouted and negotiated and length determination was done using the electronic apex locator (Propex II, Dentsply Sirona Endodontics), a size 10 K-file (Dentsply Sirona Endodontics) and RC Prep (Premier Dental, Plymouth Meeting, USA) as lubrication. Length determination was confirmed with conventional radiographs and a double curve/S-Curve was noted in the mesio-buccal canal (Figure 6).

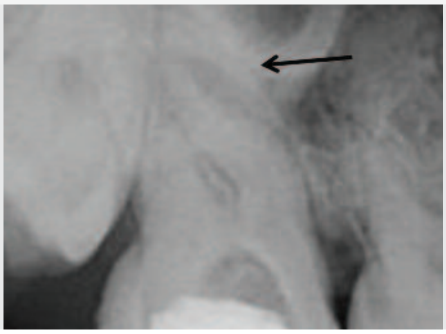

Figure 2: Pre-operative radiograph revealing challenging root canal morphology and an apical radiolucency on the apex of the mesial root

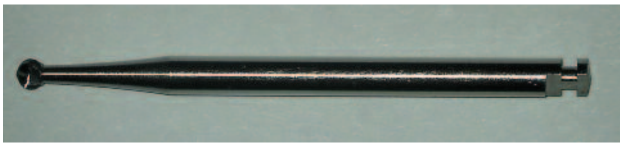

Figure 3: Long shank slow round carbide bur used under magnification for the removal of sclerotic tooth structure

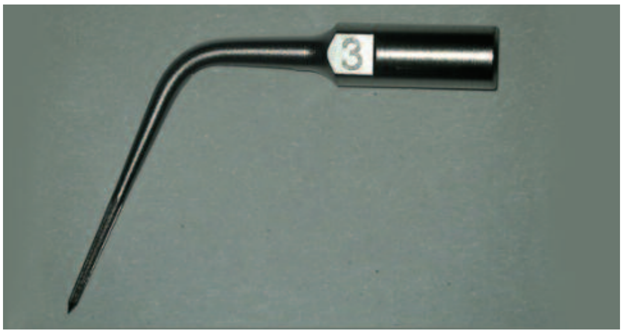

Figure 4: Start-X number 3 ultrasonic tip used under magnification for the removal of sclerotic tooth structure

The orifices were enlarged with the HyFlex EDM Orifice Opener (Coltene-Whaledent, Langenau, Germany) (Figure 7). The instrument was used with RC-Prep as lubricant and gentle apical pressure to avoid binding to the root canal walls and a brushing motion away from the furcation region. The initial glide path was created to a loose size 10 K-file with RC-Prep as lubricating agent in all canals. All canals were irrigated using 3.5% sodium hypochlorite, patency confirmed, recaptulated and re-irrigated to remove debris and prevent dentinal mud. With sodium hypochlorite left in-situ and following the manufacturer's instructions to use the instrument in a brushing motion and gentle apical pressure on the outstroke, the HyFlex EDM Glidepath File (Coltene-Whaledent, Langenau, Germany) (Figure 8) was used to complete glide path preparation on each canal to full working length. Before introduction to each canal, the file was inspected for unwinding under high magnification, but no visible signs of alteration were identified. All canals were irrigated in a similar method as described above and patency confirmed. After completion of glide path preparation, the HyFlex EDM OneFile (Coltene-Whaledent, Langenau, Germany) (Figure 9) was used to prepare each canal to full working length and sodium hypochlorite was left in-situ as lubricating and disinfection agent. The controlled memory effect of the instrument allowed pre-curving and access into all canals especially the mesio-buccal canal (Figure 10).

The file was used in a similar technique as described with the HyFlex EDM Glidepath File. Canals were dried with large paper points and dressed with calcium hydroxide paste (Calasept Plus, Nordiska Dental, Sweden) and the tooth

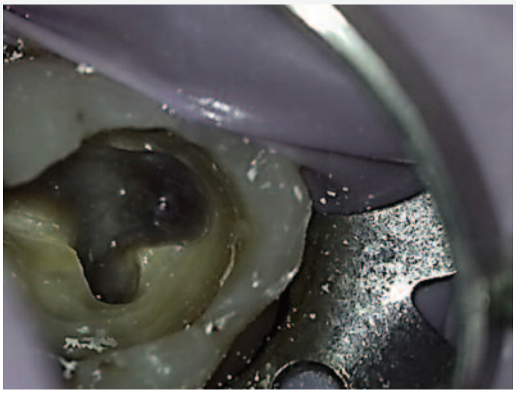

Figure 5: Removal of sclerotic tooth structure in an effort to locate MB2. No orifice(s) was detected after investigation of the pulp floor map

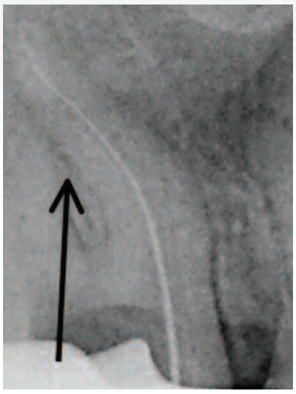

Figure 6: Confirmation of the S-curved root canal configuration in the mesio-buccal root during the length confirmation radiograph with a size 10 K-file

temporarized (Ketac Molar, 3M ESPE, Seefeld, Germany). Post-operative instructions were provided after the preparation phase of the treatment and the patient was re-scheduled for the final phase for filling.

Visit 2

The patient was seen 2 weeks after the previous visit and reported no discomfort since the last visit. The temporary restoration was removed and rubber dam isolation achieved. All canals were irrigated with 3.5 sodium hypochlorite and dried with large paper points. As a final rinse, 17% EDTA solution (Smear Clear, Kerr Dental, Orange, USA) was left in-situ for 1 minute to remove the smear layer and dried with large paper points. The HyFlex EDM OneFile gutta-percha cones were fitted and measured in all canals to confirm correct length. Canals were obturated using cold lateral condensation with Guttaflow Bioseal root canal sealer (Coltene-Whaledent, Langenau, Germany). The appropriate Electric Heated Pluggers (40/03 plugger for mesial and distal canals, 60/06 plugger for the palatal canal) (Calamus Dual, Dentsply Sirona Endodontics) were selected for gutta-percha burn-off and removal of a small coronal portion of obturation material from each canal (Figure 11). Obturations were vertically compacted after burn-off using Machtou pluggers (Dentsply Sirona Endodontics). Heated gutta-percha and vertical condensation with Machtou pluggers were used to fill the coronal void of root canal space (Calamus Dual, Dentsply Sirona Endodontics) (Figure 12 and 13). A temporary restoration was placed and the patient was re-scheduled for the restorative phase.

Discussion

According to literature, it is well documented that the extend of curvatures in the areas where root canal instruments operate play a vital role in instrument fatigue and fracture.[2] There is always the possibility that 2 or more curves can exist in the same root when a tooth is endodontically treated. The presence of a "double curve" or the "S"-curve as referred to in endodontic circles, can be one of the most challenging scenarios a treating clinician can face. The "S"-curve causes increased strain on nickel-titanium instruments during cleaning and shaping.[8] The presence of extreme curvature can also be hidden from a clinician in the fact that it may not be visible on conventional radiographs. A study conducted by Al-Sudani et al. (2012)[9] found that instrument fatigue occurs very quickly once the file encounters a double curvature. Therefore, the treating clinician has a short amount of time for canal preparation especially in the apical region of these root canals.

An investigation of available literature revealed limited information on cyclic fatigue resistance of nickel-titanium endodontic instruments in "S"-curved canals. Bending stress or cyclic fatigue can be described as the force generated within the nickel-titanium alloy by rotating an instrument in a curved root canal. This will result in repeated compression and flexing at the point of maximum curvature - a very destructive form of loading of the instrument, despite the fact that nickel-titanium has superior elasticity and that there is no binding to the canal wall.[8] In the presented case, the operator utilized a pumping motion with brushing on the outstroke during shaping in an effort to distribute forces over a greater area of the file and reduce the risk of cyclic fatigue and instrument fracture.

A factor that could greatly influence the failure rate of nickel-titanium endodontic files is the creation of a glide path. A smooth glide path will allow a relatively safe passage for subsequent rotary instruments to follow. West (2006)[10] described a glide path as a smooth, continuous channel extending from the orifice of the root canal in the pulp chamber to its most apical exit at the apex of the root. Varela-Patiňo et al. (2005)[11] found that fewer fractures occurred when a wide and smooth-walled glide path was created and the canal was pre-flared before the introduction of rotary files into the root canal. West (2010)[12] suggested that a loose 10 K-file moving freely to working length should be considered the minimum size for a glide path before rotary file introduction. It must also be emphasized that the glide path must be reproducible and free of any obstructions to avoid ledge formation, fracture of instruments, inadequate irrigation and obturation.[13] The operator in this case report followed the above guidelines before the HyFlex EDM Glidepath File was introduced and the loose 10 K-file allowed adequate progression of rotary instrumentation.

As stated before, the HyFlex EDM nickel-titanium file range has recently been introduced to the endodontic market by Coltene Whaledent. The system is unique in its EDM manufacturing process of controlled-memory (CM) nickel-titanium wire. Shen et al. (2013) stated that Controlled Memory (CM) nickel-titanium wire increases file flexibility and resistance to cyclic fatigue and also has the ability to limit iatrogenic errors during cleaning and shaping (ledge formation and instrument fractures) of curved canals.[4] According to the manufacturers, the instrument also has a "regenerative effect". The instrument has the ability to return to its original shape after a cycle in the autoclave once unwinding of the flutes is observed. In most cases, only 2 instruments are needed to complete root canal preparation once a loose number 10 K-file on working length is confirmed. The HyFlex EDM Glidepath File has a tip size of 0.10 and 5% taper and is operated at a rotation speed of 250-300 rpm's with 1.8 N.cm torque setting whilst the HyFlex EDM OneFile has a tip size of 0.25 with an 8% taper in the first 5mm's of the cutting tip and then 4% taper from 5-15 mm's from the cutting tip. The OneFile is operated at a high rotation speed of 500 rpm's with 2.5 N.cm torque setting. The system also include the optional HyFlex EDM 0.25 12% Orifice Opener to create coronal flaring. In the reported case the operator used a well-lubricated HyFlex EDM Orifice Opener with gentle apical pressure and a brushing motion for coronal enlargement of the orifices. Coronal enlargement reduces torsional resistance allowing the instrument to progress without the operator using excessive apical force. Torsional resistance can be described as the amount of stress generated within the instrument when

Figure 7: The HyFlex EDM Orifice Opener used in a brushing motion and gentle apical pressure to enlarge the root canal orifices

Figure 8: The HyFlex EDM Glidepath File used in a brushing motion to complete the glide path preparation to full working length

Figure 9: The HyFlex EDM OneFile used in a brushing motion to complete shaping of all root canals to full working length

Figure 10: The controlled memory effect allowing pre-curving and access of the HyFlex EDM OneFile in canals difficult to access

it engages the root canal wall or when the operator subjects the instrument to increased apical force.[14]

The controlled memory effect of the HyFlex EDM instruments allows pre-curving and bent to adapt to root canal curvature (Figure 10). This feature enables the instrument to maintain the original root canal shape without the "straightening" effect caused by nickel-titanium file memory. Instruments with a dominant austenite crystalline structure are generally stiffer with increased file memory compared to instruments with martensitic crystalline structure.[15] The unique EDM manufacturing process causes an increase of the austenite finish temperature of the CM-Wire alloy. In any instrument where the austenite finish temperature of the file is superior to body temperature, the

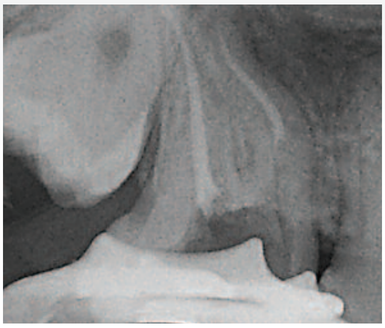

Figure 11: Coronal portion of obturated material removed from mesio-buccal canal with 40/03 electric heated plugger

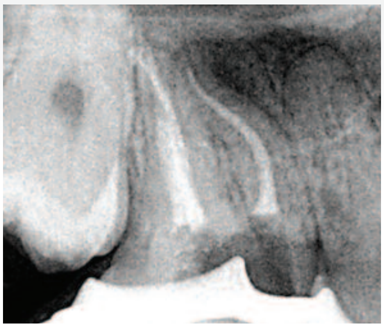

Figure 12: Obturation complete in all canals using a combination of cold lateral condensation and warm vertical condensation with Electric Heated Pluggers (EHP'S) and Calamus Dual

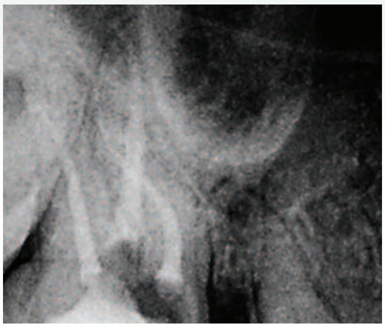

Figure 13: Mesially-angulated radiographic view separating the roots and illustrating individual obturated canals

alloy will be in a mixed martensitic, R-phase and austenitic structure at root canal temperature at the time of canal preparation. According to literature, the austenite finish temperature of the HyFlex EDM files is 52°.[16] It can be speculated that HyFlex EDM instruments can maintain most of its martensitic properties at body temperature during shaping, but further investigation will be required to confirm this speculation. Pre-curving of CM-Wire instruments also facilitates working on teeth with limited access (second and third molars) and allows management of root canals with ledges.[17] This statement can be confirmed in the presented case where limited access was encountered especially the mesio-buccal canal. The pre-curving advantage enabled the operator to gain adequate access into the root canals.

Finally, Topcuoğlu and co-workers (2016)[2] compared CM-Wire instruments to traditional nickel-titanium instruments using simulated S-shaped canals. The CM-Wire instruments evaluated in this study showed increased cyclic fatigue resistance compared to traditional nickel-titanium instruments.[2] It can only be speculated whether traditional nickel-titanium instruments would have been able to negotiate the challenging morphology found in the treated case.

Conclusion

The presented case illustrates the ability of the HyFlex EDM rotary file system to safely and efficiently negotiate challenging anatomy in spaces with limited access. The file system also provided sufficient resistance to cyclic and torsional fatigue to treat the "S" curve with reduced risk of instrument separation.

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