Clinical management of complex mandibular first molars with CBCT, ProTaper Next and GuttaCore

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Introduction

Despite the fact that there are numerous case reports in the dental literature illustrating the unusual anatomy of the mandibular first molar, there are still clinicians that fail to properly examine the pulp chamber floor under magnification to ensure location of all the canal orifices.

Adequate cleaning and shaping of all the root canals in a tooth before obturation is one of the major objectives of successful root canal treatment. Root canal treatment of the lower first molar can be very challenging, mainly due to the unusual root canal anatomy as reported in numerous literature reports.¹,²,³ The clinician’s knowledge of the variation in root canal anatomy can be one of the major contributors towards accurate location of all the root canals in a tooth. Traditionally, the location of root canals relied mainly on the clinician’s tactile dexterity and mental image of the root canal system because the ability to visualise the canal orifices was severely limited.⁴ According to Amauri et al. (2006), the use of magnification, adequate lighting and modified access cavities may assist the operator in accurate location of the root canals.⁵ The use of dental loupes (2x – 5x) and the Dental Operating Microscope (DOM) (3x – 30x) fitted with a light source can provide the clinician with superior ability to locate root canal orifices and treat cases that previously may have been deemed untreatable or would have resulted in a compromised prognosis.⁶

The two-rooted mandibular first permanent molar usually has three canals, with two root canals located in the mesial root and one root canal in the distal root.⁷ In most cases, the two mesial root canals end up in two distinct apical foramina and sometimes they merge together at the root tip to end in one foramen (Figure 1).

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Figure 1: Post-operative radiograph of a right mandibular first molar with two mesial and one distal root canal. Root canal preparation was done with ProTaper Next instruments.
According to a literature review by Baugh and Wallace (2004), the prevalence of a third mid-mesial root canal in mandibular first molars is between 1-15% (Figure 2). They also reported that the mid-mesial canal can be independent with a separate foramen (Figure 3), or this additional canal may have a separate canal orifice and then join apically with either the mesio-buccal or mesio-lingual canal (Figure 4).

The mid-mesial canal, if present, is located in the developmental groove connecting the two main canals with each other (Figure 5a). However, its orifice is usually hidden by the projection of dentine extending from the pulp chamber wall. Adequate straight-line access and examination under magnification and illumination is necessary to identify this dentine projection. According to Cantatore et al. (2009), it can be differentiated from the pulp chamber floor because its colour is lighter and similar to the
must be troughed with an ultrasonic tip towards the mesial wall until a file can be introduced into the orifice of the mid-mesial canal (Figure 5b).10

In 1971, Skidmore and Bjornal reported that 88.8% of distal roots of mandibular first molar teeth have only one canal (Figure 6), 28.9% can have two canals (Figure 7) and in rare cases it can have three root canals (Figure 8).11 In a
dentine layer that hides the MB2 orifice in maxillary molars.9 This dentine projection can be removed with an ultrasonic tip or a long shank round bur. The developmental groove should then be carefully examined under magnification and checked with a sharp explorer according to Aminsobhani et al. (2010).7 Vertucci (2005) recommends that if a depression in the developmental groove or orifice is located, the groove
recent literature review it was reported that the incidence of three root canals in the distal root of the mandibular first molar is between 0.2% and 3%.\textsuperscript{12}

In addition to these case reports, there have been several studies that show that the mandibular first molar can present with more than four root canals.\textsuperscript{1,13,14} Figure 9 demonstrates a case of a lower left first molar that presented with three separate root canals in the mesial root and two separate root canals in the distal root.

Mandibular first molars can also present with an additional root located either lingually (the radix entomolaris (RE) or buccally (the radix paramolaris (RP)).\textsuperscript{15} The presence of RE in the mandibular first molar is associated with certain ethnic groups. In populations with Mongoloid traits (for example Chinese, Eskimo and American Indians) the frequency can range from 5-30%.\textsuperscript{16,17,18,19,20,21} However, in Eurasian and Indian populations is less than 5%\textsuperscript{16} and in African populations it is less than 3%.\textsuperscript{22}

The purpose of this article is to illustrate by means of clinical case reports the clinical procedures that were followed to do root canal treatments on a lower first mandibular molars with complex root canal anatomy. In addition, the value of Cone Beam Computed Tomography (CBCT) is also illustrated.
periapical areas around the mesial and distal root apices as well as a sharp apical curvature and canal exit on the distal aspect of the distal root (Figure 10b). The axial view of midroot area revealed the presence of a mesio-buccal, mesio-lingual and one large, oval distal root canal system (Figure 10c).

An access cavity was prepared and the pulp calcification

Figure 10: (d) Magnified view of the pulp chamber after access cavity preparation. Note the evidence of a pulp calcification; (e) Start-X ultrasonic tip no.3; (f) Magnified view of pulp chamber floor after the Start-X tip no.3 was used to trough around the attached pulp stone;
**Figure 10:** (g) Start-X ultrasonic tip no.5; (h) Magnified view of pulp chamber floor after the Start-X tip no.5 was used to remove the remaining part of the pulp calcification; (i) Micro-opener size 10, 4% taper.

identified under microscope magnification (Figure 10d). A Start-X tip no. 3 (Figure 10e) was used to trough around the attached pulp stone (Figure 10f) before a Start-X tip no 5 (Figure 10g) was used to destroy the remaining part of the pulp stone up to the original pulp floor, differentiated by a distinct colour change of the dentine as observed under high magnification (Figure 10h). A Micro-Opener (Dentsply/ Maillefer) (Figure 10i) was used to locate the root canal orifices.

The initial canal negotiation confirmed a sharp apical curvature in the last few millimetres of the distal root canal (Figure 10j). A reproducible glide path was established in all the root canals up to a size 10 K-File before the glide path was enlarged with PathFile no. 1 (Figure 10k) and 2
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Root canal preparation was done with ProTaper Next X1 (Figure 10m) and ProTaper Next X2 (Figure 10n). The mesial root canals were obturated with size X2 GuttaCore obturators (Figure 10o) heated in the ThemaPrep Plus oven (Figure 10p). The distal root was obturated with two size X2 GuttaCore obturators because of wide canal configuration in the bucco-lingual direction. Figure 10q illustrates the post-operative result after obturation.

(Figure 10l).
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Case Report 2

The patient, a 44 year old female presented with a history of an emergency root canal treatment and failure to negotiate the root canals to full working length on her mandibular right first molar (Figure 11a). A CBCT sagittal view showed evidence of a periapical area around the tip of the distal root apex. (Figure 11b). The axial view of midroot area revealed the presence of a mesio-buccal, mesio-lingual, disto-buccal and disto-lingual root canal system (Figure 11c). After canal negotiation using size 08 C+ and K-Files (Dentply/Maillefer) (Figure 11d), length determination was done with three size 10 K-Files and one size 08 K-File (Figure 11e) and confirmed radiographically (Figure 11f). Reproducible glide paths were prepared using PathFiles no. 1 (Figure 10k) and 2 (Figure 10l). Upon canal preparation, it was found that ProTaper Next X1 was unable to progress to working length (26mm for mesial root canals) in the mesial root canals, despite some circumferential coronal brushing motions. It was decided to enlarge the coronal two thirds of these canals with ProTaper Next X1 and X2 before the size X1 instrument progressed easily to full working length. Four size X2 GuttaCore verifiers were fitted into the prepared root

Figure 11: (a) Pre-operative radiograph of mandibular right first molar showing evidence of a previous emergency root canal treatment; (b) CBCT – sagittal view showing evidence of a periapical area around the distal root apex (arrow); (c) CBCT-axial view of midroot area reveal the presence of a mesio-buccal, mesio-lingual, disto-buccal and disto-lingual root canal system.

Figure 11: (d) Size 08 C+ and K-Files that was used for canal negotiation; (e) Clinical view of the files that was used for length determination. Note the straight line access of the instruments into the access cavity and root canals; (f) Radiographic confirmation of working length;
Canals to full working length and confirmed radiographically (Figure 11g). Figure 11h shows a parallel view and Figure 11i a 30 degrees mesial angulated radiographic view of the final result after the four prepared root canals were obturated.

Case Report 3
A 14 year old male patient presented with a non-vital mandibular right first molar. A periapical radiograph (Figure 12a) and limited field of view CBCT scan revealed evidence of large periapical areas around the mesial and distal roots (Figure 12b). The tooth was accessed and four root canal orifices detected. Figure 12c shows the initial length determination radiograph. Examination under the Dental Operating Microscope (Global, USA) revealed the presence of an additional root canal orifice in the distal root (Figure 12d) and a dentine protuberance between the mesio-buccal and mesio-lingual root canal (Figure 12e). Closer examination of the CBCT scan revealed the presence of three root canal orifices in the coronal aspect of the distal root as well as three root canal orifices in the coronal aspect of the mesial root (Figure 12f). A part of the dentine protuberance...
was removed with a Start-X tip no.3 (Figure 10e) and the orifice of a mid-mesial root canal was detected.

Restrictive dentine was removed with a ProTaper SX (Dentsply/Maillefer) instrument by relocating the orifices mesially, away from furcal danger (Figure 12g). Figure 12h shows the final length determination for the three mesial root canals. After glide path preparation (size K-File by hand followed by PathFile no. 1 and 2), the root canal preparation of the six canals was done with ProTaper Next X1 and X2. The canals were obturated with ProTaper Next X2 gutta-percha points, using the Calamus Dual Obturation Unit (Dentsply/Maillefer). Figure 12i shows the final result after obturation and Figure 12j shows a mesial angulated view clearly illustrating the six obturated root canals.

Figure 12: (d) Magnified view (15X magnification) of the distal root canal system clearly illustrating the mesio-lingual, mid-mesial and disto-buccal canal orifices; (e) Magnified view (8X magnification) of the pulp chamber floor showed evidence of a dentine protuberance (arrows) between the mesio-buccal and mesio-lingual root canal orifices;

(f) CBCT axial view of midroot area reveals the presence of a mesio-buccal, mesio-lingual and a mid-mesial root canal system. Also visible on the CBCT scan is the outlines of three distal root canals, although they appear to be connected to form one large, oval distal root canal system; (g) Magnified view (8X magnification) of the pulp chamber floor showing the three orifices of the mesial canals after the radicular access was enlarged with a ProTaper SX instrument to ensure straight line access into the root canals;
Case Report 4
The patient, a 45 year old female presented with pain and discomfort on her mandibular left first molar, previously restored with a ceramo-metal crown. A pre-operative radiograph revealed evidence of extensive decay on the mesial margin as well as unusual root morphology (Figure 13a). The ceramo-metal crown was removed, caries excavated and a temporary crown placed. A CBCT, axial coronal slice confirmed the presence of two roots (mesial and distal)(Figure 13b). There was no clear evidence of canal orifices in the mesial root. Two canal orifices were visible in the distal root. Another axial slice in the midroot area, revealed the presence of distal root bifurcating into two separate roots. The additional root, branching off on the lingual aspect, confirmed the presence of radix entomolaris (RE)(Figure 13c).

The canals were negotiated and a length determination radiograph showed that files in the mesio-buccal and mesio-lingual root canals were short (Figure 13d). This was corrected by further negotiation of these two root canals.

Figure 13: (a) Pre-operative radiograph of mandibular left first molar that was restored with a ceramo-metal crown, showing evidence of decay on the mesial gingival margin (b) CBCT – coronal axial view showing a mesial and distal root (arrows); (c) CBCT- midroot axial view revealed the presence of a mesial root (M), distal (D) and radix entomolaris on the lingual aspect (RE).

Figure 13: (d) Length determination for the mesio-buccal, mesio-lingual, disto-buccal and radix entomolaris root canals; (e) GuttaCore X2 verifiers were fitted into the prepared root canals; (f) Radiographic confirmation of the fit of the verifiers. Note that the verifier in the distal root canal travelled past working length (white arrow), and that the sharp apical curve in the radix entomolaris was maintained after root canal preparation with the ProTaper Next Instruments (black arrow).
with the ProTaper Next X3 gutta-percha point using the continuous wave of condensation technique with the Calamus Dual Obturation Unit. Figure 13i shows a magnified view of the access cavity and pulp chamber floor clearly illustrating the position of the canal orifices. Figure 13j depicts a parallel view of the final result after canal obturation and Figure 13k shows a 30 degree mesially angulated view. Note the curvature in the apical part of the radix entomolaris that was maintained during canal preparation and obturation.

**Discussion**

The authors used a Global G6 (Global, USA)(Figure 14) or a Zumax (Zumax, China)(Figure 15) six-step microscope fitted with LED illumination during the clinical procedures depicted in this article. The LED light source on these microscope delivers brighter and whiter illumination compared to traditional metal halide and halogen light systems. This type of illumination makes the careful inspection of the pulp chamber floor to locate accessory canal orifices more predictable. Magnification and illumination can substantially improve the visualisation of root canal orifices. De Carvalho and Zuolo (2000) demonstrated in a study that the use of the DOM could increase the number of root canal orifices located in mandibular molars. In their study, 93 first and 111 second molars were examined with the naked eye followed by examination with the DOM (8-13x magnification). With the naked eye, a total of 641 canals were located. After examination with the DOM, an
canal fillings, determine the exact position and angulation of fractured instruments and to detect the presence and extent of inflammatory root resorption, just to mention a few. 27

Protaper Next (Dentsply/Maillefer) was used for root canal preparation for most of the cases depicted in this article. The key benefits of Protaper Next include simplicity, excellent cutting efficiency and predictable final canal shape to allow for cone fit with tug-back. The system also ensures a 6% taper in the apical third of a canal after preparation with only two instruments, the X1 and X2. 28

The Protaper Next instruments make use of the progressively tapered design. Each file presents with an increasing and decreasing percentage tapered design on a single file concept. The design ensures that there is reduced contact between the cutting flutes of the instrument and dentine wall, and reduced chance for taper lock (screw effect). At the same time, it also increases flexibility and cutting efficiency. 29

Another benefit of the system is the fact that the instrument is manufactured from M-wire and not traditional nickel titanium alloy. Research by Johnson et al (2008) demonstrated that the M-wire alloy could reduce cyclic fatigue by 400% compared to similar instruments manufactured from conventional nickel titanium alloys. 30 The added metallurgical benefit contributes towards more flexible instruments, increased safety and protection against instrument fracture. 31
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efficiency, as the blades will stay in contact with the surrounding dentine walls. Root canal preparation is done in a very fast and effortless manner:

- Reduces the risk of instrument fracture because there is less stress on the file and more efficient debris removal.
- The swagging motion of the instrument initiates activation of the irrigation solution during canal preparation improving debris removal.

In most of the cases depicted in this article, carrier based obturation was utilized for root canal obturation. Buchanan (2009) advocates the use of carrier-based obturators in long, narrow and severely curved canals. The flexibility of the carrier allows for obturation of these canals, however, the stripping of the gutta-percha may cause direct contact between the plastic carrier and the dentine wall in curved canals. This problem has been attributed to procedural errors such as improperly shaped canals.

Gutmann (2012) recommends that for the GuttaCore material to flow into the canal intricacies the canals should be shaped and enlarged to a minimum of ISO size 25 and a taper of 6%. This is also the minimum size and taper that

Figure 17: ProTaper Next instruments have a bilateral symmetrical rectangular cross section (except last 3mm of X1) with an offset from the central axis of rotation (except in the last 3mm of all the instruments, D0-D3). This unique design characteristic allows the instrument to experience a rotational phenomenon known as precession or swagge. The swagging movement enables the instrument to cut larger envelope of motion (red line) compared to a similarly sized instrument with a symmetrical mass and axis of rotation.

Figure 18: Size X2 GuttaCore crosslinked gutta-percha core obturator (Dentsply/Maillefer).
is recommended for root preparation\textsuperscript{37,38,39} to ensure thorough canal debridement.\textsuperscript{40,41} The canals in all the cases in the present article that were obturated with GuttaCore, were prepared up to a ProTaper Next X2 (25/06) instrument. Because of the snake-like (swaggering) wave of movement when the instrument rotates, each instrument is capable of cutting a larger envelope of motion (larger canal preparation size)(Figure 17) compared to a similarly sized instrument with a symmetrical mass and axis of rotation. This allows the clinician to use fewer instruments to prepare a root canal to adequate shape and taper to allow for optimal irrigation and obturation.

All of the above mentioned benefits of CBCT, ProTaper Next and GuttaCore crosslinked gutta-percha obturators provide the clinician with more confidence to attempt average, as well as more challenging, endodontic cases.

References

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