CASE REPORTS

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Middle mesial canal of the permanent mandibular first molars: an anatomical challenge directly related to the outcome of endodontic treatment

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Abstract

To effectively clean and shape the mandibular permanent first molars it is mandatory to understand in detail their complex internal anatomy. The middle mesial canal is an additional canal located between the usual mesiobuccal and mesiolingual canals in the mesial root of mandibular first molars. The incidence of the middle mesial canal, its relationship with main canals of the mesial root and the possibility for it to be negotiated is an important practical issue in endodontics. To identify the presence of this canal is mandatory. Accordingly, a modified endodontic access, the use of the operating microscope and periapical radiographs in two different horizontal projections are indicated to enhance the long-term favorable outcome of the endodontic treatment.

Keywords: mandibular first molar, middle mesial canal, root canal treatment.

Introduction

Normally, the first permanent mandibular molar is a two-rooted tooth. The mesial root is flattened and has a mesiodistal curvature while the distal root is mostly straight. Usually, this molar has two mesial canals (95.8%) and one distal canal (68.3%). Frequently, the mesiolingual canal is located in the long axis of the root and its trajectory to the apex is rather straight while the route of mesiobuccal canal exhibits a buccal curvature [1].

The initial systematic studies of the internal anatomy of first mandibular molar were performed *ex vivo* in early 70' on extracted teeth [1–3]. Using demineralized and cleared teeth, Hasselgren & Tronstad (1975) concluded that the obtained transparency was good enough to investigate root canals morphology [2]. Later on, Kerekes & Tronstad (1977) randomly selected 20 mandibular molars from several thousand extracted molars and found one of them having the mesial root with three canals. They also noticed in all mandibular molars that the route of mesial canals was rather irregular, quite unpredictable especially in the apical third, and their diameter varied noticeably [3].

First *in vivo* study belongs to Pomerantz *et al.* (1981) [4], who described the occurrence of middle mesial canals in mandibular first molars by clinical approach during effective root canal instrumentation and Weine (1982), who located the additional middle mesial canal in a 19-year-old female patient while performing the endodontic retreatment in the mandibular first right permanent molar [5].

Fabra-Campos (1985) found radiographically four mandibular first molars with three canals (mesiobuccal, middle mesial, and mesiolingual) in the mesial root out of 145 similar teeth that were previously endodontically treated. All three canals had independent orifices on pulp chamber floor. However, the course of intermediate middle mesial canal joined with the mesiobuccal canal in three cases and with the mesiolingual canal in only one case [6].

Over the years, numerous clinical reports signaling additional canals in the mandibular first molar, including the middle mesial, have accumulated [7–11]. Baugh & Wallace (2004) found that the incidence range of this intermediate mesial root canal is between 1% and 15% [12].

The aim of this paper is to present four clinical cases of mandibular first permanent molars with middle mesial canals that were successfully treated.

Case presentations

Case No. 1

A 20-year-old female patient, whose medical history was noncontributory, presented to the dental office with moderate pain provoked by chewing in the left first permanent lower molar (tooth 36). The tooth is slightly responding to palpation and vertical percussion. Periodontal status is normal. The preoperative radiograph

shows a deep coronal restoration and underobturated root canals. The root canal fillings also have an inhomogeneous appearance. It might be also suggested that the furcation resorption was most probably initiated by persistent endodontic infection through a lateral canal portal located on the distal aspect of the mesial root. The clinical decision was the endodontic orthograde retreatment (Figure 1).

The gutta-percha fillings of previously treated root canals were removed using rotary files ProTaper Universal Retreatment Kit (Dentsply Maillefer) and Handström hand files (Dentsply Maillefer). After a careful examination of the pulp chamber floor using an operating microscope (OPMI pico, Zeiss) that offered a better visualization and a sharp endodontic explorer DG 16 (Hu-Friedy), a third, middle mesial canal was detected in the mesial root, located between formerly treated mesiobuccal and mesiolingual. Following the negotiation and root length measurement, the middle mesial canal was regularly instrumented using rotary files Next (Dentsplay Maillefer) and 5.25% sodium hypochlorite irrigation (Chloraxid 5.25%, Cerkamed). An additional enlargement of the other previously obturated root canals was also performed using similar rotary files and copious irrigation with sodium hypochlorite (Figure 2).

According to present protocols for retreatment, a final irrigation with 2% chlorhexidine digluconate (Gluco-Chex 2%, Cerkamed) was done after a thorough removal of sodium hypochlorite from the canal with distilled water as intermediate rinse solution. A mixed paste of calcium hydroxide and chlorhexidine was introduced as inter-appointment dressing in all root canals. A sterile cotton pellet was placed over the pulpal floor and the access cavity was closed with a provisional restoration of IRM (Intermediate Restorative Material, Dentsply International).

At the next visit, tooth 36 was symptomless. The temporary dressing was removed with H-File (VDW) and copious irrigation of sodium hypochlorite solution (Chloraxid 5.25%, Cerkamed) was applied. Finally, the root canals were obturated in the same appointment by warm vertical condensation of gutta-percha using medium gutta-percha cones, DownPack (Hu-Friedy), Obtura III (Analytic Technologies), and AH Plus (Dentsply) as sealer.

The postoperative radiograph in oblique projection confirms the presence of three canals in mesial root and highlights the location of middle mesial close to the mesiobuccal canal. It also reveals the confluence of these canals and the presence of preoperative presumptive accessory canal in the apical third of the mesial root (Figure 3).

Figure 1 – ***Preoperative radiograph of tooth 36 showing underobturated root canals and deep furcation radiolucency.***

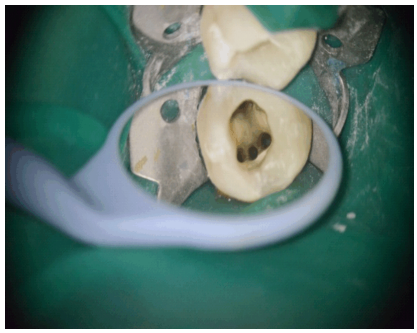

Figure 2 – ***Pulp chamber floor of tooth 36 showing three already instrumented root canals in mesial root (mesiobuccal, middle mesial, and mesiolingual) and only one distal canal.***

Figure 3 – ***Postoperative radiograph of tooth 36 showing in mesial root three confluent canals. The small spot of sealer visualizes the exit portal of a lateral canal.***

Case No. 2

A 21-year-old female patient presented to the dental clinic with symptoms of noticeable spontaneous pain and swelling of the left mandibular region. The intraoral clinical examination revealed a large coronal composite restoration and secondary caries in left lower first permanent molar (tooth 36), which did not respond to pulp vitality test with Endo-Frost Spray (Roeko). Since this tooth was also very tender to vertical and lateral finger pressure, the vertical percussion was avoided. The radiological examination showed periapical radiolucencies surrounding both root apices (Figure 4). The clinical diagnosis of acute apical abscesses was established.

Emergency treatment involved a straight-line access preparation to optimize the negotiation, apical patency and subsequent appropriate drainage of root canals. After rubber dam placement, all carious dentin and undercuts were eliminated and the access cavity was precisely extended with thinner cylindrical diamonds. Ultrasonic tip ET-20D (Satelec) and a P5 Booster (Satelec) ultrasonic unit were also used to remove the secondary dentin covering the interconnecting groove of mesial canals. A sharp endodontic probe DG 16 (Hu-Friedy), C-Pilot File (VDW), and an operating microscope (OPMI pico, Zeiss) were extremely helpful for the careful examination of the pulpal floor in tooth 36. Accordingly, three canals were detected in the mesial root (mesiobuccal, middle mesial, and mesiolingual) and two canals in the distal root (distobuccal and distolingual) (Figure 5).

After the determination of working length using Apex Locater Woodpex III (Woodpecker) and conventional radiographic record, a thorough cleaning and shaping of the main root canals was performed using rotary instruments Protaper Next X2 25/06 (Dentsply Maillefer) on mesials and Protaper Next X3 30/07 (Dentsply Maillefer) on distals. The middle mesial canal was enlarged to a slightly smaller size (30/04) than the main root canals. Using irrigation needles Endo Sterile (Cerkamed) between

each rotary file size all root canals were copiously irrigated by flooding with sodium hypochlorite solution (Chloraxid 5.25%, Cerkamed). The last irrigation with sodium hypochlorite solution was passive ultrasonic activated (UDS-A LED, Woodpecker).

For the final irrigation, a 15% EDTA (ethylene-diaminetetraacetic acid) solution (Endo Solution B 15% EDTA, Cerkamed) was used. Afterwards the root canals were dried with sterile absorbent paper points Dr. Mayer (Life & Health) and a root canal dressing with calcium hydroxide (Hydrocal, Cerkamed) was placed for a period of 14 days for disinfection, temporary sealed with packable posterior glass ionomer cement (GC Fuji IX GP Fast, GC Corp).

At two weeks from the first appointment, tooth 36 was symptom free, including lack of tenderness to vertical percussion, and the root canals were obturated with gutta-percha using the technique of thermoplastic condensation in continuous wave (DownPack, Hu-Friedy). After down-pack, the backfill was performed with Obtura III (Analytic Technologies). The root canal sealer used was AH Plus (Dentsply).

As expected, the postoperative conventional periapical radiograph, in right angle projection, gave no information about the number, length, and homogeneity of fillings in the mesial root (Figure 6). However, in oblique projection, the postoperative radiograph showed that all mesial canals had separated orifices and were joined in the apical third of the root (Figure 7).

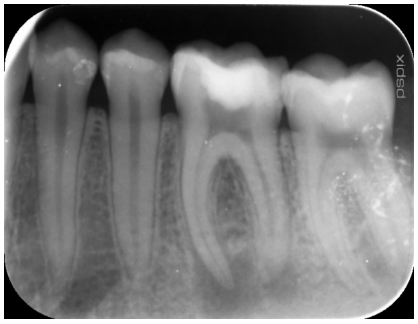

Figure 4 – ***Preoperative radiograph of tooth 36 in conventional right angle exposure showing radiolucent areas around both root apices; no supposition of an additional canal in mesial root.***

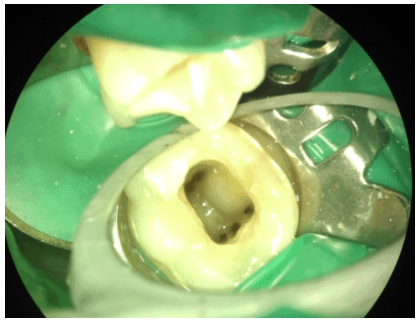

Figure 5 – ***Pulp chamber floor of tooth 36 showing three already instrumented root canals in mesial root (mesiobuccal, middle mesial, and mesiolingual) and two distal canals.***

Figure 6 – ***Postoperative radiograph of tooth 46 in conventional right angle projection impedes the visualization of the individual canals in both roots.***

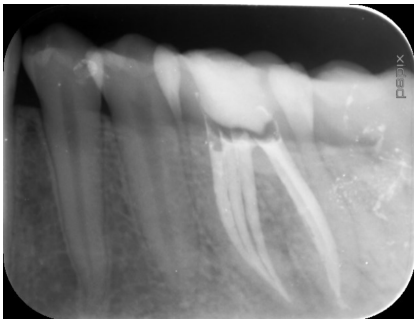

Figure 7 – ***Postoperative radiograph of tooth 46 in oblique distal projection showing that all mesial canals have separated orifices and join in the apical third of the root. Both canals of the distal root are also visualized.***

Case No. 3

A 27-year-old male presented to the dental office asking for a second opinion concerning the root canal treatment in the mandibular left first permanent molar. His dental history revealed a recent root canal treatment in tooth 36 that was completed one week ago. The medical history was noncontributory and the tooth was also asymptomatic. However, the imagistic examination by conventional periapical radiograph in mesial (Figure 8) and distal oblique projections (Figure 9) showed under-obturated root canals in both roots of tooth 36.

The clinical decision, accepted by the patient, was to retreat the tooth. Accordingly, the composite coronal restoration was removed under rubber dam isolation. Scouting the pulp chamber floor, three canals were detected in the mesial root (mesiobuccal, middle mesial and mesiolingual). Surprisingly, during the previous endodontic treatment, the mesiolingual canal was not instrumented and its pulp was found necrotic. The middle mesial canal was partially filled in its cervical third only with sealer and in the mesiobuccal canal, gutta-percha and sealer were observed. Even though the distal canal was filled with gutta-percha and sealer, some necrotic pulp remnants were also found (Figure 10).

The recorded working length of the root in the canals, using the Apex Locater Woodpex III (Woodpecker), was 20 mm (mesiobuccal), 19 mm (middle mesial), 18 mm (mesiolingual), and 18.5 mm (distal). An additional enlargement was performed using copious irrigation with 5.25% sodium hypochlorite and rotary instruments ProTaper Next X2 25/06 (Dentsply Maillefer) for mesial canals, respectively Protaper Next X3 30/07 (Dentsply Maillefer) for the distal canal (Figure 11).

A final ultrasonic activated irrigation with 5.25% sodium hypochlorite was performed, followed by a 17% EDTA irrigation before root canals filling by warm vertical compaction of gutta-percha. AH Plus was used as sealer.

The postoperative radiographs from two different angles, mesial and distal projections, showed that all root canals were properly obturated (Figure 12).

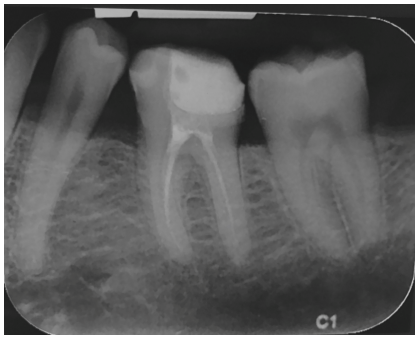

Figure 8 – ***Preoperative radiograph of tooth 36 in oblique mesial projection showing underobturated root canals.***

Figure 9 – ***Preoperative radiograph of tooth 36 in oblique distal projection showing underobturated root canals.***

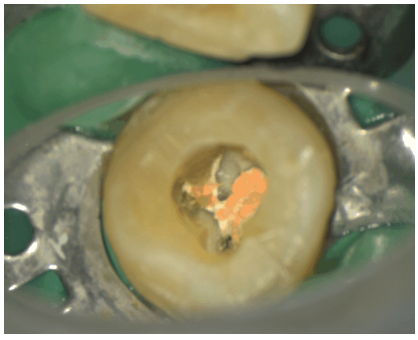

Figure 10 – ***Magnified view of pulpal floor in tooth 36 showing gutta-percha and sealer in middle mesial, mesiobuccal and distal canals. The mesiolingual canal was not previously accessed and had a necrotic pulp.***

Figure 11 – ***Magnified view of pulpal floor in tooth 36 after retreatment showing all three properly instrumented mesial canals and the distal canal.***

Figure 12 – ***Postoperative radiographs in mesial and distal projections showing the full length filled canals in both roots of tooth 36.***

Case No. 4

An 18-year-old female patient presented to the dental office to restore the tooth crown of teeth 46 and 47 that were affected by caries decay. At clinical examinations, it was found that tooth 46 was non-vital and the pulp chamber was wide opened by decay progression, while tooth 47, despite the caries depth, was still vital and symptomless. Tooth 46 gave no response at palpation and vertical percussion. Periodontal probing was also normal. The preoperative radiograph showed in tooth 46 an extremely advanced damage of tooth crown and chronic apical periodontitis affecting both roots (Figure 13).

Considering the age of the patient the clinical decision was to perform an orthograde conservative root canal treatment in tooth 46 and a vital conservative one in tooth 47, namely an indirect capping. After carefully removing the carious dentin on the pulp chamber floor with Black spoons, a supplementary middle mesial root canal orifice was observed under magnification, which was located between the emergences of mesiobuccal and mesiolingual canals. The final refinement of access cavity was performed with safe-ended tungsten carbide EndoZ bur (Dentsply Maillefer) before the cleaning and shaping of all root canals with rotary files ProTaper Next X2 (Dentsply Maillefer) to the working length and copious irrigation with 5.25% sodium hypochlorite (Chloraxid 5.25%, Cerkamed). As final irrigation of the root canals a 15% solution of EDTA (Endo Solution B 15% EDTA, Cerkamed) was used.

The subsequent root canal obturation was accomplished at the end of the same appointment using the standard technique of warm vertical condensation of gutta-percha and AH Plus sealer (Dentsply). The postoperative radiograph in oblique projection showed three independent canals in the mesial root of tooth 46, mesiobuccal, middle mesial, and mesiolingual, even though in the cervical third the middle mesial and mesiobuccal canals appear to have in common a segment of their route (Figure 14).

The one-year follow-up, X-ray exposure in oblique projection definitely revealed the healing in progress of chronic apical periodontitis at both roots of tooth 46, which highlights the clinically pivotal role of cleaning and shaping of accessory canals. Meanwhile, the evolution of indirect capping in tooth 47 proves to also be effective as the pulp vitality is preserved, there is no history of spontaneous pain and the periradicular bone is free of radiolucencies (Figure 15).

Figure 13 – ***Preoperative radiograph of tooth 46 showing an advanced carious damage of tooth crown and chronic apical periodontitis affecting both roots.***

Figure 14 – ***Postoperative radiograph of tooth 46 showing in mesial root three independent canals and sealer overextension in distal root as evidence of a lateral canal foramen.***

Figure 15 – ***Control radiograph of tooth 46 at one-year showing healing in progress (almost healed lesions) of chronic apical periodontitis at both root apices.***

Discussion

Over the years, several papers reported the presence of three root canals in the mesial root of the mandibular permanent first molar [4–14]. The supplementary third mesial canal, the middle mesial, is located centrally on the pulpal floor, between the mesiobuccal and mesiolingual canals [11].

The diameter of the middle mesial canal is smaller than the other two main mesial canals and is age related, since, as long as the dental pulp is vital, it is progressively narrowing due to the continuously apposition of secondary dentin [6, 7, 11]. Accordingly, numerous endodontists concluded that the access in middle mesial canals is facilitated in younger patients, less than 21 years of age, by their maximal diameter at this age group [4–7, 9].

Depending on the course of the middle mesial canal from the pulpal floor orifice to the apical foramen, three different morphological patterns were described. Usually, the canal may be independent, when both orifices are distinct or confluent, when they converge either with the mesiobuccal (more frequent) or the mesiolingual, and have a common apical terminus. Though middle mesials canals have separate orifices on the pulpal floor, several of them do not follow a clear demarcate route, hesitating as to whom of the main mesial canals to join. However, it seems that more frequent the middle mesial joins the mesiobuccal canal in the apical or middle third of the root [6].

Sometimes, when a passage (transverse anastomosis) to the mesiobuccal or mesiolingual canals is found with a small diameter root canal file, the morphological pattern is considered a fin [4, 9–11]. Pomeranz *et al.* (1981) observed more frequent mesiolingual than mesiobuccal fins, possibly due to the slightly larger diameter of mesiolingual canals [4]. After root canal filling, especially in the case of a morphological type fin, the middle mesial canal cannot be separated on the postoperative radiograph from the main canal at the cervical third [7, 9].

However, in clinical practice, the confluent design of this intermediate mesial canal mostly was found. According to Fabra-Campos (1989), the middle mesial and mesiobuccal canals join in the apical third of the root in 65% of cases. An approximately twice-lower incidence was recorded for confluence of the middle mesial with the mesiolingual (30%). Only in 5% of cases, the middle mesial canal had an independent course [9].

It is also worthy to notice that the incidence of the third mesial canal in mandibular molars is higher in the first molar than in the second one (range 2.07 – 12%) and definitely an even higher proportion of three canals was found in mesial roots of lower molars as compared to distal roots of same teeth [4, 7].

According to the standard protocols of root canal treatment, the preliminary mandatory conditions to a better clinical examination of the pulpal floor aiming to detect a supplementary root canal are rubber dam placement, complete removal of old coronal restorations and caries, access cavity enlargement, and adequate magnification [11].

However, the clinical practice proved that the detection of root canal orifices is closely related to the anatomical configuration of the endodontic system. Before starting to scout for an intermediate mesial canal, it might also be useful to remove with a round bur the protruded dentin from the mesial wall of the pulp chamber that separate the orifices of main canals. Having a direct and improved visibility is easier to explore the line joining the mesiobuccal and mesiolingual canals [6, 9].

Fabra-Campos (1985) [6] and Martinez-Berna & Badanelli [7] suggest to firstly enlarging the main root canals and later to look for any small intermediate depression that could indicate the middle mesial canal by sliding a thin explorer from the mesiolingual to the mesiobuccal position. The middle mesial canal may be found by carefully exploring the interconnecting groove between orifices of main mesiobuccal and mesiolingual canals with a fine endodontic probe such as the DG 16 and when a depression is found, depending on the canal diameter, a size 06, 08 or 10 K-file is introduced to negotiate the canal [11].

To facilitate the detection of the additional mesial canal a dried pulpal floor is recommended to be achieved. While performing a vital pulpectomy the occurrence of a bleeding point between the main mesial canals is of tremendous importance to locate the middle mesial canal orifice.

Once the canal is detected, for a more efficient further

instrumentation, it is better to slightly enlarge its orifice with a small diameter Gates Glidden bur [6, 9]. Clinically, it is of paramount importance to avoid the enlargement of middle mesial canals to the same degree as the main mesial canals due to the risk of fenestration [9]. Even though, it seems embarrassing to spend more time exploring the pulpal floor to detect a middle mesial canal, it is much more beneficial to avoid further endodontic complications than to leave this narrow root canal un-negotiated and untreated [9].

The outcome of endodontic treatment in mandibular first molars may be often jeopardized by the morphological irregularities of the complex root canal system [13]. Such abnormalities found within the endodontic system of these teeth are the network of anatomical communications between mesiobuccal and mesiolingual canals and isthmuses, also called intercanal pulpal passageways, which typically link two ore more canals in the mesial root [13, 14].

In mandibular molars, various anatomical abnormalities were described, such as first molars with five, six or seven canals, a middle mesial canal, an isthmus connecting the mesiobuccal and mesiolingual canals or both distal canals in Vertucci type II configuration, a C-shaped anatomy of the second molar, and an additional distolingual root [7, 13–15]. In routine practice, for easier identification of the second canal in the distal root of the permanent mandibular first molar, it was also suggested to modify the outline of the access cavity to a rectangular design [16, 17].

The ability to locate the middle mesial canal or second canal in the distal root of the mandibular first molar depends on the endodontist's clinical experience and it is definitely improved by using an operating microscope. An experienced endodontist may identify a more complex anatomy of the endodontic system or adequately fill the extra-canals, while magnification is supportive in overcoming the procedure difficulty [13, 18, 19]. However, it seems that surgical loupes are relatively less effective compared to the operating microscope [18].

Adequate cavity access and visibility are definitely the main prerequisites to improve the detection of additional root canals when we are suspicious. A better visualization of pulp chamber floor footprint is extremely helpful to locate them [13–15, 20]. Moreover, Nosrat *et al.* (2015) claims that the use of the operating microscope is the key to identify middle mesial canals in mandibular first permanent molars [14].

When calcifications were found, the visibility of the pulpal floor was readily obtained by removing them with ultrasonic scalers. A cotton pellet is very useful to dry the pulp chamber floor and allow the sharp endodontic explorer to examine the mesial developmental groove were the middle mesial canal is located [17].

In case of calcified orifices of the root canals, a microscope is identifying without difficulty the difference on the pulpal floor between the calcified canals aperture and surrounding root dentin while facilitating the dentin coverage removal with ultrasonic instruments [18, 19].

However, Yoshioka *et al.* (2002) reported that 7% of all the root canal orifices in the mesial root of permanent mandibular first molars and 3% in the mesial root of permanent mandibular second molars could not be detected even using an operating microscope, as compared to 100% identification of canals in the distal root of both molars [18].

Though the morphology of the endodontic system is sometimes more complicated, it seems that a better understanding of the root canals anatomy would be more useful to locate canal orifices under magnification [18, 19].

Conclusions

The middle mesial canal is an additional canal located between the usual mesiobuccal and mesiolingual canals in the mesial root of mandibular first molars. Even though its incidence is low, the importance of looking for this canal has a high clinical relevance. A modified endodontic access, the use of the operating microscope and periapical radiographs in two different horizontal projections are indicated to enhance the long-term favorable outcome of endodontic treatments.

Conflict of interests

The authors declare that they do not have any conflict of interests.

Author contribution

Authors #4 (Irina-Maria Gheorghiu) and #5 (Alexandru-Andrei Iliescu) have equal contributions to this paper.

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