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CASE REPORT

Endodontic Management of An Unusual Mandibular First Molar with Six Canals: A Case Report and Systematic Review

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ABSTRACT

The permanent mandibular first molar is frequently involved in conventional root canal treatment due to its function and position in the oral cavity. Additional root canals mandate accurate diagnosis and conservative management to prevent any procedural errors. The first independent middle mesial canal incidence was verified in mandibular molars in 1974, with a global incidence of 10.8–27.0%. Reporting of the middle distal canal in the endodontic literature is scarce, with an incidence of 0.2–3%. The present case report describes the endodontic management of an unusual permanent mandibular first molar with three canals in the mesial and distal roots, diagnosed with irreversible pulpitis and apical periodontitis. A dental operating microscope and multiple angulated radiographs were used to identify the unusual morphology, and this was confirmed with cone-beam computed tomography imaging. The access cavity was modified to a trapezoidal shape, and the pulp chamber was carefully explored following root dentinal maps to expose additional canals by ultrasonic troughing. Incorporating a dental operating microscope and cone-beam computed tomography imaging in routine endodontic cases facilitates a better understanding and visualization of the complex root canal anatomy, making even the management of endodontically challenging cases more predictable.

Key words: endodontic anatomy, endodontic treatment, mandibular molar, root canal system

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INTRODUCTION

Successful root canal treatment requires complete disinfection of the root canal system, followed by three-dimensional obturation. However, anatomical complexities, such as numerous lateral canals, fins, ramifications, and intercanal communications, often hamper the disinfection and debridement process. Any untreated canal or anatomical constraint may act as a niche for microorganisms to thrive, resulting in the nonhealing of apical periodontitis and endodontic failure.[1,2] Thus, an effective root canal treatment necessitates a complete understanding of the intricate root canal anatomy. Conventional endodontic therapy frequently involves the mandibular first molar, the first permanent tooth to erupt in the oral cavity.[2,3] The complex root canal system of the mandibular first molar has been well preserved in the endodontic literature, including extra roots, an isthmus between the root canals, the C-shaped root canal configuration, and accessory canals, which mandate careful and conservative instrumentation to prevent any procedural error. Vertucci and Williams and Barker et al. verified the first independent middle mesial canal (MMC) incidence in mandibular molars in 1974.[3,4] It has been interchangeably called "accessory mesial canal," "mesiocentral canal," and "middle mesial (MM)," canal with a frequency between 10.8% and 27% across various ethnicities and ages.[5–7] Pomeranz classified MMCs into three categories: fin, confluent, and independent. A fin is when an instrument can pass freely between the mesiobuccal (MB) or mesiolingual (ML) canal and the MMC. The canal is confluent when an MMC originates as a separate orifice but

apically joins with the MB or ML canal. An established independent MMC originates as a separate orifice and terminates as a separate foramen.[8]

Documentation of the middle distal canal in the endodontic literature is rare. Its incidence is extremely low, ranging from 0.2% to 3.0% in reported cases. Post-treatment disease can subsequently occur if the canal is not located and properly debrided.[9–12]

Cone-beam computed tomography (CBCT) imparts a three-dimensional perspective and is noninvasive, is reliable, and has many advantages over conventional clinical decision-making methods. It allows the visualization of slices in three dimensions without compromising the tooth and associated vital structures.[13] Therefore, clinicians can be well acquainted with the intricate root canal anatomy and topographic locations of additional canal orifices.

The present case report describes the endodontic management of an unusual permanent mandibular first molar with three canals in the mesial and distal roots. A dental operating microscope (DOM) and multiple angulated radiographs were used to identify the unusual morphology, and this was confirmed using CBCT images. The access cavity was modified to a trapezoidal shape to include all the canals. The pulp chamber was carefully explored following root dentinal maps to expose additional canals by ultrasonic troughing. Following biomechanical preparation, the canals were chemically debrided, aided by sonic activation, and obturated three-dimensionally.

CASE REPORT

A 15-year-old female patient reported to the Department of Conservative Dentistry and Endodontics, Aligarh Muslim University, Aligarh, India, with the chief complaint of severe spontaneous pain in tooth #46. Intraoral examination revealed poor oral hygiene conditions and concomitant gingivitis. The pocket probing depth was recorded at four points using a manual periodontal probe (UNC 12 Probe, HuFriedy, Chicago, IL, USA). The measured depth was 2 mm, lying within the normal range. Pretreatment examinations (cold and electric pulp tests) revealed irreversible pulpitis in tooth #46, as both tests elicited an exaggerated response in tooth #46 compared with the adjacent and contralateral teeth. The patient complained of sensitivity to percussion only on tooth #46. Root canal therapy was recommended with the patient's informed consent upon discussing treatment options. The pretreatment radiograph (Figure 1) revealed the loss of lamina dura and widening of the apical periodontal ligament space, suggestive of apical periodontitis. However, the radiograph showed no signs of any unusual morphology of the mandibular molar.

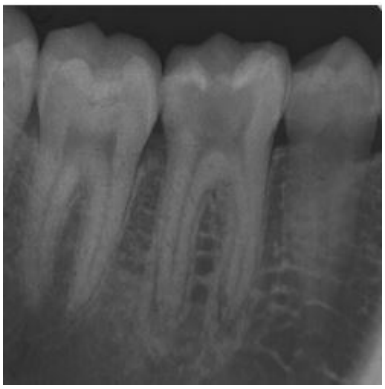


Figure 1. A preoperative radiograph of the right mandibular first molar.

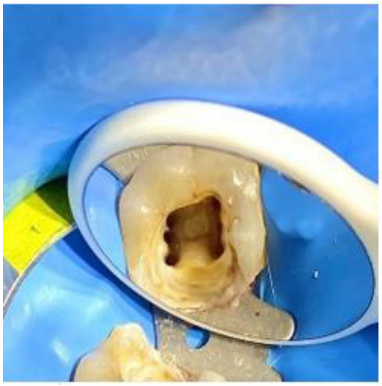


Figure 2. Access cavity preparation. Clinical view of the three separate canal orifices in the mesial and distal roots.

Figure 3. A) Initial working length radiograph with six endodontic files in place. **B)** Initial working length radiograph with six endodontic files taken at the distal angulation.

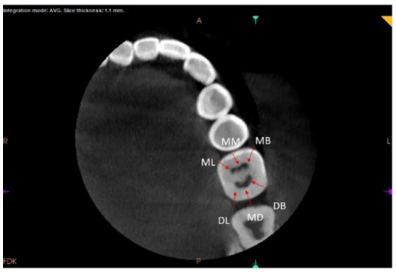


Figure 4. Axial CBCT image of mandibular first molar demonstrating six canals in the mesial and distal roots (ML: Mesiolingual; MM: Middle Mesial; MB: Mesiobuccal; DB: Distobuccal; MD: Middle Distal; and DL: Distolingual).

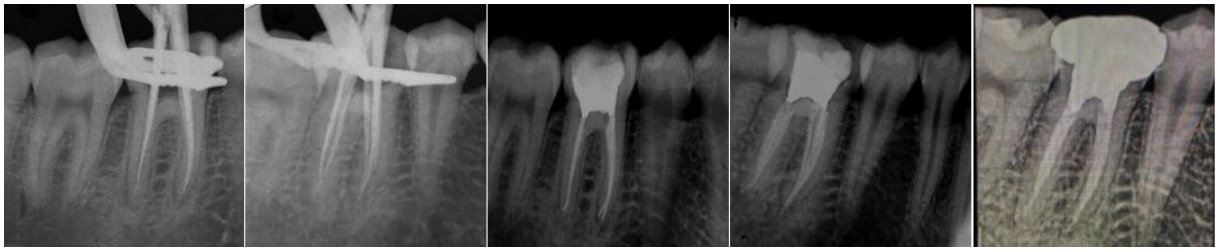


Figure 5. A) Master cone radiograph. B) The master cone radiograph was taken at the distal angulation. C) Postoperative radiograph; 6 canals were obturated. D) Postoperative radiographs taken from the distal aspect; 6 canals were obturated. E) Recall radiograph 1 year after the completion of the treatment.

Initially, oral prophylaxis was done to reduce gingival inflammation, and the patient was further scheduled for endodontic treatment. On the next visit for endodontic treatment, the tooth was locally anesthetized with 2% lidocaine and 1:80,000 epinephrine, rubber dam isolation was ensured, and access opening was subsequently performed. The carious and decayed tooth structure was removed. Access cavity preparation was completed and refined using Endo-Access and Endo-Z Burs (Dentsply, Maillefer, Baillaigues, Switzerland). Initial scouting of the root canal system was done with the DG-16 explorer and then with size 10 K-files (Dentsply) until they displayed resistance. Initially, only five root canal orifices were located (three in the distal root and two in the mesial root) at the level of the cemento-enamel junction (CEJ). The canal orifices were coronally preflared with ProTaper Sx Gold (Dentsply Tulsa Dental Specialties, Tulsa) to improve access and provide better visualization.

Further exploration of the chamber was carried out under a dental operating microscope (Seiler IQ German Optics, Germany) following the root dentinal maps. The pulp chamber was troughed using ultrasonic tips Start-X™ #1, #2, and #3 (Dentsply Maillefer) to remove the dentinal obstruction and enable negotiation of the internal anatomy; one more orifice, the middle mesial, was located in the mesial root (Figure 2).

The canals were irrigated with 3% sodium hypochlorite and 17% EDTA. Working length radiographs were taken to detect the presence of multiple canals. An apex locator (Propex Pixi, Dentsply) was used to verify the working length of all six root canals. Additional IntraOral Periapical radiographs were taken at different angulations to confirm the independent presence of each canal in the mesial and distal roots (Figures 3A and 3B).

To confirm the presence of all six canals (three in the mesial root and three in the distal root), the patient was referred for a cone-beam computed tomographic scan (Carestream Inc., Rochester, NY). The exposure parameters of CBCT were 60–90 kVp and 2–15 mA in sections 85 mm thick (Figure 4).

The images were carefully examined to detect the presence of independent canals. Biomechanical preparation of the canals was completed by Mtwo NiTi rotary files (VDW, Munich, Germany) individually using a crown-down technique to a master apical size 30 and 6% taper. Following chemico-mechanical preparation, the canals were dried with absorbent paper points, and the remaining fluid was aspirated using a 29-gauge Navi Tip (Ultradent Products Inc., South Jordan, UT). An intracanal calcium hydroxide dressing was placed, and the patient was scheduled for the next appointment one week later. The intracanal dressing was removed at the second appointment, and copious irrigation was performed. Final irrigation with 17% EDTA to remove the smear layer, followed by 3% sodium hypochlorite, was performed before obturation. The Endoactivator (Dentsply Tulsa Dental Specialties, Tulsa, OK) was used to actively irrigate the canals with 3% sodium hypochlorite and 17% EDTA, alternating with normal saline. Obturation was accomplished using a warm vertical compaction technique by downpacking and backfilling using the thermoplastic obturation system Obtura III (SybronEndo, Orange, CA) and AH-26 as a root canal sealer (Dentsply Maillefer). A temporary filling (Cavit G, 3M ESPE) was placed, and the patient was kept on follow-up visits. At one week of follow-up, the patient was completely asymptomatic, and the access cavity was restored with composite resin (Tetric N Ceram; Ivoclar Vivadent AG, Bendererstrasse, Liechtenstein) (Figure 5A–5D). The tooth was restored with full coverage porcelain fused metal restoration (Figure 5E), and the patient was completely asymptomatic at 6 months and 1 year.

METHODS

This systematic review is reported using the PRISMA guidelines and the PICO framework to address the following clinical question: "Prevalence and management of six canals in permanent mandibular molars."

Literature search strategy

An exhaustive search was conducted to identify

articles published between January 1970 and April 2022 in the PUBMED electronic database to search for the keywords "mandibular first molar" OR "root canal anatomy" OR "root canal morphology" AND "number of canals and mesial root" AND "molar" AND "number of canals and distal root" OR "mesial root canal configuration" AND "distal root canal configuration." Titles and abstracts were evaluated, and only case reports of six canals in the mandibular molars written in the English language were included. Case reports of six canals in the maxillary molar or more than six canals in the mandibular molars were excluded. The full texts of the selected articles were then obtained and reviewed, the references of those papers were manually searched, and cross-citations were detected.

Study selection process

The case reports included mature permanent teeth with deep caries and a clinical diagnosis of irreversible pulpitis with or without apical periodontitis. The intervention was nonsurgical root canal treatment, and the primary outcome was the success of root canal treatment with at least a one-year follow-up measured by any absence of clinical symptoms and resolution of radiographic signs.

Exclusion criteria

Studies on primary teeth; expert opinions or reviews; case reports of six canals in the maxillary molar or more than six canals in mandibular molars; studies in languages other than English. The PRISMA flow chart (Fig. 1) illustrates the selection process. The screening and assessment of eligibility criteria involved the independent screening of titles and abstracts by two assessors (SMUN and SA). The full texts of the selected articles were then obtained and reviewed, the references of those papers were manually searched, and cross-citations were detected.

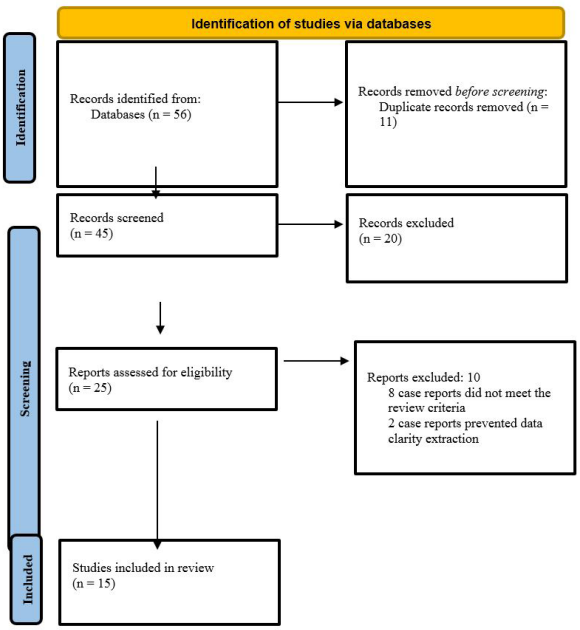
Data extraction

Data were extracted by two authors independently (SMUN and SKM), and in cases of disagreement, the inclusion criteria relevant to the review were strictly followed and verified independently by three different authors (RKT, AK, and SA).

Data synthesis

The entry of data and synthesis were carried out in Review Manager, Version 5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark).

PRISMA 2020 Flow Diagram



RESULTS

The details of the study selection process are outlined in Figure 1. Twenty-five full-text articles were assessed for eligibility, and 10 were excluded. The reasons for exclusion are explained in Figure 1. The full texts of the selected articles were then obtained and reviewed, the references of those papers were manually searched by two independent reviewers (SA and SKM), and cross-citations were detected. At the end of the process, 15 case reports presenting 18 cases of six canals in permanent mandibular molars were selected.

DISCUSSION

The literature has preserved the complexity of the root canal of mandibular first molars in which the mesial root has harbored two, three, or four canals, and the distal root encases four, three, or two canals, respectively (Table 1). These accessory canals often merge with the main canals or exit as independent canals.[14–28] Weine et al., Pineda and Kuttler, and Vertucci have famously given the classification of root canal configuration and morphology in the endodontic literature.[3,29] In a comprehensive study conducted by Sert and Bayirli in 2004, 14 new canal types were reported.[30,31]

Table 1. Reported cases for mandibular molars having six root canals (according to the classification given by Ahmed et al.[32])

Authors	Country	Ethnicity	Gender	Age	Mesial canals	Distal canals	Root and root canal configuration
Martínez-Berná and Badanelli[14]	Spain	Caucasian	Female	22	3	3	Double-rooted mandibular first molar: $^{2}46\ M^{3}\ D^{3-2}$ Double-rooted mandibular first molar: $^{2}36\ M^{3}\ D^{3-1}$
Ghoddusi et al.[15]	Iran	N/A	Female	30	2	4	Four-rooted mandibular first molar: $^{4}46\ MB^{1}\ ML^{1}\ DB^{2}\ DL^{2}$
Kontakiotis and Tzanetakis[16]			Male	30	4	2	Double-rooted mandibular first molar: $^{2}46\ M^{4-1}\ D^{2-1}$
Aminsobhani et al[17]	Iran	N/A	Female	30	4	2	Double-rooted mandibular first molar: $^{2}36\ M^{4-2}\ D^{2-1}$
Ryan et al[18]	USA	N/A	Female	52	3	3	Double-rooted mandibular first molar: $^{2}46\ M^{3}\ D^{3}$
Gupta et al.[19]	India	N/A	Female	38	3	3	Double-rooted mandibular first molar: $^{2}46\ M^{3-2}\ D^{3-2}$
Baziar et al.[20]	Iran	N/A	Male	42	2	4	Double rooted mandibular first molar: $^{2}46\ M^{2}\ D^{4-2}$
Hasan et al.[21]	Pakistan	N/A	N/A	N/A	3	3	Double-rooted mandibular first molar: $^{2}36\ M^{3-2}\ D^{3-2}$
Sinha et al.[22]	India	N/A	Female	18	4	2	Double-rooted mandibular first molar: $^{2}36\ M^{4-2}\ D^{2}$
Jain et al.[23]	India	N/A	Female	20	4	2	Double-rooted mandibular first molar: $^{2}46\ M^{4-2}\ D^{2-1}$
Maniglia-Ferreira et al.[24]	Brazil	N/A	Male	28	3	3	Double-rooted mandibular first molar: $^{2}46\ M^{3}\ D^{3}$
Martins and Anderson[25]	Portugal	Caucasian	Male	33	3	3	Three-rooted mandibular first molar: $^{3}46\ M^{3-1}\ DB^{1}\ DL^{2-1}$
	USA	Caucasian	Female	37	4	2	Double-rooted mandibular first molar: $^{2}46\ M^{4-2}\ D^{2}$
Hashem AAR et al.[26]	Egypt	N/A	Female	56	3	3	Double-rooted mandibular first molar: $^{2}6\ M^{3}\ D^{3}$
Bhargav K et al[27]	India	N/A	Female	38	4	2	Three-rooted mandibular first molars: $^{3}36M^{4-2}DB^{1}DL^{1}$ $^{3}46M^{4-2}DB^{1}DL^{1}$
Subramaniam Ramachandran V et al.[28]	India	N/A	Male	35	3	3	Three-rooted mandibular first molar: $^{3}36M^{3-2}DB^{2-1}DL^{1}$

A review of the literature shows that so far, only 15 case reports have documented the occurrence of six canals in a permanent mandibular first molar, with distal root demonstrating complex root canal configurations, mainly Type (4-2), Type (3-2), and Type (3-1).[14,19–21]

As reported by Skidmore and Bjorndal,[33] 88.8% of distal roots of the mandibular first molar harbored only one canal, while 28.9% contained two canals. The distal root of the mandibular first molar has rarely been documented with three canals; its reported incidence was noted as 1.7% in the Indian population, 0.2% in the Senegalese population, 1.7% in the Turkish population, 0.7% in the Burmese population, 1.6% in the Thai population, and 3% in the Sudanese population.[10]

Most laboratory studies have not reported the presence of the third canal in the distal root. Reuben et al., using spiral computerized tomography (SCT), conducted a study of 125 mandibular first molars, and none of the teeth exhibited three canals in the distal root.[10]

A few classic articles have reported the presence of two canals in the mesial root.[34] The incidence of the middle mesial canal in the permanent mandibular first molar was reported to be 1–15% by Baugh and Wallace.[35] However, based on the study design, the incidence of the middle mesial canal in the mandibular first molar has been reported differently, ranging from 0.95% to 46.2%. In the same study, the authors reported the incidence of MMC as 13.725%, whereas an ambiguous isthmus was found to be 52.94%.[36] As confirmed by previous reports, three cases reported six canals in the mandibular first molar having separate foraminal exits.[18,24,26]

In the present case, a dental operating microscope and multiple angulated intraoral periapical radiographs were used to reveal the additional canals. A dental operating microscope as a necessary adjuvant to improve the identification and localization of the missed canals was suggested by Azim et al.[5] and Karapinar-Kazandag et al.[36] Using an operating microscope can help the clinician manage anatomic deviations in complex cases and understand the topography of the pulp chamber floor and the exact locations of the canals' orifices. The inclusion of magnification is now considered a must for successful endodontics.[37] The present case demonstrates that the success of an endodontically challenging case is mainly dependent on the use of magnification, which allows for quickly identifying the six distinct root canal orifices.

The American Academy of Oral and Maxillofacial Radiology and the American Association of Endodontists recommend using a small/limited field of view to locate missed canals, as issued in the joint position statement in 2015. CBCT can be considered a better alternative for visualizing complex root canal morphology in three dimensions without considerable harm to the associated tooth structures.[38]

The additional root canals were confirmed by CBCT imaging in the present case. The axial section at the cementoenamel junction confirmed the presence of two roots and six root canals, namely, the mesiobuccal (MB), middle mesial (MM), distobuccal (DB), mesiolingual (ML), middle distal (MD), and distolingual (DL). The access cavity was modified to a trapezoidal shape based on the information obtained from the CBCT images and visual inspection of the root dentinal maps under DOM. Kottoor et al.[39] suggested that following the developmental root fusion line (DRFL) in the pulp chamber can provide important diagnostic clues in identifying root canal anatomy. The use of ultrasonic troughing under magnification serves as a helpful guide in negotiating the calcific blockage and gaining access to the root canal system, as was done in the present case.

The increased separation between the canal orifices is responsible for their termination in separate foramina. Therefore, each canal should be treated independently. In the present case, the mesial and distal roots had canals with Type (3-2), as per the classification given by Ahmed et al.[32] for root canal configurations, and each of the canals was treated independently. The presence of isthmuses, anastomosis, and fins is frequent in multirooted teeth, posing inaccessible areas to be debrided via mechanical instrumentation alone. Hence, root canal debridement should be boosted by chemical irrigation using sonics or ultrasonics.[40] In the present case, complete debridement after biomechanical preparation was ensured using sonic-aided chemical debridement followed by three-dimensional obturation.

A systematic review of the root anatomy and canal configuration of the permanent mandibular first molar reported that three canals were present in 61.3%, followed by four canals in 35.7%, and five in almost 1% of cases. However, various in vivo studies conducted by endodontists have demonstrated the four canals in about 45% of treated cases.[41,42] These findings suggest that the operator's experience is crucial when successfully dealing with a complex case. Interestingly, a few case reports have also implicated the presence of six or even seven canals.[43]

The buccolingual extension of the mesial root houses many intercanal communications and isthmuses; therefore, their possibility should not be exempted. The classification of isthmus configurations was given by Hsu and Kim in 1997, with Type V most commonly occurring among the mesial roots of mandibular molars. Type V is a wide cluster of pulp tissue between two main canals.[44] The authors also reported the presence of Type V isthmuses in about 20% of the distal roots and 55% in mesial roots.[29] As established,

these areas are inaccessible to instrumentation; hence, the improved irrigation protocol should focus on preventing endodontic failure.

CONCLUSION

Incorporating a dental operating microscope in routine endodontic cases facilitates better visualization of the complex root canal anatomy. CBCT can be considered a better alternative to conventional radiographs to understand complex root canal morphology in three dimensions without considerable harm to the associated tooth structures, making managing endodontically complex cases more predictable. Therefore, every clinician should have these indispensable tools at their disposal. One factor that plays a pivotal role in the identification and management of mandibular first molars with this variation is ethnicity, which significantly affects the frequency of roots and the anatomy of the pulpal floor. Additionally, root dentinal maps are helpful guides for tracing extra/missed canals. Furthermore, a patient presenting with an atypical tooth shape and unusual contour should provide a diagnostic clue and warrant additional imaging to confirm any anatomical variations. Further studies should be conducted in populations with large sample sizes to obtain more detailed information regarding anatomical variations in the root canal system of permanent mandibular first molars.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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