# Endodontic re-treatment of the mandibular first molar with six root canals: A case report

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Received May 22, 2025; Accepted January 8, 2026

DOI: 10.3892/etm.2026.13099

**Abstract.** Root canal anatomy of the mandibular first molar typically encompasses 3-4 canals. However, mandibular first molars may contain >4 root canals, emphasizing the need for heightened diligence among clinicians when conducting root canal therapy (RCT) on these teeth. Within the present case report, a 40-year-old Chinese female patient presented to The Third People's Hospital of Chengdu (Chengdu, China) in November 2023 with masticatory pain for 2 months in the lower right posterior region, after previous therapy at the People's Hospital of Wenjiang District (Sichuan, China) in July 2008. Examination using angulated radiographs and magnification instruments demonstrated six root canal systems in the mandibular first molar. Root canal re-treatment was performed and follow-up at 6 and 24 months was conducted following sealer extrusion. The patient was asymptomatic with decreased periapical radiolucency and area of extruded sealer. The present report highlights the importance of exploration and meticulous interpretation of canal morphology in the absence of advanced imaging techniques, also underscoring the efficient management of intricate root canal anatomy by conventional methods. By documenting this rare six-canal structure, the present report augments anatomical knowledge of mandibular first molars and reminds clinicians to anticipate unexpected variations during RCT.

## Introduction

Endodontic therapy primarily aims to cure or prevent periradicular periodontitis (1,2). Failure to identify and treat all root canals can result in unsuccessful root canal treatment, as bacteria persist and multiply in overlooked canals, potentially causing unresolved existing inflammation or novel inflammatory episodes in the periapical tissues (3,4). Therefore, a thorough understanding of the root canal anatomy and its variations is key in comprehensive debridement and shaping.

The mandibular first molar, which most frequently requires endodontic therapy (5), typically has two roots, the mesial and distal (6). The mesial root usually houses two canals and the distal root may contain one or two canals. However, a recent investigation using micro-CT scanning indicated that the root canal anatomy of the mandibular first molar appears more intricate (7). Variations may include a third canal in the developmental groove of the mesial root, termed the middle mesial canal (MMC), with a prevalence of 0.26-45.80% (8). Additionally, the rare occurrence of a third canal in the distal root, known as the middle distal canal (MDC), varies with ethnicity and ranges from 0.2 to 3.0% (9). Given its rarity, the presence of six root canals in the mandibular first molar has been documented in a limited number of cases (9-20). The present report illustrates a successful instance of root canal retreatment in such a complex case.

## Case report

A 40-year-old Chinese female patient with no notable medical history presented to The Third People's Hospital of Chengdu (Chengdu, China) in November 2023 with chief complaints of pain in the lower right molar during mastication, persisting for 2 months. Additionally, the patient reported that the restoration on the same tooth had fractured 1 day earlier. The patient also recalled having undergone 'endodontic treatment' (July 2008) at the People's Hospital of Wenjiang District (Sichuan, China). This previous therapy involved partial pulp removal and mummification therapy on teeth nos. 45 and 46, followed by bridge restorations, which progressively deteriorated. Clinical examination revealed a notable fistula tract on the soft tissue surrounding tooth no. 46, which elicited slight pain and discharged pus upon palpation. The probing depth of the gingival sulcus was normal at all points except for the buccal intermediate of tooth no. 46, where a localized periodontal pocket measuring 7 mm was noted. Following the removal of the crown, tooth no. 46 displayed grade 1 mobility according to Miller's mobility index (21). Vertical percussion on the affected teeth caused noticeable pain and pulpal electro-vitality tests yielded no response. Periapical X-rays indicated high-density images in the crowns of teeth nos. 45 and 46, extending into the pulp cavity, with indistinct root canal images suggesting the presence of calcified canals. Additionally, diffuse radiolucent

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*Key words:* root canal retreatment, middle mesial canal

areas were observed in the apical regions of both teeth and the periodontal ligament space surrounding the cervical third and root bifurcation was widened (Fig. 1A). A dental cone-beam CT (CBCT) scan was recommended to improve understanding of the severity of the disease and the morphology of the root canal system. However, the patient declined this examination. Based on the clinical examination and radiographic findings, tooth no. 46 was diagnosed with chronic apical periodontitis. After being fully informed about their condition, the patient was given the option of non-surgical endodontic treatment or implant placement following extractions, with additional periodontal therapy potentially required. The patient opted for endodontic retreatment. Before beginning the treatment, the patient provided informed consent for all diagnostic and therapeutic procedures. Additionally, the Ethics Review Board of Chengdu Third People's Hospital (Sichuan, China) granted approval for the present report (approval no. 2025-S-83).

The first root canal treatment was performed in November 2023. Following removal of the defective restorations, teeth nos. 45 and 46 were isolated with a rubber dam (Fig. 1B). The previous filling material and secondary caries were removed and the pulp mummification materials within the pulp chamber were accessed. Furthermore, an endodontic ultrasound ET20 tip compatible with the Suprasson P5 Newtron device (both Acteon; Satelec), was employed to clear the pulp cavity of calcified and necrotic tissue. Subsequently, marked calcification was noted on the chamber floor, which appeared light brown and complicated the identification of the root canal orifices. With the aid of a dental operating microscope (DOM; Zumax Medical Co., Ltd.), a DG-16 endodontic explorer (Hu-Friedy) was used to probe the root canal orifices and the orifices of the mesiobuccal (MB), mesiolingual (ML), distobuccal (DB) and distolingual (DL) canals were initially detected. The wide separation of the MB and ML orifices raised suspicions of additional root canals. An ET25 ultrasonic tip (Acteon) was used to remove the calcified tissue in the isthmus between these orifices. The 'champagne bubble test' (22) was applied by flooding the pulp chamber with 3% sodium hypochlorite (NaClO). The effervescence rising from the isthmus areas guided the tip of a DG-16 explorer, leading to the identification of an additional middle mesial (MM) canal. The same method between the DL and DB orifices revealed the middle distal (MD) root canal.

Preoperative radiographic images revealed a narrowed, blurred root canal contour, suggestive of diffuse calcification. During the initial attempt at canal negotiation with stainless steel hand files, the operator encountered calcification in the upper portion of the root canal. Under direct visualization of the DOM, the ultrasonic ET20 tip was used cautiously to remove calcified deposits and establish straight-line access to the coronal portion of the canal. However, due to limited visibility, negotiating the apical portion, particularly in curved, narrowed segments, posed notable challenges, increasing the risk of root perforation or file fracture. To decrease potential complications, a staged approach utilizing C+ files was employed to address the apical segment. This strategy leveraged the high flexural strength of C+ files, in combination with EDTA irrigation, to lubricate the canal and facilitate debris removal. The canal was instrumented to the apical foramen, with the working length determined using the electronic Root ZX II Apex Locator (J. Morita Corp.). A total of six root canals were prepared in tooth no. 46, including three mesial canals (ML, MM and MB) and three distal canals (DL, MD and DB). During root preparation, it was observed that the MM canal was confluent with the MB canal at the apical third, while the distal root comprised three separate canals. The canals were shaped using ProTaper Gold rotary instruments (Dentsply Sirona) with a crown-down instrumentation technique (23). The ultimate dimension size was achieved by expanding from the initial file by three sizes. For the narrow additional root canals (MM and MD), a conservative shaping strategy using the TruNatomy system (Dentsply Sirona) was adopted to avert excessive dentin removal and lateral root perforation. MB, ML, DB and DL canals were prepared to an F3 file size, the MM canal expanded to an F2 size and the MD canal was shaped to an apical diameter of 0.20 mm with a 4% taper (Fig. 1C and D). Throughout the mechanical preparation phase, each root canal was irrigated with 20 ml 3% NaClO using conventional syringe irrigation to ensure adequate and thorough debridement. This was followed by ultrasonic (27-32 kHz) agitation, performed 3 times per canal, with each cycle lasting 20 sec. A photodynamic disinfection system (EasyinSmile) was used to enhance root canal disinfection. A low-viscosity thionine blue, acting as the photosensitizer (PS), was injected into each root canal, followed by agitation with an endo activator (EasyinSmile) to ensure uniform distribution. The activator tip was positioned 2 mm from the apex, activated for 30 sec and repeated twice. Residual PS was removed by irrigation with 10 ml sterile saline, after which the canals were dried with absorbent paper points, filled with calcium hydroxide and the coronal portion was sealed with glass-ionomer cement.

At the 10-day follow-up, the patient reported improvement, experiencing no discomfort in the affected tooth. Vertical percussion of tooth no. 46 elicited no pain and the sinus tract had resolved. The tooth was isolated with a rubber dam and the root canal was rinsed using 20 ml 3% NaClO and ultrasonic activation before being obturated with the 'continuous wave of condensation' technique (24) using gutta-percha and iRoot SP bioceramic sealer (Innovative BioCeramix, Inc.; Fig. 2A and B). The root canal orifices were sealed with Filtek™ Z350 XT flowable composite resin (3M ESPE; 3M Deutschland GmbH), and the crown was restored using Filtek™ P60 composite resin (3M ESPE; 3M Deutschland GmbH). Postoperative multi-angle radiographs confirmed the correct placement of the gutta-percha cones. Notably, some iRoot SP paste extruded from the apical foramen to ensure maximal sealing (Fig. 2C and D). After completing the root canal treatment, the patient was referred to the Department of Prosthodontics at Chengdu Third People's Hospital (Sichuan, China) for the fabrication of a full ceramic crown to protect tooth no. 46. At the 6 month follow-up (June 2024), the patient reported no discomfort with the treated tooth no. 46. Clinical examination revealed healthy surrounding gingiva without redness or swelling, a negative percussion response and normal periodontal probing depths. Furthermore, X-ray images exhibited a successful non-surgical root canal treatment, with a visible decrease in the dark shadow surrounding the furcation and root apex. A residual high-density radiopaque area corresponding to the extruded sealer was observed (Fig. 3). At 24 month follow-up in November 2025, the patient remained

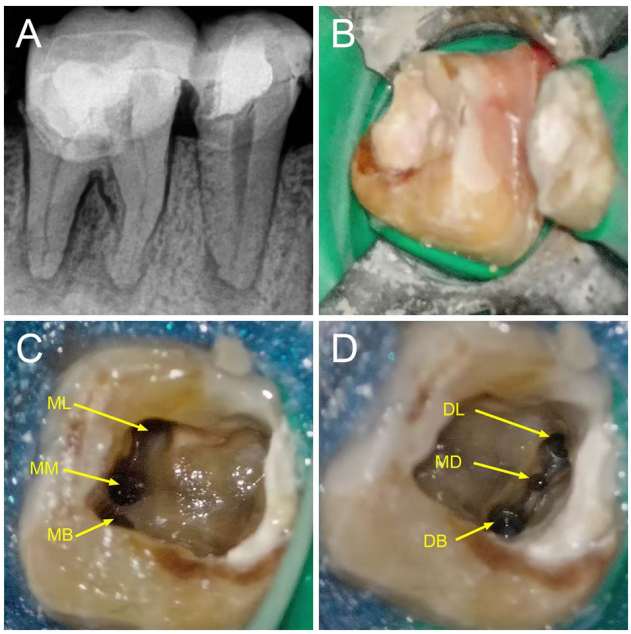


Figure 1. Clinical and radiographic assessment (November 2023). (A) Preoperative apical radiographs of teeth nos. 45 and 46. (B) Rubber dam isolation of teeth nos. 45 and 46. Dental microscopic observation of three (C) mesial and (D) distal root canal orifices of tooth no. 46 following preparation. ML, mesiolingual; MM, Middle Mesial; MB, Mesiobuccal; DL, Distolingual; MD, Middle Distal; DB, Distobuccal.

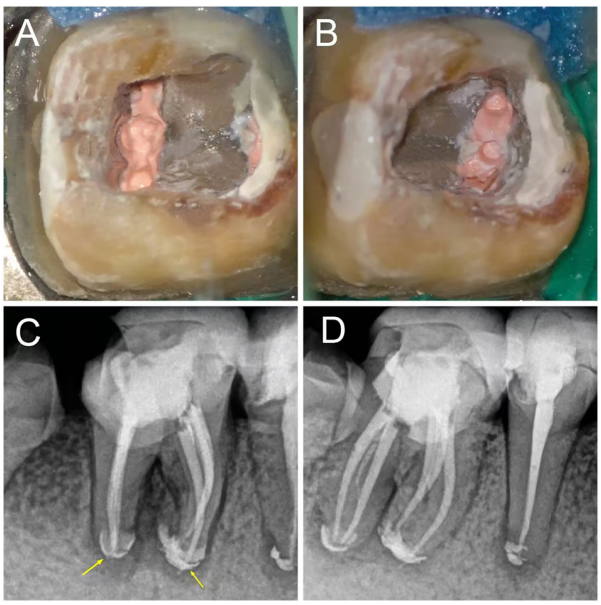


Figure 2. Post-obturation clinical and radiographic assessment (November 2023). (A) Pulp chamber view of three obturated (A) mesial and (B) distal root canals. (C) Post-obturation periapical radiograph (straight orthogonal view) taken in November 2023. Arrows indicate high-density filling material extruding beyond the apex. (D) Post-obturation periapical radiograph (mesio-oblique view).

asymptomatic. Multi-angle radiographic evaluation revealed complete resolution of the periapical and furcation radiolucencies, with a decrease in the extent of the extraradicular high-density area (Fig. 4A and B). Thus, continuous follow-up every 6-12 months with the patient is important; if the patient

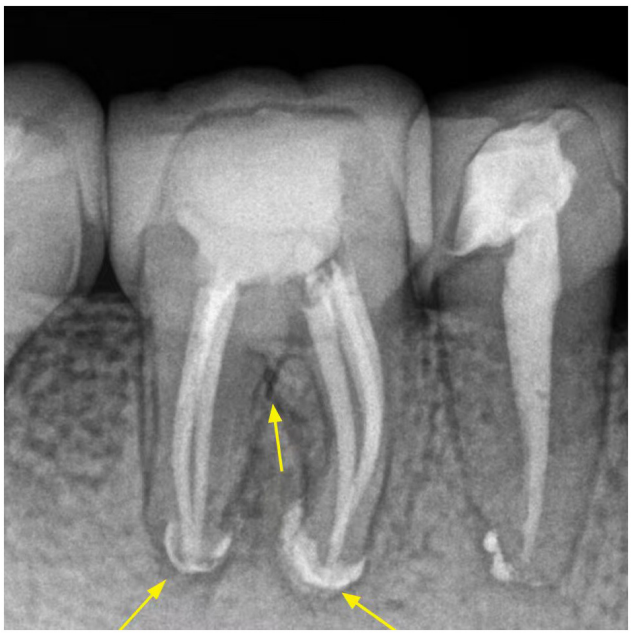

Figure 3. Radiographic assessment at the 6-month follow-up. Periapical radiograph showing the radiolucent area in the furcation and periapical region decreased. The high-density extruded filling material beyond the apex also decreased in tooth no. 46. Arrows indicate the reduced periapical radiolucency and the resorbing extruded filling material.

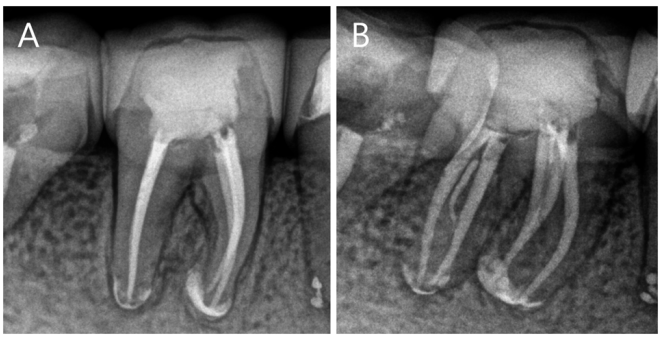


Figure 4. Radiographic assessment at the 24-month follow-up. (A) Straight orthogonal and (B) mesio-oblique views of periapical radiographs of tooth no. 46.

experiences unresolved periapical inflammation or recurrent discomfort, apical surgery may be considered.

## Discussion

The present case demonstrated notable challenges due to complex and variable root canal morphology, specifically due to the presence of six canals, including the MMC and MDC. Procedural complexity was increased by calcification that obscured canal orifices, limited visualization and the inherent difficulties associated with non-surgical endodontic retreatment, including the removal of resistant filling materials and regaining apical patency. According to the classification system for root and root canal morphology outlined by Ahmed *et al* (25), tooth no. 46 presented with two roots, a mesial root classified as $M^{3-2}$ (three canals, with the MB and MM canals merging in the apical third and the ML canal remaining separate) and a

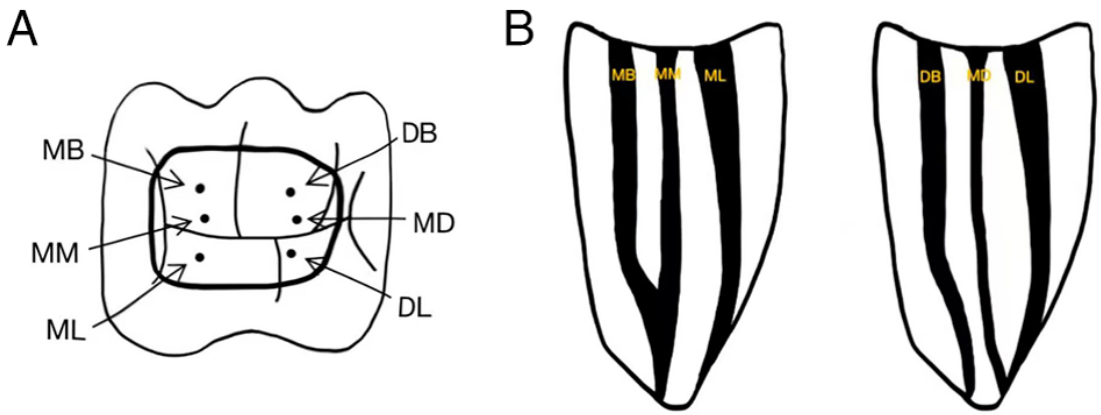


Figure 5. Diagrammatic representations of the root canal morphology. (A) Diagram of the location of the orifices of the six canals. (B) Diagrammatic illustration of the mesial and distal root canal configuration. MB, mesiobuccal; DB, distobuccal; MM, middle mesial; MD, middle distal; ML, mesiolingual; DL, distolingual.

distal root classified as $D^{3-3}$ (three independent canals). Thus, the overall configuration of this tooth was $^{2}46M^{3-2}D^{3-3}$ (Fig. 5). The majority of reported cases with additional root canals have described a confluent configuration (9,10,12-16,18). However, cases featuring three separate root canals (11,17,20) are rare. Since Vertucci and Williams (26) identified the presence of MMC in the mandibular first molar in 1974, considerable research (8,9,27) has been conducted on the incidence of MMC. Results have varied widely, influenced by factors such as sample size, methodology, instrumentation and the technical proficiency of researchers. The incidence of MMC ranges from 0.26 to 45.8% (8), with a prevalence of 1.9% identified in the Chinese population in a study by Ni *et al* (27). The occurrence of MDC is rarer, with reports varying from 0.2 to 3.0% (9).

CBCT is a diagnostic tool in contemporary endodontic practice (28). By generating ultra-thin cross-sectional images from multiple angles, CBCT minimizes geometric distortion, image elongation and shortening (29). However, the routine use of CBCT remains controversial due to the high radiation exposure (30) and cost. In the present case, the absence of CBCT data compromised the accurate assessment of root canal morphology. When CBCT imaging is unavailable, conventional periapical radiographs alone are often insufficient to visualize the complexity and number of root canals. In such situations, the use of multi-angled radiographic projections may enhance diagnostic accuracy. Additionally, the DOM and ultrasonic instruments are key for identifying and negotiating concealed canals while preserving the remaining tooth structure. The DOM provides notable magnification and illumination, enhancing the visibility of the pulp chamber and chamber floor (31). The enhanced view offered by DOM allows dental ultrasonic devices to remove dentin debris or calcification with greater precision and clarity than conventional handpieces (32). When used in conjunction with the microprobe DG-16, meticulous probing along the sulcus increases the likelihood of discovering additional canals. Despite the limitations posed by the absence of CBCT in the present case, the MMC and MDC were identified using multi-angle X-ray apical radiographs and magnification equipment. Other methods for identifying variant root canals include staining the floor of the pulp chamber with 1% methylene blue dye, performing the champagne bubble test with NaClO, guided troughing techniques or the 'red line test' (33).

Another challenge in the present case was the retreatment of calcified root canals. The patient had undergone pulp mummification 15 years ago, with recurrent signs developing. Pulp mummification therapy aims to coagulate and necrose tissue and microorganisms near the mummifying agents, rather than achieving thorough cleaning and disinfection of the root canal (34). Such treatment typically results in conditions such as residual pulpitis and chronic or acute periapical inflammation due to incomplete treatment (4). Although calcification may partially seal the root canal system, it complicates subsequent cleaning, disinfection and filling if the initial treatment fails. Effective retreatment of calcified canals requires the correct selection of rotary files and preparation techniques (35). The C+ file is suitable due to its high resistance to bending, which allows it to navigate calcified canals without distortion (36). Manual files, used alongside EDTA or NaClO, not only serve as lubricants but also facilitate the removal of debris and smear layers from the canal (37). In mechanical preparation, it is typically advisable to increase the working width of the root canal to remove more infected dentin (38). However, additional root canal variations typically present as narrow, tortuous, curved or communicating with one of the primary root canals. The final working width should be controlled to avoid excessive dentin removal, which may weaken the root structural integrity or result in lateral root perforation (39). Mechanical preparation alone is typically insufficient to completely remove tissue debris and bacterial biofilms, especially in small or irregularly shaped root canals. As a result, effective cleaning and disinfection require the integration of complementary irrigation techniques (40,41). Traditional syringe irrigation, sonic, ultrasonic and negative pressure irrigation systems have been adopted (42). These methods enhance debris removal and more effectively eradicate bacterial biofilms in the apical regions (43).

Root canal obturation represents the final stage of endodontic therapy and aims to hermetically seal the canal system and eliminate residual microorganisms. Optimal obturation is achieved when the filling material terminates precisely at the apical foramen (44). However, apical inflammation or

operator-induced over-preparation may result in sealer extrusion (45). Owing to its superior biocompatibility, iRoot SP is used in contemporary obturation protocols (46). Previous studies have shown that extruded iRoot SP may undergo gradual dissolution in periapical tissue fluids, followed by phagocytosis or encapsulation by fibrous tissue (47-49). Another investigation reported that iRoot SP extrusion does not adversely affect periapical healing (50). Ultimately, the clinical outcome is influenced by both the composition and the amount of extruded sealer. Thus, long-term follow-up is key in patients with sealer extrusion. This represents another limitation of the present report. The presence of a high-density image beyond the apical area in X-ray films suggested extrusion of the sealer material following root canal obturation. Across the follow-up period, the suspicious area of high density appeared to decrease. However, this may still lead to variations in treatment outcomes.

In conclusion, the present report demonstrated that successful retreatment of a mandibular first molar with six canals is achievable through systematic canal exploration and disciplined operative strategies, even without CBCT. Clinicians should suspect additional canals when encountering atypical chamber anatomy or calcification and rely on multi-angled radiographs, DOM-assisted inspection and ultrasonic troughing to localize hidden orifices. Careful long-term follow-up is recommended, particularly when sealer extrusion or extensive root calcification is present.

**Acknowledgements**

Not applicable.

**Funding**

No funding was received.

**Availability of data and materials**

The data generated in the present study may be requested from the corresponding author.

**Authors' contributions**

ML managed the treatment of the patient, conceived the study and collected the clinical data. CW was responsible for analyzing and interpreting the data and wrote the manuscript. ML and CW confirm the authenticity of all the raw data. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

Informed consent was obtained from the patient for all diagnostic and therapeutic procedures described in the present case report. In addition, approval was granted by the Ethics Review Board of Chengdu Third People's Hospital (approval no. 2025-S-83).

**Patient consent for publication**

Written informed consent was obtained from the patient for the publication of the present case report and any accompanying images.

**Competing interests**

The authors declare that they have no competing interests.

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