CASE SERIES

Turk Endod J 2025;10(3):247–253
doi: 10.14744/TEJ.2024.59244

A trilogy tale: Middle mesial canals in permanent mandibular molars - A case series

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The mandibular molars are often conferred with varied anatomies and are more prone to be subject to an endodontic intervention. Therefore, familiarity with these varying aberrant morphologies is of utmost importance to an endodontist. The complex anatomy of permanent mandibular molars, particularly the existence of the middle mesial canals (MMCs), presents significant challenges in endodontic treatment. MMCs can be classified into one of the three types: Fin, confluent, and independent, with the last being the rarest. Inadequacy to identify and treat these canals can precipitate persistent infection and subsequent endodontic failure. This article presents three clinical cases elucidating the detection and management of MMCs in permanent mandibular molars. Advanced diagnostic techniques, including magnification, ultrasonic troughing, and cone-beam computed tomography, can be diligently used to locate and negotiate these canals. All cases involved meticulous cleaning, shaping, and obturation, resulting in successful outcomes. The discussion emphasizes the importance of a systematic approach to canal exploration, the use of modern imaging modalities, and conservative instrumentation to preserve root integrity. The identification and treatment of MMCs are critical for predictable endodontic outcomes. This article underscores the significance of MMCs in endodontics and provides practical insights for their management.

Keywords: Cone-beam computed tomography; endodontic failure; middle mesial canal; permanent mandibular molars; root canal anatomy.

Introduction

The ultimate goal of endodontology is to avert and eradicate apical periodontitis and promote periradicular tissue healing (1). It aims for the reduction of bacterial load and a hermetic three-dimensional filling of the canals. The intricate anatomy of mandibular molars has long posed a challenge in endodontics, particularly with the identification and management of accessory canals. One such aberrancy is the middle mesial canal (MMC) located in the mesial roots of permanent mandibular molars, which has been a subject of intrigue and clinical importance in endodontics. First elaborated by Vertucci et al. (2) and Barker et al. (3) in 1974, the MMC is often overlooked due to its elusive nature and the challenges associated with its detection. A meta-analysis conducted by Al-Maswary et al. (4) in 2023 revealed that the global occurrence of the MMC is 4.4% in permanent mandibular first molars and 1.3% in permanent mandibular second molars. These findings highlight the importance of increased awareness and care-

Cite this article as: Sikdar D, Rohilla S, Pal Singh A, Lau H, Chaudhary M. A trilogy tale: Middle mesial canals in permanent mandibular molars - A case series. Turk Endod J 2025;10:247-253.

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Submitted: March 31, 2025 Revised: July 03, 2025 Accepted: July 07, 2025 Published: December 09, 2025

ful exploration during endodontic treatments to ensure proper identification and management of such anatomical variations.

In a groundbreaking clinical study examining 100 permanent mandibular molars, Pomeranz et al. (5) discovered MMCs in 12 permanent molars and classified them into three distinct morphological types:

Fin: Characterized by the ability of an instrument to freely pass in between the mesiobuccal (MB) or mesiolingual (ML) canal and the MMC.

Confluent: Defined by the MMC originating separately but merging apically with either the MB or ML canal.

Independent: Identified by the MMC originating and terminating as a separate entity with its own foramen.

Goel et al. (6) reported that 15% of permanent mandibular first molars exhibited MMCs in their specimens. Interestingly, only 6.7% of these canals were classified as independent, emphasizing the rarity of distinct MMCs with a separate origin and foramen.

The identification and management of MMCs demand the use of advanced diagnostic tools and a deep comprehension of root canal anatomy. Inability to locate and treat these canals can have dire consequences in the form of persistent infections, unsuccessful treatment outcomes or the necessitation for retreatment. Another factor to pay attention to while dealing with MMCs is the concept of danger zone. The danger zone in mandibular molars refers to the distal aspect of the mesial root, which consists of a thin, straight layer of dentin. This area is particularly vulnerable to strip perforation during root canal instrumentation. The concept of the danger zone and safety zone in mandibular molars was first introduced by Abou-Rass, Frank, and Glick, highlighting their critical role in ensuring safe and effective cleaning and shaping procedures (7). With ongoing advancements in imaging technologies and endodontic instrumentation, clinicians are increasingly equipped to detect and effectively treat these challenging anatomical variations.

This article delves into the morphology, diagnostic considerations, and clinical strategies for addressing MMCs in mandibular molars, providing insights into their significance in achieving predictable endodontic outcomes.

Case Presentation

Case 1

A 16-year-old male patient visited the Restorative and Endodontic Clinic, complaining of spontaneous pain in the lower right molar region. The medical history of the patient was non-contributory. Upon intraoral examination, extensive caries was identified in the permanent right mandibular first molar (Fig. 1A). A radiographic examination using Kodak RVG 5100 sensor (Carestream Health, Inc., Rochester, NY, USA) operated at 70kVp, 8mA with an exposure time of 0.4 sec revealed deep caries in the tooth and no specific pathosis in its periapical tissues (Fig. 1B). Additionally, a moderate periodontal issue was observed in the first molar, and the tooth exhibited tender-

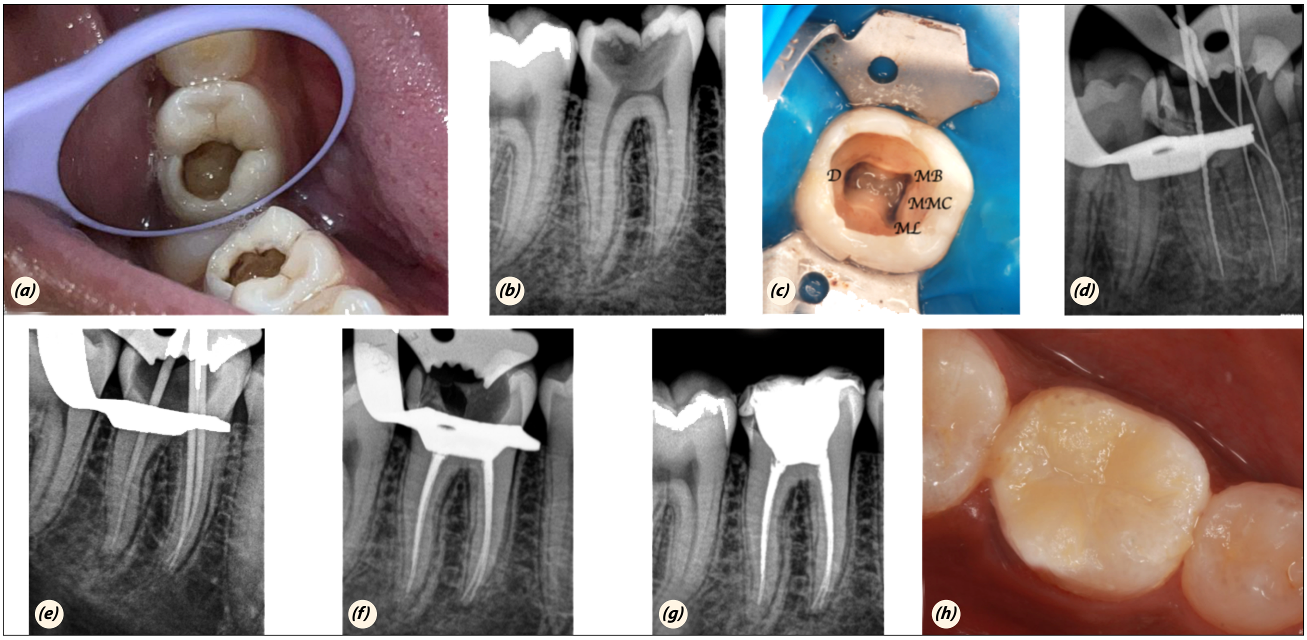

Fig. 1. **a)** Preoperative clinical picture; **b**) Preoperative radiograph #46; **c**) Middle mesial canal; **d**) Working length determination; **e**) Master cone; **f**) Obturation; **g&h**) Post obturation restoration.

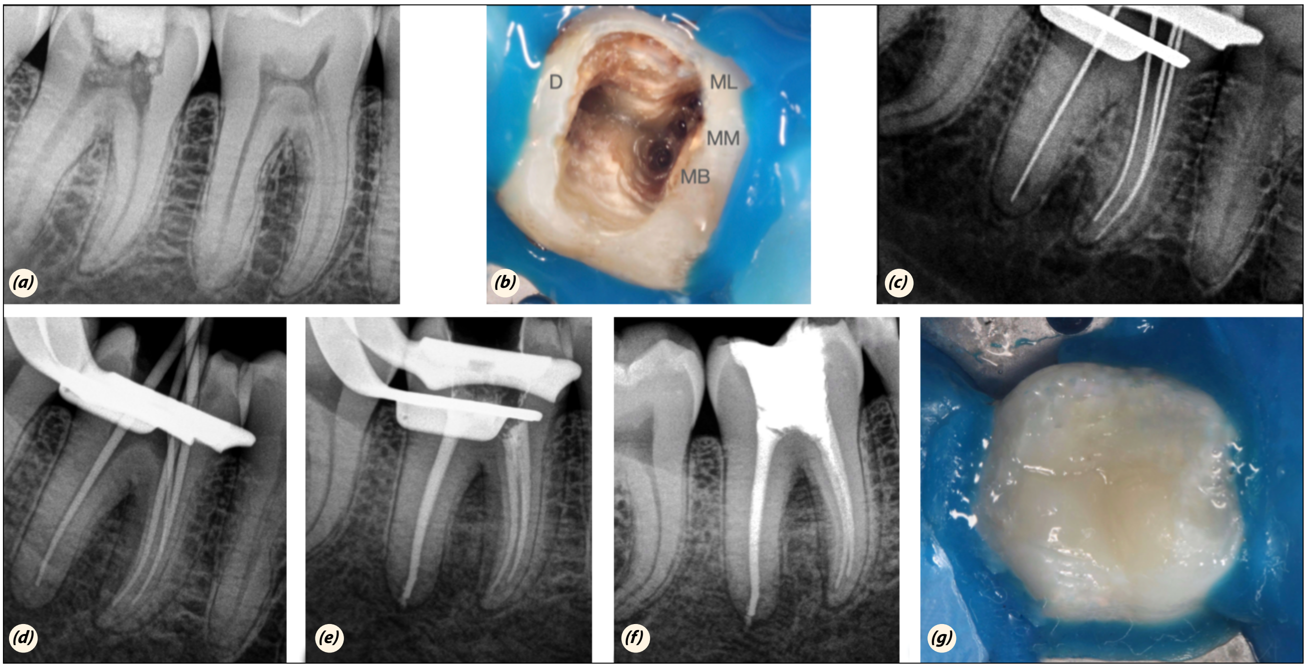

Fig. 2. **a)** Preoperative radiograph #47; **b)** Middle mesial canal; **c)** Working length determination; **d)** Master cone; **e)** Obturation; **f&g)** Post obturation restoration.

ness on percussion. The tooth gave a delayed response to electric pulp tester (EPT). Based on the clinical and radiographic findings, a diagnosis of chronic irreversible pulpitis with symptomatic apical periodontitis in tooth 46 owing to caries was confirmed. An informed consent was obtained before commencing the treatment. After isolating the tooth with a rubber dam, the dental caries was excavated employing diamond burs, and proper endodontic access was achieved. Following thorough irrigation of the pulp chamber, inspection of the chamber floor revealed orifices corresponding to the MB, ML, and distal canals (Fig. 1C).

A thorough examination of the groove between the MB and ML canal orifices using troughing with ultrasonic tip led to the localization of the MMC orifice, which was then subsequently negotiated. The working lengths were taken with the aid of an electronic apex locator (Root ZX; Morita, Tokyo, Japan) and verified radiographically (Fig. 1D). The MMC was found to be of confluent type joining with ML canal apically.

All canals were prepared using NeoEndo Flex rotary instruments (Orikam Healthcare India Private Limited) up to #25, 4% for rest of canals and #20, 4% for MMC with copious irrigation using 3% sodium hypochlorite (NaOCl), 17% ethylenediaminetetraacetic acid (EDTA), and saline. The irrigants were activated with EndoActivator for 30 seconds each time. The canals were then dried with sterile paper points, calcium hydroxide (CH) was placed, and the tooth was temporarily restored with teflon tape (PTFE) and Cavit (Dentsply Sirona). The minimal preparation of the MMC was done to avoid chances of strip perforation in the danger zone.

At the next visit which was one week later, the tooth had become completely asymptomatic. Following verification of the master cones (Fig. 1E), the canals were obturated and sealed with AH Plus sealer (Dentsply DeTrey GmbH, Konstanz, Germany) and gutta-percha (Fig. 1F). A definitive post-endodontic restoration was performed to ensure a good coronal seal and the patient reported no postoperative complications (Fig. 1G; Fig. H).

Case 2

A male patient, 27 years of age, with no significant medical history, came in with pain in the lower right back tooth region. He reported having undergone a restoration procedure five days prior in his native village. A radiograph captured with Kodak RVG 5100 sensor (Carestream Health, Inc., Rochester, NY, USA) operated at 70kVp, 8mA with an exposure time of 0.4 sec revealed a previously initiated RCT in tooth 47 (Fig. 2A). The periodontium was also affected, and the tooth exhibited tenderness to percussion. The tooth showed no response to EPT. A diagnosis of previously initiated root canal therapy with symptomatic apical periodontitis was made. Informed consent was taken before initiating the treatment. After rubber dam isolation of the tooth, the existing restoration was removed, and proper endodontic access was established. Following thorough irrigation of the pulp chamber with 3% NaOCl, inspection of the chamber floor revealed orifices belonging to the MB, ML, and distal canals. The groove extending between the mesiobuccal and mesiolingual canal orifices was carefully examined with a DG-16 probe which led to the discovery of the MMC orifice, which was then negotiated (Fig. 2B). An electronic apex locator (Root ZX; Morita, Tokyo, Japan) was employed to measure the working lengths and verified radiographically. The MMC was confluent with the MLC (Fig. 2C).

The canals were debrided and shaped with the NeoEndo Flex rotary instruments (Orikam Healthcare India Private Limited) up to #25, 4% for all canals except the MMC which was instrumented up to #20, 4% with intermittent irrigation copiously using 3% NaOCl and saline. The irrigants were activated with EndoActivator for 30 seconds each time. The canals were dried with sterile paper points and CH was introduced for one week. The tooth was temporarily restored with PTFE tape in the pulp chamber followed by Cavit (Dentsply Sirona). Minimal preparation of MMC aided in avoiding any iatrogenic perforations in the danger zone.

At the subsequent appointment, the patient reported as asymptomatic. Following verification of the master cone length, the canals were obturated and the sealer used was bioceramic sealer (Bio – C, Angelus) (Fig. 2D; Fig. 2 E). A definitive post endodontic restoration was performed with composite resin and the patient reported no post-operative complications (Fig. 2F; Fig. 2G).

Case 3

A female patient, 16 years of age, with no significant medical history walked into the Department of Conservative Dentistry and Endodontics with a 3–4-day history of pain in the lower right back tooth region. Clinical examination revealed deep occlusal caries in tooth 46, which showed positive responsiveness to EPT and was tender to percussion. Radiographic findings showed occlusal caries approaching the pulp, periradicular radiolucency, and ir-

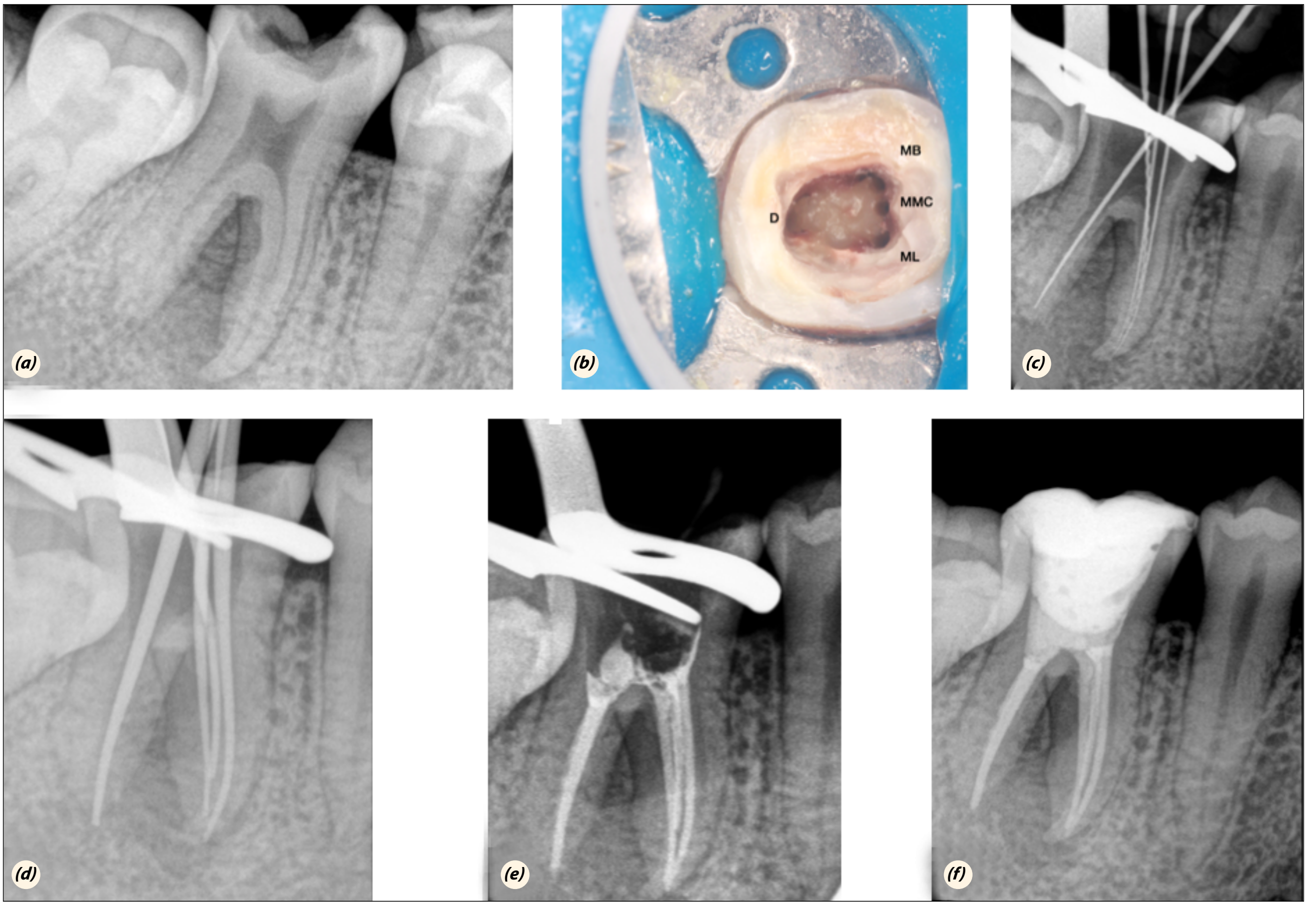

Fig. 3. **a)** Preoperative radiograph #46; **b)** Middle mesial canal; **c)** Working length determination; **d)** Master cone; **e)** Obturation; **g)** Post obturation restoration.

regular root outlines suggestive of external inflammatory resorption, leading to a final diagnosis of chronic irreversible pulpitis with symptomatic apical periodontitis due to caries in 46 and external inflammatory root resorption owing to caries in 46 (Fig. 3A). The RVG was captured using Kodak RVG 5100 sensor (Carestream Health, Inc., Rochester, NY, USA) operated at 70kVp, 8mA with an exposure time of 0.4 sec. Informed consent was taken before the treatment was commenced. After administering local anesthesia and achieving rubber dam isolation, the caries was excavated, and an endodontic access cavity prepared. Inspection of the pulp chamber floor revealed four canal orifices: MB, MM, ML, and distal, with the MMC being confluent with the MBC (Fig. 3B). All canals were negotiated, and working lengths were determined using an apex locator and confirmed radiographically (Fig. 3C). The canals were instrumented using NeoEndo Flex Rotary Files (Orikam Healthcare India Private Limited) up to #25, 4% for all canals except for MMC which was instrumented up to #20, 4% with copious irrigation using 3% NaOCl and saline which was activated using EndoActivator. After drying the canals with sterile paper points, CH was placed in the canals, and the tooth was temporarily restored with Cavit (Dentsply Sirona).

On the subsequent appointment the patient reported no pain or symptoms. The intracanal dressing of CH was removed with sonic agitation using saline. Drying of the canals was accomplished with sterile paper points and the master cone fit checked radiographically (Fig. 3D). Obturation was carried out using Bio-C sealer (Angelus) (Fig. 3E). A post-endodontic restoration was performed to ensure adequate coronal seal (Fig. 3F; Fig. 3G).

Patient Perspective

All three patients are satisfied with the treatment provided and have been kept on follow up.

Discussion

An incidence of as high as 42% missed root canals have been reported in endodontically treated teeth (8). This significant percentage highlights that variability anatomy of the root is more a rule than an exception. Given such morphological aberrancies, it is crucial for clinicians to go beyond predetermined assumptions surrounding the number of roots and root canals.

In the previous study by Al-Maswary et al. (4), the global frequency of occurrence of MMCs in permanent mandibular first molars, was reported to be 4.4% and that in permanent mandibular second molars to be 1.5%. Bansal et al. (9) revealed much higher prevalence of MMC in mandibular first and second molars, ranging from 16% to 60%. Prevalence of the MMCs was lower (9%) and is at the lower end of the reported range in the international literature as reported by Palottil et al. (10) for an Indian subpopulation. Srivastava et al. (11) found that 24 MMCs were fused with MB and ML and 2 MMCs were independent. Another important factor found in conjunction with the MMC is the occurrence of isthmus in these teeth. According to Tahmasbi et al. (12) as high as 64.7% frequency of isthmus was reported in the mesial roots of mandibular molars. According to Bharatiya et al. (13) there was an almost equal division of male and female patients and the overall prevalence rate for MMC was found to be 8.6%. Therefore, a meticulous and stepwise approach is essential for identifying these anatomical variations. This includes broad anticipation of anomalies, coupled with clinical precision through the use of adequately-exposed and properly processed periapical radiographs taken from multiple angulations, enhanced visualization with Loupes or dental operating microscopes and accessory illumination, the use of front-surface mirrors, optimal access cavity preparation, and a careful intra- and inter-canal exploration. This sort of a diligent approach helps in achieving the best possible outcome for endodontic treatment of teeth.

Krasner and Rankow investigated the relationship between the pulp chamber, the clinical crown, and the pulp chamber floor, establishing a set of laws that provide clinicians with valuable guidance for locating difficult-to-find canals (14). One of the primary reasons for treatment failure in endodontics is the inadequacy to detect additional canals or recognize unusual canal configurations (15,16).

To address these challenges, conservative techniques utilizing an ultrasonic tip or round bur to trough which can effectively remove dentinal protuberances obstructing access to the groove extending between the mesiolingual and mesiobuccal canal orifices. Once access to the developmental groove is achieved, a conscientious examination with the sharp pointed tip of an endodontic explorer often aids in locating the elusive MMC orifice. If a depression or orifice is identified, ultrasonic tips can be used to trough the groove, enabling negotiation of the intermediate canal with a small file. Aside from these, Micro-Openers (Dentsply Maillefer, Switzerland), various dyes like methylene blue, champagne bubble test, endodontic explorers are other methods for detecting extra canals.

Advanced imaging techniques are equally critical. Digital radiographs taken at different angulations provide essential observations regarding canal configurations. La et al. (17) advocated the use of cone-beam computed tomography (CBCT) for the clinical detection and effective management of independent middle mesial canals in permanent mandibular first molars.

The canals can be obturated using single cone technique with appropriate sealer or for a better seal be obturated with warm vertical compaction of gutta percha for the apical 5mm using a downpacking technique with System B and followed by back packing using a thermoplastizing unit (eg. Obtura III, Calamus, Ultrafil 3D etc.) which have been shown to produce a good seal with the least amount of voids in the obturation.

Despite that a number of authors have acquiesced the presence of three orifices in the mesial root, reports of three independent canals remain rare. This additional MMC may either have a separate orifice and remain independent or merge with the mesiobuccal or mesiolingual canal in the apical direction.

Given these anatomical characteristics, the MMC should not be overly enlarged to prevent the risk of perforation as it often has a diameter smaller than the mesiobuccal and mesiolingual canals. Engaging the use of Gates-Glidden drills should be approached with extreme skepticism when necessary to minimize the likelihood of weakening the root structure or better still avoided altogether. A conservative approach to canal preparation is essential to preserve the integrity of the mesial root and ensure successful treatment outcomes.

This case series lags in the aspect of failing to employ the use of CBCT which has been proven to be a useful adjunct in diagnosing aberrant morphologies of root canal systems.

Conclusion

Treating additional aberrant canals presents significant challenges; however, failing to locate and treat these canals is a leading cause of endodontic failures. A thorough investigative radiological evaluation, adjunct by the use of CBCT is greatly helpful in locating the additional aberrant canals. Aided by good visualisation, magnification with loupes or dental operating microscope, a good rubber dam isolation ensures longevity of the endodontic treatment in the long term.

Authorship Contributions: Concept: D.S.; Design: S.R.; Supervision: S.R., H.L.; Materials: M.C.; Data: D.S.; Analysis: S.R.; Literature search: S.R.; Writing: D.S.; Critical revision: A.P.S.

Use of AI for Writing Assistance: Not declared

Source of Funding: None declared.

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval: Ethical approval was not required for this study.

Informed consent: Written informed consent was obtained from patients who participated in this study.

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