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Case Report

Four distal root canals in a two-rooted permanent mandibular first molar: Report of a rare case, its incidence, and literature review

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ABSTRACT

Understanding root canal anatomy and its variations is an essential part of the success of endodontic treatment. This case report represents an extremely rare occurrence of four distal root canals in a two-rooted mandibular first molar (MFM). Nonsurgical endodontic treatment of MFM was performed with the aid of the dental operating microscope and ultrasonic troughing tips. PubMed database (www.ncbi.nim.nih.gov/pubmed) was searched for relevant articles using specific search terminologies for conducting the literature review. Data extraction was performed in relation with the inclusion and exclusion criteria provided in the study. Quantitative data synthesis was performed. Only four cases (including the present case) of four distal root canals in two-rooted MFMs have been reported in dental literature. Among these, three cases were reported in the Indian population. The overall incidence of four canals in a distal root of two-rooted MFMs is 0.09% according to clinical/laboratory studies. The most common distal root canal configurations of two-rooted MFMs found in clinical/laboratory studies were Vertucci type I (68.15%) followed by type II (37.6%) and type III (35.08%). A meticulous understanding of the anatomical variations, preoperative awareness, and intraoperative care to identify the landmarks of usual as well as any unusual anatomy of the root canal system will help to increase the rate of clinical success.

Keywords: Anatomic variations, distal root canals, endodontic treatment, mandibular first molar

INTRODUCTION

A clinician needs to invest thorough and exhaustive efforts to find extra root canals. Failure to locate and treat the extra canals contributes to unsuccessful root canal treatment. Incidences of missed roots or canals among the teeth requiring endodontic retreatment have been reported to be as high as 42%.[1] The prevalence of missed canals was reported to be 11.2% in mandibular first molars (MFMs).[2] In that, 86% of the missed canals were found in distal roots and 14% in mesial roots.[3] Missed canals remain untreated and act as a nidus for infection containing pulp tissue remnants, microbiota, and irritants which inevitably compromise the treatment outcome.

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The typical prevalent canal morphology of MFM is the presence of two roots with either three or four root canals. There are many reported cases in the literature regarding the presence of three distal root canals in two-rooted MFMs,[4] but limited data are available for more than three distal root canals in two-rooted MFMs.[5-7] This case report with a literature review aims to present a very rare anatomical variation of four distal root canals in a two-rooted MFM.

CASE REPORT

A 25-year-old male patient reported to the department of conservative dentistry and endodontics with pain in

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the mandibular left first molar for 2 days. The patient's medical history was noncontributory and vital signs were within normal limits. Clinical examination revealed a deep proximo-occlusal carious lesion involving the pulp in relation to the left MFM. The tooth was tender on vertical percussion and palpation. Pulp testing using cold test and electrical pulp tester elicited a negative response. There was no sinus tract present in the involved tooth. Radiographic examination revealed a deep carious lesion involving the distal pulp horn and widening of the periodontal ligament space [Figure 1a]. Clinical and radiographic findings led to a diagnosis of symptomatic irreversible pulpitis with symptomatic apical periodontitis. Nonsurgical endodontic treatment was planned for the patient.

The tooth was anesthetized with 1.8 ml of 2% lignocaine containing 1:200,000 adrenaline (Lignox A 2% Indoco Remedies, Mumbai, India). Caries excavation was done from the distal aspect of tooth using a high-speed airotor. Pre-endodontic build-up was performed using posterior composite resin (P60, 3M Dental Products, St Paul, MN, USA). Under rubber dam isolation, an endodontic access cavity was prepared with a nonend cutting tapered fissure bur (Endo-Z, Dentsply Maillefer, Ballaigues, Switzerland). Initially, three canal orifices, namely mesiobuccal (MB), mesiolingual (ML), and distobuccal (DB), were located in the first step and following the first law of symmetry by Krasner and Rankow, a distolingual (DL) canal was located under dental operating microscope (DOM). In the second step, mid mesial (MM) canal exploration was done using a DG 16 endodontic explorer (Hu-Friedy, Chicago, IL, USA). As DB and DL canals were widely separated, exploration using START-X #3 ultrasonic tip (Dentsply Sirona, Ballaigues, Switzerland) was carried out along the isthmus, extending between them in the third step. Further, two additional canals were located in-between DB and DL canals. Hence, a total of seven canal orifices were located, three within the mesial root and four in the distal root [Figure 1b]. According to the proposed anatomically based nomenclature, these canals were termed MB, MM, and ML in the mesial root and DB, linguo-DB (L-DB), bucco-DL (B-DL), and DL in the distal root.[8] Initial canal negotiation was carried out with #8 and #10 K-files (Mani, Inc., Tochigi, Japan). Working length was estimated with an apex locator (Root ZX mini-J Morita MFG. Corp., Kyoto, Japan) and confirmed with digital radiographs [Figure 1c]. A cone-beam computed tomography (CBCT) scan is considered to be an important diagnostic tool for confirmation of the complex configurations of root canals, but it was not feasible at that time. Intraoral working length radiograph clearly indicated toward the existence of 3-2 configuration in the mesial root and 4-3-2-1 configuration in the distal root. Cleaning and shaping was performed using Hyflex CM rotary files (Coltène/Whaledent, Langenau, Germany). Irrigation was performed using normal saline and 2.5% sodium hypochlorite solution (Prime Dental Products, Thane, India). A side-vented irrigation needle (RCT vents irrigation needle, Prime Dental Products Pvt. Ltd., Mulund, Mumbai) was used during irrigation. Nonsetting calcium hydroxide dressing was placed for 1 week. By the second appointment, the patient was asymptomatic. 17% ethylenediaminetetraacetic acid (Pulpdent Corporation, Watertown, MA, USA) followed by 2% chlorhexidine digluconate (Prime Dental Products, Mumbai, India) were used as the final irrigants which were agitated using sonic activation (Endoactivator, Dentsply Maillefer, USA). Master cone radiograph was taken followed by cold lateral compaction using AH Plus epoxy resin-based sealer (Dentsply Maillefer, Konstanz, Germany) and Hyflex CM gutta-percha points (Coltène/Whaledent) [Figure 1d]. The access cavity was then restored with posterior composite resin (P60, 3M Dental Products, St Paul, MN, USA), and a full-coverage crown was given [Figure 1e]. A CBCT scan of the mandibular left first molar region was obtained to confirm the quality of the treatment done, with exposure parameters of 90 kV and 7 mA. A complete morphology of

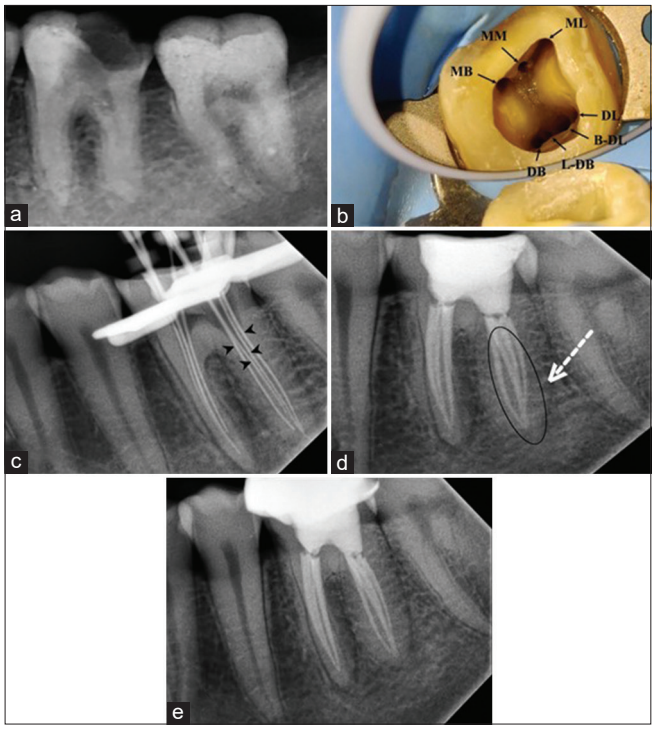

Figure 1: (a) Intraoral periapical radiograph showing deep proximoocclusal carious lesion involving pulp (b) clinical view of the access cavity preparation showing seven distinct root canal orifices; MB, MM, ML, DB, L-DB, B-DL, and DL. (c) Working length radiograph. Four distal root canals are clearly illustrated (black arrows). (d) Postobturation radiograph. A white dotted arrow indicates 4-3-2-1 distal root canal configurations. (e) Follow up radiograph with a permanent restoration. MB: Mesio-buccal, MM: Mid-mesial, ML: Mesio-lingual, DB: Distobuccal, L-DB: Linguo-distobuccal, B-DL: Bucco-distolingual, DL: Distolingual

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the root canal system was obtained in coronal, axial, and sagittal sections of 0.15-mm thickness. CBCT revealed four distal root canals [Figures 2a and 3a], which merged into three in the middle third [Figures 2b and 3b], followed by two [Figures 2c and 3c] and ultimately one apical foramen [Figures 2d and 3d] in the apical third of the distal root.

Literature review

Selection of data

The PubMed database (http://www.ncbi.nlm.nih.Gov/PubMed, last accessed 27 September 2020) was searched for relevant articles using a combination of the following search terms: mandibular first molar, distal root, and four root canals.

Extraction of data

A total of 575 studies were identified with search terminologies. After removal of duplicate articles, the titles and abstracts of the remaining articles were independently assessed for relevance by two of the four authors of this literature review. Potentially relevant full-text articles were retrieved according to the inclusion criteria provided later. The reference list of each article was then manually checked for further eligible articles.

Inclusion and exclusion criteria

The inclusion criteria were as follows:

- Studies that reported distal root canal configurations of two-rooted MFM
- Studies that evaluated root canal configurations only on permanent molars
- Studies that were published in the English language
- Studies that were published in a peer-reviewed journal.

The exclusion criteria were as follows:

- Studies that could not be retrieved in full texts
- Systemic review and meta-analysis.

Data synthesis

Overall, 23 studies (10 clinical, 13 laboratories) and 4 case reports (including presented case) matched with the inclusion criteria and were selected for further analysis [Figure 4].

Table 1 presents the following information from the clinical/laboratory studies:[9-31]

- The study author(s) and year of publication
- The country in which the study was performed and the method used to study the internal morphology
- The study samples (number of distal roots and origin of the sample, if mentioned)
- The incidence of four canals in a distal root of two-rooted MFM
- The root canal configurations of distal root according to Vertucci's classification and its variations
- The root canal configurations of distal root other than Vertucci's types.

Table 2 presents the following information from the reported cases:

- The study author (s) and year of publication
- The country in which the treatment was performed
- The age and sex of the patient
- Location (right or left) of the treated tooth
- The internal root canal morphology
- The diagnostic tools were used to detect and/or confirm the presence of extra canals.

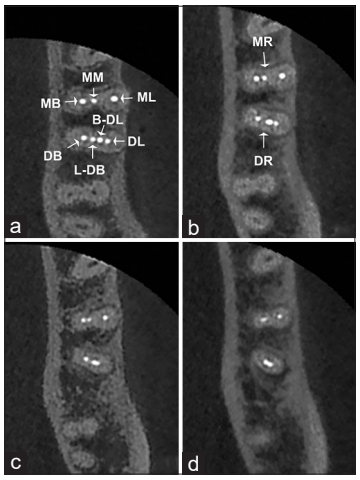

Figure 2: CBCT axial sections at different levels (a-d) showing a MR and a DR as well as 4-3-2-1 root canal configurations in a single distal root. CBCT: Cone beam computed tomography, MR: mesial Root, DR: Distal root

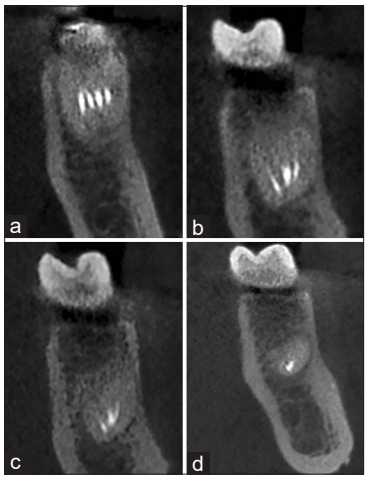

Figure 3: CBCT coronal sections (a-d) showing 4-3-2-1 root canal configurations within the distal root. CBCT: Cone beam computed tomography

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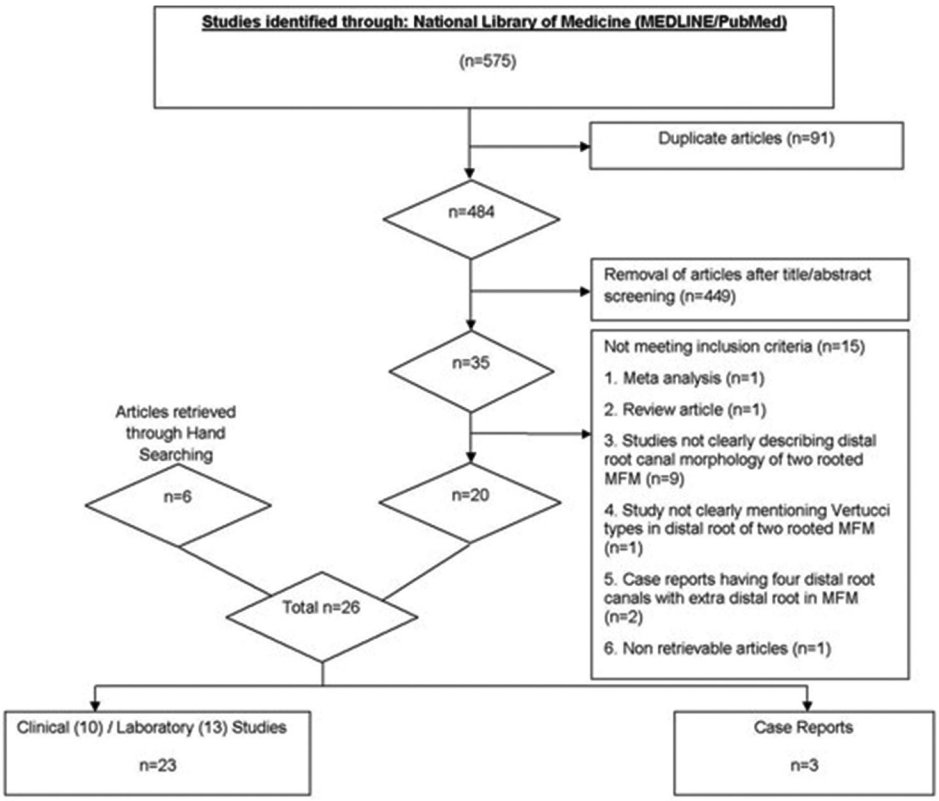

Figure 4: Flow chart describing data retrieval for the literature review

Incidence of four distal root canals in two-rooted mandibular first molar

A total of 23 studies (n = 7843 teeth) reported data on root canal configurations in the distal root of two-rooted MFMs. The incidence of four distal root canals in two-rooted MFMs was found 0.09%. This very low incidence is indicative of a very rare occurrence.

Internal morphology of distal root canals in two-rooted mandibular first molars according to Vertucci types

A total of 7725 two-rooted MFMs were reported for distal root canal configurations according to Vertucci types. Here, the most common Vertucci types of canal configurations were type I (68.15%) followed by type II (37.6%), type III (35.08%), type IV (9.79%), type V (1.262%), type VI (0.15%), type VII (0.09%), and type VIII (0.026%).

Internal morphology of distal root canals according to additional types in Vertucci's classification

Many different classification systems for classifying canal configurations in mandibular molars have been proposed by different authors. However, some of the complex root canal configurations are yet not possible to classify by these classifications. Hence, Ahmed *et al*.[32] introduced a new classification system that can categorize more complex root and root canal configurations. It can be used easily and precisely in research, clinical practice, and training. In the presented case, root canal configurations can be classified as $^{2}36M^{3\text{-}2}D^{4\text{-}3\text{-}2\text{-}1}$ according to Ahmed *et al*.[32]

DISCUSSION

MFM is acknowledged to reveal a complex and wide range of variations in the morphology of its root canal system.[4] Baziar *et al*.[5] reported the first case of four distal root canals in a two-rooted MFM. Later, Sinha *et al*.[6] and Arora *et al*.[7] also reported four distal root canals in a two-rooted MFM. Various studies using different methods to present the root canal configurations of distal roots have also been found in the literature. Among them, only three studies reported the occurrence of four distal root canals in two-rooted MFMs. Filpo-Perez *et al*.[19] and Wolf *et al*.[25] reported the complex configurations of four root canals in a distal root according to the path they take from root canal orifices to apical foramina by Micro-CT evaluation. Peiris *et al*.[22] also found four distal root canals in a two-rooted MFM by clearing technique.

Various terminologies have been employed in dental literature to describe the roots and root canal systems of mandibular molars. Traditional popular terms are simple to use but inappropriate and imprecise in terms of anatomically locating the canals. A new nomenclature based on an anatomical

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Table 1: Distal root canal configurations in two-rooted mandibular first molar

Author	Year	Country	Study method	Sample (distal root)	Root canal configurations (according to Vertucci classification), *n* (%)	Root canal configurations other than Vertucci, *n* (%)
Gulabivala *et al*.[9]	2001	Burmese	*In vitro*, clearing technique	Group 2 104 Group 3 21	Group 1 (excluded due to extra distal root) Group 2 (two separate roots – both mesial and distal roots are flat mesio-distally) Type I: 63 (60.6) Type II: 16 (15.4) Type III: 3 (2.9) Type IV: 14 (13.4) Type V: 4 (3.8) Type VI: 3 (2.9) Group 3 (two separate roots – mesial roots are flat mesio-distally, distal roots are conical) Type I: 17 (81) Type II: 4 (19)	Group 2 2-3: 1 (12.5)
Wasti *et al*.[10]	2001	South Asian Pakistanis	*In vitro*, clearing technique	30	Type I: 9 (30) Type II: 8 (26.7) Type IV: 6 (20.0) Type V: 6 (20.0) Type VI: 1 (3.3)	
Gulabivala *et al*.[11]	2002	Thai	*In vitro*, clearing technique	103	Type I: 70 (67.9) Type II: 5 (4.8) Type III: 4 (3.9) Type IV: 17 (16.5) Type V: 3 (2.9) Type VIII: 2 (1.9)	2-3: 2 (1.9)
Al-Qudah and Awawdeh[12]	2009	Jordanian	*In vitro*, clearing technique	317	Type I: 168 (50.9) Type II: 56 (17) Type III: 15 (4.5) Type IV: 30 (9.1) Type V: 36 (10.9) Type VI: 4 (1.2) Type VII: 2 (0.6)	2-1-2-1: 2 (0.6) 2-3: 3 (0.9) 3-1: 1 (0.3)
Rwenyonyi *et al*.[13]	2009	Ugandan	*In vitro*, clearing technique	224	Type I: 190 (84.8) Type II: 3 (1.3) Type III: 2 (0.9) Type IV: 21 (9.4) Type V: 6 (2.7) Type VI: 2 (0.9) Type VII: 0	
Wang *et al*.[14]	2010	Western, Chinese	*In vivo*, CBCT	410	Type I: 258 (62.9) Type II: 40 (9.7) Type III: 3 (0.7) Type IV: 103 (25.1) Type V: 2 (0.5)	2-3: 2 (0.5) 2-3-2: 2 (0.5)
Chourasia *et al*.[15]	2012	Indian	*In vitro*, clearing technique	150	Type I: 98 (65.3) Type II: 31 (20.6) Type III: 2 (1.3) Type IV: 14 (9.3) Type V: 5 (3.3)	
Kim *et al*.[16]	2013	Korean	*In vivo*, CBCT	1435 (female - 772 and male - 663)	Female Type I: 502 Type II: 155 Type III: 2 Type IV: 101 Type V: 12 Male Type I: 454 Type II: 118 Type III: 2 Type IV: 69 Type V: 18	Male 2-3: 2

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Table 1: Contd...

Author	Year	Country	Study method	Sample (distal root)	Root canal configurations (according to Vertucci classification), *n* (%)	Root canal configurations other than Vertucci, *n* (%)
Demirbuga *et al*[17]	2013	Turkish	*In vitro*, CBCT	Female – 460 Male – 361	Female Type I: 383 (83) Type II: 30 (6.5) Type III: 15 (3.25) Type IV: 28 (6.07) Type V: 4 (0.86) Male Type I: 288 (79.5) Type II: 24 (6.62) Type III: 15 (4.14) Type IV: 21 (5.8) Type V: 13 (3.59)	
Nur *et al*.[18]	2014	Turkish	*In vivo*, CBCT	Female – 471 Male – 589	Female Type I: 282 (60) Type II: 65 (14) Type III: 9 (2) Type IV: 95 (20) Type V: 20 (4) Male Type I: 349 (59) Type II: 68 (11) Type III: 12 (2) Type IV: 110 (19) Type V: 50 (8)	
Filpo-Perez *et al*.[19]	2015	Brazilian	*In vivo*, Micro-CT	100	Type I: 76 (76) Type II: 3 (3) Type IV: 1 (1) Type V: 7 (7)	2-1-2-1: 1 1-2-3: 4 1-3-1-2: 1 3-2-3-2-1: 1 1-2-3-2-1: 1 1-2-1-2-1-2: 1 1-2-1-2-1-3: 1 1-2-3-2-4-2: 1 2-1-2-1-2-1-2-3-2-4: 1 1-2-3-4-3: 1
Mukhaimer[20]	2014	Palestinian	An *ex vivo*, CBCT	320	Type I: 184 (57.5) Type II: 72 (22.5) Type III: 34 (10.6) Type IV: 26 (8.1) Type V: 4 (1.3)	
Torres *et al*.[21]	2015	Belgian and Chilean	*In vivo*, CBCT	Belgian – 140 Chilean – 137	Belgian Type I: 102 (72.86) Type III: 24 (17.14) Type V: 13 (9.29) Type VII: 1 (0.71) Chilean Type I: 108 (78.83) Type III: 17 (12.4) Type V: 8 (5.84) Type VII: 4 (2.92)	
Peiris *et al*.[22]	2015	Sri Lankan	*In vitro*, clearing technique	386	Type I: 252 (65.28) Type II: 18 (4.66) Type III: 37 (9.59) Type IV: 22 (5.70) Type V: 50 (12.95) Type VI: 1 (0.26)	1-2-3-2: 3 2-3-4: 1
Zafar and Alrahabi[23]	2015	Saudi Arabia	*In vitro*, CBCT	100	Type I: 80 (80) Type II: 2.5 (2.5) Type III: 10 (10) Type V: 7.5 (7.5)	
Faraz *et al*.[24]	2015	Pakistani	*In vitro*, clearing technique	123	Type I: 81 (65.8) Type II: 18 (14.6) Type IV: 24 (19.5)	

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Author	Year	Country	Study method	Sample (distal root)	Root canal configurations (according to Vertucci classification), *n* (%)	Root canal configurations other than Vertucci, *n* (%)
Wolf *et al*.[25]	2016	Egyptian	An *ex vivo*, Micro-CT	118		1-1-1/1: 69 1-1-1/2: 12 1-1-2/2: 5 1-1-1/3: 4 1-1-2/3: 4 2-2-1/1: 4 2-2-2/2: 4 1-2-2/2: 2 2-1-1/1: 2 2-2-2/3: 2 1-2-1/1: 1 1-2-1/2: 1 1-2-2/3: 1 1-2-3/3: 1 2-1-1/2: 1 2-2-1/2: 1 2-2-3/3: 1 1-1-1/4: 3 (2.5)
Caputo *et al*.[26]	2016	Brazilian	*In vivo* CBCT	342	Distal right root Type I: 130 (77.8) Type II: 10 (6) Type III: 17 (10.2) Type IV 4 (2.04) Type V: 6 (3.6) Distal left root Type I: 132 (75.4) Type II: 12 (6.9) Type III: 21 (12) Type IV: 3 (1.7) Type V: 7 (4)	
Celikten *et al*.[27]	2016	Turkish Cypriot	*In vivo*, CBCT	Female – 199 Male – 182	Type I: 174 (87.4) Type II: 15 (7.5) Type III: 1 (0.5) Type IV: 9 (4.5) Type I: 146 (80.2) Type II: 30 (16.4) Type IV: 4 (2.1) Type V: 1 (0.5) Type VI: 1 (0.5)	
Pérez-Heredia *et al*.[28]	2017	Spanish	*In vivo*, CBCT	119	Type I: 86 (72.3) Type II: 22 (18.5) Type III: 7 (5.9) Type IV: 3 (2.5)	2-3-2: 1 (0.8)
Madani *et al*.[29]	2017	Iranian	*In vivo*, CBCT	149	Type I: 119 (79.8) Type II: 16 (10.7) Type III: 7 (4.6) Type IV: 5 (3.3) Type V: 2 (1.3)	
Madjapa and Minja[30]	2018	Tanzanian	*In vitro*, clearing technique	146	Type I: 87 (59.6) Type II: 39 (26.7) Type IV: 20 (13.7)	
Kantilieraki *et al*.[31]	2019	Greek	*In vivo*, CBCT	461	Type I: 377 (81.7) Type II: 58 (12.6) Type III: 12 (2.6) Type IV: 7 (1.5) Type V: 3 (0.6)	

Total number of samples=7843, Overall incidence of four distal root canals (7843/7)=0.09%, Samples examined for Vertucci types=7725. CBCT: Cone-beam computed tomography, CT: Computed tomography

position has been proposed for an extensive anatomical description of the roots and root canals in mandibular molars by Valerian Albuquerque *et al*.[8] The proposed nomenclature helps to precisely name roots and canals, inclusive of complex morphologic variations, based on anatomical considerations. According to the proposed nomenclature, the distal root canal system of the presented case has been described as having DB, L-DB, bucco-DL (B-DL), and DL canals.

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Table 2: Case reports of four distal root canals in two-rooted mandibular first molar

Author	Year	Country	Tooth	Age	Sex	Type of study	Distal root canal configuration	Aids to locate/confirm extra canal
Baziar *et al*.[5]	2014	Iran	36	42	Male	Clinical RCT	According to Sert and Bayirli Type XIV (4-2) canal configurations	CBCT
Sinha *et al*.[6]	2014	India	46	18	Female	Clinical RCT	According to Sert and Bayirli Type XIV (4-2) canal configurations	CBCT, ultrasonic tips
Arora *et al*.[7]	2015	India	36	30	Female	Clinical RCT	According to Gulabivala supplemental canal configurations Type XI (4-2)	Exploring (DG-16), magnification (loupes)
Present case	2020	India	36	25	Male	Clinical RCT	According to new proposed classification $^{2}36M^{3-2}D^{4-3-2-1}$	Exploring (DG-16), ultrasonic tip, magnification (DOM)

CBCT: Cone-beam computed tomography, RCT: Root canal treatment, DOM: Dental operating microscope

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Clinical considerations

The risk of missing the anatomy during root canal treatments is high due to the complexity of the root canal system. Any type of root canal configuration is possible in any tooth. There is an increased probability of finding aberrant canal configurations in premolars and molars.[33]

Multiple angulated preoperative radiographs are invaluable prerequisites for root canal treatment. A proper access cavity preparation is of prime importance in localizing the orifices of the root canals. The symmetry, shape, and position of canal orifices and the developmental root fusion lines should be carefully evaluated. If only a narrow, round distal canal orifice is found that is not centered in the root, other canal orifices should be suspected. If two orifices are found further apart than their usually assumed position, extra canals should be suspected between them. To find hidden and extra canals, an adequate armamentarium is required; the DOM will provide enhanced lighting and visibility, whereas ultrasonic tips (US) will allow a controlled and delicate removal of calcifications and other interferences to the canal orifices. According to Keleş and Keskin,[34] an association of the DOM with ultrasonic troughing might improve root canal orifice detection.

Broad, flat roots are much more likely to contain multiple canals and intercanal ramifications than conical roots. From CBCT, the actual buccolingual width of the root can be determined, and detection of multiple canals becomes easier.

Vertucci found the proximity of the canal orifices to each other as an indicative factor of whether they are fused or remain as separate canals. It was found that when the separation was more than 3 mm, the canals remained separate, whereas they fused together if it was lesser. When the distance between root canal orifices reduced, they were found to fuse more coronally.

Branched canal configurations and other additional canal types may render complete debridement of canal systems difficult. The use of manual agitation, positive and negative apical pressure technique, sonic and ultrasonic activation, photon-induced photoacoustic streaming, and photodynamic therapy may help to reach the inaccessible areas of the root canal system.

During biomechanical preparation, the intermediate canal should not be enlarged as much as the main canal because of loss of more amount of radicular dentin, which decreases the prognosis of endodontically treated tooth. If two or all of the canals share a common apical foramen, the canal with direct access to the apex is prepared and obturated up to the full working length, while other canal (s) are supposed to be filled up to the junction points. In this situation, the nickel–titanium rotary instruments should be preceded by hand files to avoid buckling and instrument separation. Missed or untreated root canals have resulted in an adverse effect on endodontic outcomes. According to Baruwa *et al*.,[2] endodontically treated teeth with missed canals presented 4.4 times higher odds of being associated with periapical lesions than the endodontically treated teeth without missed canals.

CONCLUSION

Awareness of highly complex canal configurations, incorporation of adequate clinical skills, use of DOM with ultrasonic troughing for detection of orifices, and novel technological devices for debridement and obturation will lead to a successful endodontic outcome.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Hoen MM, Pink FE. Contemporary endodontic retreatments: An analysis based on clinical treatment findings. J Endod 2002;28:834-6.
2. Baruwa AO, Martins JN, Meirinhos J, Pereira B, Gouveia J, Quaresma SA, *et al.* The influence of missed canals on the prevalence of periapical lesions in endodontically treated teeth: A cross-sectional study. J Endod 2020;46:34-9.e1.
3. Witherspoon DE, Small JC, Regan JD. Missed canal systems are the most likely basis for endodontic retreatment of molars. Tex Dent J 2013;130:127-39.
4. Beyraghshamshir R, Zarei M, Sekandari, S. A mandibular first molar with three distal canals: A case report and literature review. Iran Endod J 2019;14:216-9.
5. Baziar H, Daneshvar F, Mohammadi A, Jafarzadeh H. Endodontic management of a mandibular first molar with four canals in a distal root by using cone-beam computed tomography: A case report. J Oral Maxillofac Res 2014;5:e5.
6. Sinha N, Singh B, Langaliya A, Mirdha N, Huda I, Jain A. Cone beam computed topographic evaluation and endodontic management of a rare mandibular first molar with four distal canals. Case Rep Dent 2014;2014:306943.
7. Arora A, Acharya SR, Sharma P. Endodontic treatment of a mandibular first molar with 8 canals: A case report. Restor Dent Endod 2015;40:75-8.
8. Valerian Albuquerque D, Kottoor J, Velmurugan N. A new anatomically based nomenclature for the roots and root canals-part 2: Mandibular molars. Int J Dent 2012;2012:814789.
9. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. Int Endod J 2001;34:359-70.
10. Wasti F, Shearer AC, Wilson NH. Root canal systems of the mandibular and maxillary first permanent molar teeth of south Asian Pakistanis. Int Endod J 2001;34:263-6.
11. Gulabivala K, Opasanon A, Ng YL, Alavi A. Root and canal morphology of Thai mandibular molars. Int Endod J 2002;35:56-62.
12. Al-Qudah AA, Awawdeh LA. Root and canal morphology of mandibular first and second molar teeth in a Jordanian population. Int Endod J 2009;42:775-84.
13. Rwenyonyi CM, Kutesa A, Muwazi LM, Buwembo W. Root and canal morphology of mandibular first and second permanent molar teeth in a Ugandan population. Odontology 2009;97:92-6.
14. Wang Y, Zheng QH, Zhou XD, Tang L, Wang Q, Zheng GN, *et al.* Evaluation of the root and canal morphology of mandibular first permanent molars in a western Chinese population by cone-beam computed tomography. J Endod 2010;36:1786-9.
15. Chourasia HR, Meshram GK, Warhadpande M, Dakshindas D. Root canal morphology of mandibular first permanent molars in an Indian population. Int J Dent 2012;2012:745152.
16. Kim SY, Kim BS, Woo J, Kim Y. Morphology of mandibular first molars analyzed by cone-beam computed tomography in a Korean population: Variations in the number of roots and canals. J Endod 2013;39:1516-21.
17. Demirbuga S, Sekerci AE, Dinçer AN, Cayabatmaz M, Zorba YO. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular first and second molars in Turkish individuals. Med Oral Patol Oral Cir Bucal 2013;18:e737-44.
18. Nur BG, Ok E, Altunsoy M, Aglarci OS, Colak M, Gungor E. Evaluation of the root and canal morphology of mandibular permanent molars in a south-eastern Turkish population using cone-beam computed tomography. Eur J Dent 2014;8:154-9.
19. Filpo-Perez C, Bramante CM, Villas-Boas MH, Húngaro Duarte MA, Versiani MA, Ordinola-Zapata R. Micro-computed tomographic analysis of the root canal morphology of the distal root of mandibular first molar. J Endod 2015;41:231-6.
20. Mukhaimer RH. Evaluation of root canal configuration of mandibular first molars in a Palestinian population by using cone-beam computed tomography: An *ex vivo* study. Int Sch Res Notices 2014;2014:583621.
21. Torres A, Jacobs R, Lambrechts P, Brizuela C, Cabrera C, Concha G, *et al.* Characterization of mandibular molar root and canal morphology using cone beam computed tomography and its variability in Belgian and Chilean population samples. Imaging Sci Dent 2015;45:95-101.
22. Peiris R, Malwatte U, Abayakoon J, Wettasinghe A. Variations in the root form and root canal morphology of permanent mandibular first molars in a Sri Lankan population. Anat Res Int 2015;2015:803671.
23. Zafar M, Alrahabi M. Cone beam computed tomography for exploring morphology of mandibular first molar. Br J Med Med Res 2015;6:514-21.
24. Faraz SA, Tariq A, Jameel A. Root canal morphology of mandibular first permanent molars – Karachi sample. Pak Oral dent 2015:35;294-8.
25. Wolf TG, Paqué F, Zeller M, Willershausen B, Briseño-Marroquín B. Root canal morphology and configuration of 118 mandibular first molars by means of micro-computed tomography: An *ex vivo* study. J Endod 2016;42:610-4.
26. Caputo BV, Noro Filho GA, de Andrade Salgado DM, Moura-Netto C, Giovani EM, Costa C. Evaluation of the root canal morphology of molars by using cone-beam computed tomography in a Brazilian population: Part I. J Endod 2016;42:1604-7.
27. Celikten B, Tufenkci P, Aksoy U, Kalender A, Kermeoglu F, Dabaj P, *et al.* Cone beam CT evaluation of mandibular molar root canal morphology in a Turkish Cypriot population. Clin Oral Investig 2016;20:2221-6.
28. Pérez-Heredia M, Ferrer-Luque CM, Bravo M, Castelo-Baz P, Ruíz-Piñón M, Baca P. Cone-beam computed tomographic study of root anatomy and canal configuration of molars in a Spanish population. J Endod 2017;43:1511-6.
29. Madani ZS, Mehraban N, Moudi E, Bijani A. Root and canal morphology of mandibular molars in a selected Iranian population using cone-beam computed tomography. Iran Endod J 2017;12:143-8.
30. Madjapa HS, Minja IK. Root canal morphology of native Tanzanian permanent mandibular molar teeth. Pan Afr Med J 2018;31:24.
31. Kantilieraki E, Delantoni A, Angelopoulos C, Beltes P. Evaluation of root and root canal morphology of mandibular first and second molars in a Greek population: A CBCT Study. Eur Endod J 2019;4:62-8.
32. Ahmed HM, Versiani MA, De-Deus G, Dummer PM. A new system for classifying root and root canal morphology. Int Endod J 2017;50:761-70.
33. Cantatore G, Berutti E, Castellucci A. Missed anatomy: Frequency and clinical impact. Endod Top 2006:15;3-31.
34. Keleş A, Keskin C. Detectability of middle mesial root canal orifices by troughing technique in mandibular molars: A micro-computed tomographic study. J Endod 2017;43:1329-31.