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Cone-Beam Computed Tomography Analysis of Root Canal Morphology in Mandibular First Molars in Erbil Population: A Retrospective Study

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Abstract

Background and objectives: The mandibular first molars have a variety of abnormal canal morphologies; many authors have researched the frequency of these anatomical variants and their relationship to gender. The objective of this study is to analyze root canal morphology using Cone-Beam Computed Tomography in Erbil population.

Method: This retrospective study, conducted in Erbil in the Kurdistan region of Iraq from January 2023 to January 2024, evaluates Cone-Beam Computed Tomography images of 100 mandibular first molars. The evaluation focused on the following details: the number of roots, the number of apical foramina, the frequency distribution of root canal configurations based on Vertucci's classification, and the frequency of occurrence of both the middle mesial canal and radix entomolaris.

Result: The study included 100 patients. The middle mesial canal was present in 3.7% of patients under 30 years old, compared with 2.2% of those aged 30 years or older (p = 1.000). Four out of 100 patients (4%) had three roots, while the remaining patients had two roots. Only 4% of the sample exhibited radix entomolaris.

Conclusion: Mandibular first molars typically have two main roots. Type I is the most common shape for distal canal, while for the mesial canal, type II, IV are more common, with middle-aged individuals showing a higher frequency of middle mesial canals. Variation also occurs in root number, apical foramina presence, extra roots and different canal configuration.

Keywords: Anatomical configuration, Apical foramina, Cone-Beam Tomography, Mandibular first molar, Radix entomolaris

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Introduction

An extensive understanding of the anatomy and morphology of the root canal, as well as how these vary within normal ranges, is necessary for the successful outcome of an endodontic procedure. Anatomical abnormalities in the root and root canal system might present a significant endodontic difficulty to dentists practicing dentistry. Therefore, in order to prevent potential difficulties and unwanted failures during endodontic procedures, a detailed study of their anatomy and variations is crucial.[1] The number of root and root canal configuration classification systems proposed by Weine and Vertucci The mandibular molars have a variety of abnormal canal morphologies, the most prevalent of which are an extra distolingual root and canal.[2-4] and a third canal in the mesial root known as middle mesial canal (MMC) Vertucci and William.[5,6] as well as Barker et al Previous studies have reported a frequency of this canal ranging from 0.26–46.15 when endodontic treatment is required, and this additional canal has gotten extra care.[7-9] The prevalence of radix entomolaris (RE) varies throughout populations. (RE)s are more common in people of Mongoloid descent Chinese, Taiwanese, and Korean populations, for instance.[10-14] Even though East Asia is where they are usually found.[10,14] The arteries and nerve fibers supplying the pulp and periodontal ligament are found in the apical foramen (AF) aperture, which is the apical third of the tooth root's external surface.[15] Kyaw et al., reported that the mesiobuccal canal had 1-6 foramina, while mesiolingual canals had 1-4 foramina.[16] Cone-Beam Computed Tomography (CBCT) is a consistent, non-invasive, and non-destructive technique that when combined with 3D software imaging, is now thought to be the most precise method of examining the morphology of root canal systems. Cone beam computed tomography is advantageous because it is less expensive, requires less space, has a limited field of view, shorter scanning time and most importantly, Cone beam computed tomography provides a reduced average radiation dosage compared to CT scans.[17] It offers a high-resolution depiction of the tooth morphological structure and proves to be an invaluable information resource for practitioner.[18] This study aimed to investigate the root canal morphology and configuration of mandibular first molar (MFM) teeth in the Erbil city population of Iraq using (CBCT), it provides critical insights into the root canal morphology of mandibular first molars, aiding clinicians in anticipating anatomical variations during endodontic treatment. By using CBCT, practitioners gain precise, high-resolution views of complex canal structures, reducing the risk of missed canals and improving treatment success rates.

Patients and methods

One hundred (CBCT) images of the MFM (left and right) from Erbil residents who underwent CBCT exams as part of their dental checkup, diagnosis, or treatment planning between January 2020 and January 2023 are included in this retrospective cross-sectional study. This work was submitted to the Kurdistan Higher Council of Medical Specialties for ethical and scientific approval. The study was conducted at Diamond Private Dental Polyclinic in Erbil, in the Kurdistan region of Iraq, from January 2023 to January 2024. The inclusion criteria include: mandibular first molar with complete root formation, intact roots without fractures or cracks, mandibular first molar without periapical lesions and Cone-Beam Computed Tomography images of good quality and without any artifacts. Exclusion criteria: Metallic restoration, previous root canal treatment, posts or crown restorations, external or internal Root resorption, evidence of periapical surgery canal calcification, any developmental anomalies, and orthodontic

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brackets and bands. Age and gender information's are provided from the data archives from Diamond Private Dental Polyclinic. Rolling the toolbar gently from the pulp chamber to the apex allows for the examination of serial axial, coronal, and sagittal views of (CBCT) pictures until a diagnosis is agreed upon for each instance. The evaluation and examination of the root canal morphology of every mandibular first molar on the right or left side. The following factors were investigated: Frequency of occurrence of (MMC), number of roots, frequency of occurrence of (RE), number of (AF), frequency distribution of root canal configurations defined in accordance with Vertucci's classification. [3] The Statistical Package for Social Sciences (SPSS, version 26) was used to analyze the data. The proportions of the two study groups were compared using the chi-square test of association. When the predicted frequency (value) of more than 20% of the table's cells was less than 5, Fisher's exact test was utilized. A p-value of ≤ 0.05 was considered statistically significant.

Results

One hundred patients were included in the study. The mean age was 28.74 years with a standard deviation (SD) of 7.45 years, a median of 29 years, and an age range of 16 to 49 years. The largest proportion of the sample (45%) was aged 20-29 years. Around two-thirds (62%) of the sample were females. The right side was studied in 54% of the patients, whereas the left side was studied in 46% of the sample Table (1). The middle mesial canal was present in 3.7% of the patients under 30 years, compared with 2.2% of those aged ≥ 30 years (p = 1.000). The presence of the middle mesial canal was noticed in one male patient (2.6%) and two female patients (3.2%), and the rate was 3% in the whole sample. The difference between males and females was not significant (p = 1.000), as presented in Table (2).

Table (1): Basic characteristics of the studied sample

	No.	(%)
Age (years)		
< 20	9	(9.0)
20-29	45	(45.0)
30-39	37	(37.0)
≥ 40	9	(9.0)
Gender		
Male	38	(38.0)
Female	62	(62.0)
Side		
Right	54	(54.0)
Left	46	(46.0)
Total	100	(100.0)

Table (2): Occurrence of the middle mesial canal by age and gender

	Middle mesial canal			
	Present	Absent	Total	p-value*
	No. (%)	No. (%)	No. (%)	
Age				
<30	2 (3.7)	52 (96.3)	54 (100.0)	
≥30	1 (2.2)	45 (97.8)	46 (100.0)	1.000
Gender				
Male	1 (2.6)	37 (97.4)	38 (100.0)	
Female	2 (3.2)	60 (96.8)	62 (100.0)	1.000
Total	3 (3.0)	97 (97.0)	100 (100.0)	

*Calculated by Fisher's exact test.

Four out of 100 patients (4%) had three roots (5.3% among males and 3.2% among females), and the rest of the patients had two roots. No significant association was detected with gender (p = 0.633). Regarding the type of mesial canal, it was type 2 in 51% of the patients, and type 4 in 32% of the patients, but the difference between males and females was not significant (p = 0.207). More than two-thirds (67%) of the patients had type 1 distal canal, and the difference was also not significant (p = 0.645), as presented in Table (3).

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Table (3): Association between the studied variables with gender

	Gender			
	Male	Female	Total	p-value*
	No. (%)	No. (%)	No. (%)	
Number of roots				
2	36 (94.7)	60 (96.8)	96 (96.0)	
3	2 (5.3)	2 (3.2)	4 (4.0)	0.633
Mesial canal type				
1	0 (0.0)	2 (3.2)	2 (2.0)	
2	17 (44.7)	34 (54.8)	51 (51.0)	
3	2 (5.3)	0 (0.0)	2 (2.0)	
4	15 (39.5)	17 (27.4)	32 (32.0)	
6	4 (10.5)	9 (14.5)	13 (13.0)	0.207
Distal canal type				
1	26 (68.4)	41 (66.1)	67 (67.0)	
2	1 (2.6)	0 (0.0)	9 (9.0)	
3	1 (2.6)	0 (0.0)	16 (16.0)	
4	1 (2.6)	1 (1.6)	2 (2.0)	
5	1 (2.6)	3 (4.8)	4 (4.0)	
6	1 (15.8)	7 (11.3)	1 (1.0)	
7	2 (5.3)	10 (16.1)	1 (1.0)	0.645
Total	38 (100.0)	62 (100.0)	100 (100.0)	

*Calculated by Fisher's exact test.

Only 4% of the whole sample had (RE), but there was no significant difference (p = 0.633) between the rate of males (5.3%) and that of females (3.2). The same can be applied to the apical foramen of radix (p = 0.633), as presented in Table (4).

Table (4): Occurrence of radix entomolaris by gender

	Gender			
	Male	Female	Total	
	No. (%)	No. (%)	No. (%)	p-value**
Radix entomolaris				
No	36 (94.7)	60 (96.8)	96 (96.0)	
Yes	2 (5.3)	2 (3.2)	4 (4.0)	0.633
Apical foramen of radix				
No	36 (94.7)	60 (96.8)	96 (96.0)	
Yes	2 (5.3)	2 (3.2)	4 (4.0)	0.633
Total	38 (100.0)	62 (100.0)	100 (100.0)	

**Calculated by Fisher's exact test.

One or two mesial foramen was presented in (70%). The majority (55%) of the whole sample had one mesial foramen, and the rest (45%) had two mesial foramina, while one or two distal foramina was presented in (30%) the majority (85%) of the whole sample had one distal foramen, and the rest (15%) had two distal foramina, Table (5).

Table (5): Number of apical foramina in mandibular first molars

	No. (%)
Mesial foramen number	
1	55 (55.0)
2	45 (45.0)
Distal foramen number	
1	85 (85.0)
2	15 (15.0)
Total	100 (100.0)

*Calculated by the Chi-square test.

Discussion

This retrospective cross-sectional study demonstrated the analysis of the morphology and configuration of root canal of mandibular first molar by (CBCT). Mandibular first molars are the permanent teeth that come out of the mouth first. During the course of their eruption, these teeth are particularly affected by cavities and frequently need endodontic therapy.[19] The numerous anatomical variances provide a technical challenge to successful endodontic therapy, Cone-Beam Computed Tomography images offer a dependable method for identifying complex canal layouts and instrumenting them later. [20] The extra (MMC) in the mesial root was found to be more prevalent in middle-aged groups.[21] The (MMC) has been minimally studied and shows a widely varying prevalence across different populations.[22] In this study, results indicate that the (MMC) was more frequently observed in patients younger than 30 years compared to those 30 years and older, with no statistically significant difference. These findings align

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closely with those from a study conducted by Al Shehadat et al.[23] In current study, the (MMC) was observed in one male patient (2.6%) and two female patients (3.2%), with an overall prevalence of about 3% in the whole sample. This finding contrasts with several studies showing a higher occurrence of (MMC) in females than males.[24] Additionally, because younger patients generally have fewer physiological or pathological pulp calcifications than older patients, it's often easier to detect additional root canals in younger individuals.[25] (MFM)generally have two roots, positioned mesially and distally.[26] In the present study, two-rooted (MFM) were much more common than three-rooted ones. Most of these findings align with prior research on western chines individuals, where two rooted (MFM) were predominant, with a smaller proportion exhibiting three roots.[27]Additionally, a study published in the journal of endodontics found that both genders had a high prevalence of two distinct roots in (MFM) which is consistent with the findings in our study.[28] The result of this study illustrated that type II configuration was most common in mesial roots, being more prevalent females than males, followed by type IV, which was more frequently observed in males. This consistent with studies reported that type II being the most prevalent followed by type IV.[29] However, unlike the low occurrence of type III and type V in our community, research by Torres et al., found a higher prevalence of these types.[30] In distal roots, type I canal configuration was the most common.[31] Similarly, in our study, type I arrangement was most common predominant configuration in both males and females. As in previous research, only a small percentage of Vertucci types II and III were detected.[32] The result of current study indicates that the prevalence of third root RE of (MFM) is 4%, while no significant difference was found between males and females, this align with studies showing no gender-based variation.[33] The presence of third root (RE) can complicate endodontic treatment and may increase the risk of treatment failure if a canal is missed.[34] Few researches investigated into the (AF) of mandibular molars using (CBCT).[35] Findings of our study shows that most mesial roots had one or two foramina, as did a smaller portion of distal root, another study similarly found that a single foramen was common in mesial roots .[36] However, the findings of the present investigation differ from those of another study conducted by Asijavičienė et al., which reported a higher prevalence of one or two foramina in both mesial and distal roots.[37] Based on the study performed by Yang et al., states that the presence of three canals that merge before the apical foramen and join to form one or two apical foramina has a minor effect on the treatment result.[38]

Conclusion

Most (MFM) have two roots. For the distal canal, type I is the most prevalent shape, while for the mesial canal, type II, IV. Middle mesial canal has the highest frequency in the middle-aged group. Regarding the quantity of roots, occurrence of (AF), additional root, or distribution of various canal configurations of (MFM), no discernible variation was seen between both genders.

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Conflict of interest

The authors recorded no conflict of interest.

Reference

1. Cleghorn BM, Goodacre CJ, Christie WH. Morphology of teeth and their root canal systems. In: Ingle JI, Bakland LK, Baumgartner JC, editors. Ingle's

https://doi.org/10.56056/amj.2026.474

Endodontics. 6th ed. Hamilton: BC Decker; 2008. 151–220.
2. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. Oral Surg Oral Med Oral Pathol1969; 28:419–25.
3. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984; 58:589–99.
4. Huang RY, Cheng WC, Chen CJ, Lin CD, Lai TM, Shen EC, et al, Three-dimensional analysis of the root morphology of mandibular first molars with distolingual roots. Int Endod J. 2010;43(6):478-84.
5. Nosrat A, Deschenes RJ, Tordik PA, Hicks ML, Fouad AF. Middle mesial canals in mandibular molars: incidence and related factors. J Endod. 2015; 41(1):28–32.
6. Vertucci FJ, Williams RG. Root canal anatomy of the mandibular first molar. JN J Dent Assoc. 1974;45(3):27.
7. Barker BC, Parsons KC, Mills PR, Williams GL. Anatomy of root canals. III. Permanent mandibular molars. Aust Dent J. 1974;19(6):408–13.
8. 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(12):1516–21.
9. Azim AA, Deutsch AS, Solomon CS. Prevalence of middle mesial canals in mandibular molars after guided Troughing under high magnification: anin vivo investigation. J Endod. 2015;41(2):164–8.
10. Zhang R, Wang H, Tian YY, Yu X, Hu T, Dummer PM. Use of Cone-beam computed tomography to evaluate root and canal morphology of mandibular molars Chinese individuals. Int Endod J. 2011; 44:990–9.
11. Tu MG, Tsai CC, Jou MJ, Chen WL, Chang YF, Chen SY, et al. Prevalence of three-rooted mandibular first molars among Taiwanese individuals. J Endod. 2007; 33:1163–6.
12. Tu MG, Huang HL, Hsue SS, Hsu JT, Chen SY, Jou MJ, et al. Detection of permanent three-rooted mandibular first molar by cone-beam computed tomography imaging in Taiwanese individuals. J Endod. 2009; 35:503.
13. Song JS, Choi HJ, Jung IY, Jung HS, Kim SO. The prevalence and morphologic classification of distolingual roots in the mandibular molars in a Korean population. J Endod. 2010; 36:653–7.
14. Bharti R, Arya D, Saumyendra VS, Kulwinder KW, Tikku AP, Chandra A. Prevalence of radix entomolaris in an Indian population. Indian J Stomatol. 2011; 2:165–7.
15. Grossman LI. Endodontic Practice. Philadelphia: Lea & Feboger; 1976:170–89.
16. Maung Kyaw M, Ha JH, Jin MU, Kim YK, Kim SK. Anatomical profile of the mesial root of the Burmese mandibular first molar with Vertucci's type IV canal configuration. J Oral Sci. 2017;59(4):469–74.
17. Acar B, Kamburoğlu K, Tatar İ, Arıkan V, Çelik HH, Yüksel S, et al. Comparison of microcomputerized tomography and cone-beam computerized tomography in the detection of accessory canals in primary molars. Imaging Sci Dent 2015; 45:205-211.
18. Hull TE, Robertson PB, Steiner JC, del Aguila MA. Patterns of endodontic care for a Washington state population J Endod 2003; 29:553–6.
19. Bhatia S, Kohli S, Parolia A, Yap NH, Lai CT, Tan EH. Prevalence of radix molar in mandibular permanent molars: an observational study in Malaysian population. Oral Health Dent Manag.2015;14:32–6.
20. Caputo BV, Noro Filho GA, de Andrade Salgado DM. Evaluation of the Root Canal Morphology of Molars by Using Cone-beam Computed Tomography in a Brazilian

https://doi.org/10.56056/amj.2026.474

Population: Part I. J Endod. 2016; 42(11): 1604–1607.
21. Bhatti UA, Muhammad M, Javed MQ, Sajid M. Frequency of middle mesial canal in mandibular first molars and its association with various anatomic variables. Aust Endod J. 2022 Dec;48(3):494-500.
22. Tomaszewska IM, Skinningsrud B, Jarzębska. Internal and external morphology of mandibular molars: An original micro-CT study and meta-analysis with review of implications for endodontic therapy. Clin Anat. 2018; 31(6): 797–811.
23. Al Shehadat S, Waheb S, Al Bayatti SW, Kheder W, Khalaf K, Murray CA. Cone beam computed tomography analysis of root and root canal morphology of first permanent lower molars in a Middle East subpopulation. J Int Soc Prev Community Dent. 2019 Sep 1;9(5):458-63.
24. Pan JY, Parolia A, Chuah SR, Bhatia S, Mutalik S, Pau A. Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. BMC oral health. 2019 Dec; 19:1-5.
25. Karapinar-Kazandag M, Basrani BR, Friedman S. The operating microscope enhances detection and negotiation of accessory mesial canals in mandibular molars. J Endod. 2010 Aug;36(8):1289-94. doi: 10.1016/j.joen.2010.04.005. Epub 2010 Jun 14.
26. e Pablo OV, Estevez R, Peix Sanchez M, Heilborn C, Cohenca N. Root anatomy and canal configuration of the permanent mandibular first molar: a systematic review. J Endod. 2010; 36:1919–31.
27. Song JS, Kim SO, Choi BJ, Choi HJ, Son HK, Lee JH. Incidence and relationship of an additional root in the mandibular first permanent molar and primary molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107: e56–60.
28. 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. Medicina oral, patologia oral y cirugia bucal. 2013 Jul;18(4): e737.
29. Zaatar El, al Anizi SA, al Duwairi Y. A study of the dental pulp cavity of mandibular first permanent molars in the Kuwaiti population. J Endod 1998; 24:125-7.
30. 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(2): 95-101.
31. Gulabivala K, Opasanon A, Ng YL, Alavi A. Root and canal morphology of Thai mandibular molars. Int Endod J 2002; 35:56-62.
32. Schafer E, Breuer D, Janzen S. The prevalence of three-rooted mandibular permanent first molars in a German population. J Endod. 2009; 35:202–5.
33. Carlsen O, Alexandersen V. Radix paramolaris in permanent mandibular molars: identification and morphology. Scand J Dent Res. 1991 Jun;99(3):189-95. doi: 10.1111/j.1600-0722. 1991.tb01884. x/
34. Chandra S. Prevalence of Three Rooted Mandibular Permanent First Molars in South Indian Population Contemp Clin Dent. 2017 Jan-Mar;8(1):38–41. doi: 10.4103/ccd.ccd_699_16/
35. Sierra-Cristancho A, González-Osuna L, Poblete D, Cafferata EA, Carvajal P, Lozano CP, Vernal R. Micro-tomographic characterization of the root and canal system morphology of mandibular first premolars in a Chilean population. Scientific reports. 2021 Jan 8;11(1):93.
36. Fan B, Pan Y, Gao Y, Fang F, Wu Q, Gutmann JL. Three-dimensional morphologic analysis of isthmuses in the mesial roots of mandibular molars. J Endod. 2010 Nov 1;36(11):1866-9.

https://doi.org/10.56056/amj.2026.474

37. Asijavičienė, U., Drukteinis, S. Suduiko, A. Microcomputed tomography evaluation of the root canals morphology of the mandibular first molars. Stomatologija. 2020;22(3):75-79.
38. Yang Y, Wu B, Zeng J, Chen M. Classification and morphology of middle mesial canals of mandibular first molars in a southern Chinese subpopulation: a cone-beam computed tomographic study. BMC Oral Health. 2020 Dec;20: 5-9.

https://doi.org/10.56056/amj.2026.474