

Cone Beam Computed Tomography Analysis of Root and Root Canal Morphology of First Permanent Lower Molars in a Middle East Subpopulation

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ABSTRACT **Aim:** The aim of this study was to investigate variations in the number of roots and root canals in first permanent lower molars (FPLMs) using cone beam computed tomography (CBCT). **Materials and Methods:** A total of 640 CBCT images were analyzed using SIDERIS XG software version 2.62 (Sirona Dental Systems, Bensheim, Germany). The entire root anatomy of FPLMs was investigated in three dimensions and the number of roots, root canals, and the number of canals per root were recorded. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, version 24, (IBM Corporation, USA) to determine the relationship between root anatomy and gender, age, or tooth location (right or left side). **Results:** The majority of FPLMs had two roots (96%), whereas the remaining 32 FPLMs (4%) had three roots. Almost two-thirds of the sample (62.7%) had three root canals, whereas only three cases (0.4%) of the FPLMs had six canals. When comparing bilateral differences in the distribution of root canals, it was determined that a quarter of FPLMs (24.1%) had an unequal number of canals. Moreover, there were differences in the number of additional canals between the mesial and distal roots with 17.5% of the former having three canals as compared with only 0.5% of the distal root. Interestingly, not more than one canal was observed in all additional root cases. No significant differences were observed in the number of canals between males and females or between right and left sides of the examined FPLMs ($P > 0.05$). **Conclusion:** Dental clinicians should be aware of the presence of an additional root in 4% of FPLMs, and about a quarter of the cases (27%) had an extra middle mesial canal in the mesial root, which was found to be more prevalent in middle age groups.

KEYWORDS: Cone beam computed tomography, lower molars, morphology, root, root canal

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INTRODUCTION

Significant understanding of root morphology and root canal configuration is an essential prerequisite for successful endodontic therapy.^[1,2] The inability to instrument and clean all the root canals during root canal treatment (RCT) can lead to endodontic failure. Therefore, variations in root canal morphology present a serious challenge for the clinician when undertaking traditional RCT.^[3,4] Clinicians must be aware of this complexity and should be able to decide whether it is within their capabilities.^[5]

The morphology of first permanent lower molars (FPLMs) has been widely reported within the literature as this is the most frequent tooth requiring RCT

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procedures.^[6] The majority of these teeth have two roots; one mesial and one distal with two or three canals in the mesial root and one, two, or three canals in the distal root.^[6] The most common canals in the mesial root are the mesiobuccal and mesiolingual canals. A middle mesial (MM) canal can sometimes be found between the two other mesial canals in a groove known as the developmental groove. When a MM canal is absent, it is believed that a wide anastomosis, known as an isthmus, is present between the two mesial canals.^[7] On the basis of previous findings, the incidence of MM canals ranges from 1% to 15%.^[8,9]

The canals in the distal root of FPLMs are the distal canal (if one canal is present) or if two canals are present, the distobuccal and distolingual. The presence of a third middle distal canal is also occasionally found between the two distal canals.^[10] A developmental groove usually connects the orifices of these canals. Another unusual anatomy of FPLMs is the potential presence of an additional distolingual or mesiobuccal third root known as radix entomolaris or radix paramolaris, respectively.^[11]

Several *in vitro* and clinical studies have reported on the morphology of root canals. Studies have investigated macroscopic tooth sections,^[1] root canal staining and clearing,^[12] polyester resin impressions,^[13] transparent tooth specimen,^[14] conventional and digital radiographs,^[15] or computed tomography techniques.^[16-18]

Cone beam computed tomography (CBCT) is an important diagnostic tool in dental practice.^[19,20] It enables clinicians to observe the target area in three different planes (sagittal, coronal, and axial) and thus provides three-dimensional (3D) information.^[21] It has the advantage of visualizing the root morphology in 3D and provides accurate information of the canals' convergence or divergence from each other.^[22] The aim of this retrospective study was to investigate the variation in the number of roots and canals in FPLMs in patients attending the University Dental Hospital Sharjah (UDHS) using CBCT imaging. No previous studies have used CBCT to analyze the number of roots and canals within the United Arab Emirates population.

MATERIALS AND METHODS

Following UDHS policy, all patients at UDHS sign a consent letter allowing the usage of their X-ray data in research works. Ethical approval (No. REC-17-12-15-01, January 30, 2018) was obtained to use patient records from the UDHS. A total of 640 CBCT images from the archives of UDHS were examined for their

suitability for inclusion in this study on FPLM teeth. This was the total number of CBCT exposures taken during 2016 in UDHS. The cases were restricted to permanent dentitions that had at least one FPLM, no distortion of the CBCT image and no previous RCT of the FPLM. The exclusion criteria included patients with primary or mixed dentition, CBCT images with distortion, and cases with bilateral extracted or root canal treated FPLMs. Subsequently, 165 cases were excluded from the study.

The three planes of the CBCT were analyzed carefully using SINDEXIS XG software, version 2.62 (Sirona Dental Systems, Bensheim, Germany). The 3D images were displayed on a 20-inch liquid crystal display monitor of resolution 1280 × 1024 pixels. Image magnification and contrast were adjusted until optimal visualization was achieved. The entire root anatomy from the canal orifice to the root apex was viewed. Observations on the number of roots, root canals, and the number of canals per root were recorded. Other demographic information that was analyzed over a 4-month time frame included the gender and age group [Table 1].

STATISTICAL ANALYSIS

Analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, version 24 (IBM Corporation, USA) and significance level set at 5%. Descriptive analysis was used to describe the sample and the prevalence of canals and roots of FPLMs. Chi-squared test of independence was used to determine if a significant relationship was present between root anatomy and gender, age, or tooth location (right or left side).

Table 1: Summary of the sample with first permanent lower molar

FPLMs	Right 396 (49.1%)	Left 411 (50.9%)	Total (n = 807)	Bilateral subset 332 (82.3%)
Gender				
Male	224	226	450 (55.8%)	188
Female	172	185	357 (44.2%)	144
Age				
11–20	3	6	103 (12.8%)	47
21–30	20	24	276 (34.2%)	116
31–40	16	23	219 (27.1%)	90
41–50	16	18	138 (17.1%)	52
51–60	6	5	55 (6.8%)	22
61–70	2	3	13 (1.6%)	4
71–80	1	0	3 (0.4%)	1

No significant differences in the number of canals were found between age groups, right and left sides, or males and females (*P* > 0.05, level of significance at 0.05)

RESULTS

A total of 807 individual FPLMs were analyzed, with 332 patients having bilateral FPLMs. The number of males (55.8%) was greater than the number of females (44.2%). The distribution of cases with bilateral FPLMs is presented in Table 1.

Most FPLMs had two roots (96%). Only 32 FPLMs (4%) had three roots [Figure 1C] [Table 2]. FPLMs with one or four roots were not observed in this study. Statistical analysis revealed that the occurrence of number of roots was not associated with gender, age, or tooth location ($P > 0.05$).

FPLMs with three root canals were shown to be the most prevalent (62.7%), followed by FPLMs with four canals (28.7%), and then with five canals (6.9%). FPLMs with two canals were observed in 10 cases (1.2%), whereas FPLMs with six canals were observed in only three cases (0.4%). The majority of bilateral FPLMs had the same number of canals on both sides (75.9%). Conversely, 24.1% of bilateral FPLMs had an unequal number of canals [Tables 2 and 3]. No significant differences in the number of canals were found between age groups, right and left sides, or males and females ($P > 0.05$).

The distribution of canals by the number of roots is presented in Table 4. The mesial root contained one canal [Figure 1A] in 1.2%, two canals in 80.3%, and three canals in 17.5% of cases [Table 3] [Figure 1D]. The distal root contained one canal in 78.1%, two canals in 20.5%, and three canals in 0.5% of cases [Figure 1B]. The extra root contained only one canal in all observed cases. For two-rooted FPLMs, the most prevalent occurrence was two canals within the mesial and one canal at the distal roots (62.7%); followed by double canals per root (14.8%) and three canals at the mesial and one canal at the distal (11.4%). No significant differences were present in the number of canals between males and females or between right and left sides of the examined mandibles ($P > 0.05$).

DISCUSSION

CBCT is a useful tool in identifying the morphology of root canal systems. Its accuracy is comparable to the modified canal staining and tooth-clearing technique.^[23] CBCT imaging is more accurate than conventional radiographs as it allows for 3D reconstruction and visualization of the external and internal anatomy of teeth.^[24] This study has the advantage of using CBCT scanning to examine root and root canal morphology

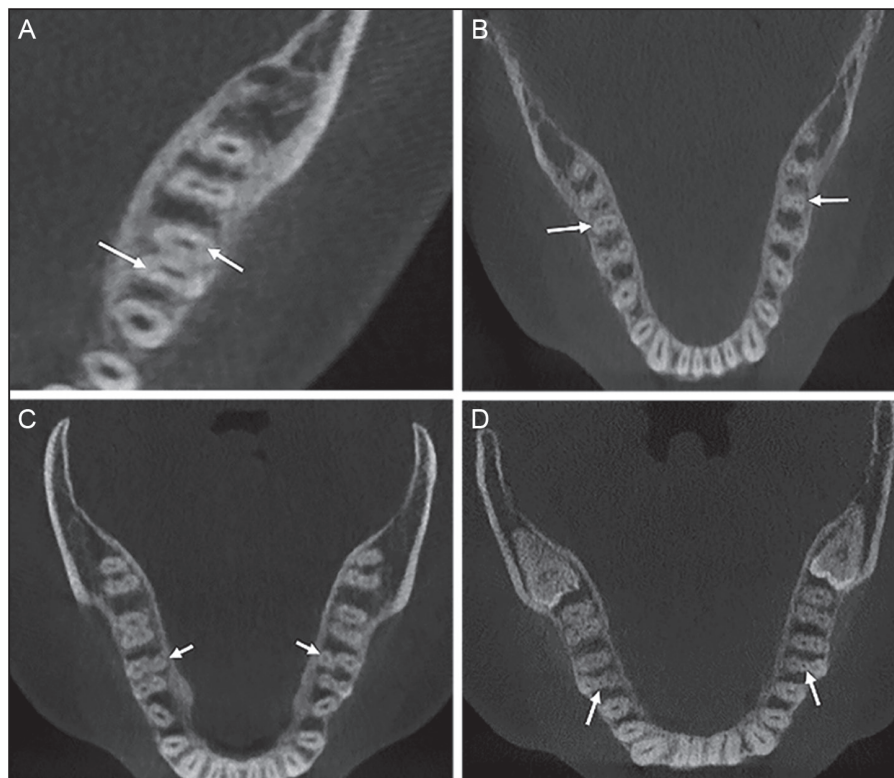


Figure 1: Different uncommon anatomies in first permanent lower molars (FPLMs). (A) Two canals in the left FPLM (arrows). (B) Three distal canals in left FPLM and two in the right (arrows). (C) Bilateral radix entomolaris (arrows). (D) Bilateral middle mesial canals (five canals in each FPLM, arrows)

of FPLMs. The investigation was performed in a relatively short time and at lower cost as samples were obtained from the UDHS radiology records. The final number of included cases were much higher than the earlier related studies. Therefore, it was accepted as an appropriate sample size according to the earlier peer review publications.

FPLMs erupt early and thus are more prone to dental caries, endodontic treatment, and possible early extraction.^[25] It is important for the clinician to be aware of the variation of root morphology and root canal configuration before commencing root canal therapy to enhance the successful outcome of endodontic treatment and prevent early loss of these teeth.^[4]

FPLMs usually have two roots, one located mesially and the other root located distally. The presence of an additional third root has been reported in previous studies. The extra root may be located buccally (known as radix paramolaris) or lingually (known as radix endomolaris or entomolaris).^[11] The radix entomolaris root is considered to be a normal morphology variant that can be identified as an Asian trait.^[26] It is more common in the Mongoloid rather than in the Caucasoid race.^[23]

In this study, the occurrence of the number of roots of FPLMs was independent of gender or sides of the mandible. The likelihood of finding unequal number of roots between the right and left FPLMs was small (2.71%) with the majority of cases having two roots on both mandibular sides (94.58%). If the right FPLM had two roots, there was a weak probability to find three roots on the left FPLM. However, if the right FPLM had three roots, the left FPLM had 64.3% greater odds of having three roots. The finding from this study is

Table 2: Number of roots present within bilateral first permanent lower molars

Left Number of roots	Right		Total (n = 332)
	Two	Three	
Two	314 (94.58%)	4 (1.2%)	318 (95.78%)
Three	5 (1.51%)	9 (2.71%)	14 (4.22%)

Table 3: Number of canals present within bilateral first permanent lower molars

Left Number of canals	Right					Total (n = 332)
	Two	Three	Four	Five	Six	
Two	2	1	0	0	0	3
Three	2	180	21	1	0	204
Four	1	26	62	14	1	104
Five	0	1	7	11	1	20
Six	0	0	0	1	0	1

No significant differences in the number of canals were found between right and left sides ($P > 0.05$), level of significance at 0.05

in harmony with the studies carried out on Taiwanese and East Coast Malaysian populations, where no difference was found between genders.^[27,28] However, it is in disagreement with some previous studies where the presence of distolingual root was reported to be more prevalent in males on the right side^[29] or the left side.^[26] The differences in outcomes may be due to different methods of case selection and different sample sizes.

The three-rooted FPLMs were observed in 4% of cases. This incidence is very similar to that established in previous studies conducted on Caucasian (2.2%),^[30] Sudanese, and Senegalese (3.0%) patients.^[31,32] However, it was lower than that found in the patients from East Coast of Malaysia (11.9%),^[27] and much lower than that found in the East Asian, Western China (25.8%),^[33] and Taiwanese (25.3%) populations.^[28] It is not clear whether this variation is due to sampling variation, regional differences, or because of ethnic and genetic diversity. Although the percentage of three-rooted FPLMs is small in this study, special attention should be given to such cases during RCT. Failure to detect and treat this additional root may lead to endodontic failure.

In this study, the number of canals per FPLMs ranged between two and six. The higher percentage (62.7%) was for three canals; two located in the mesial root and

Table 4: Distribution of canals by the number of roots at mesial and distal (roots)

Number of roots	Mesial root: no. of canals	Distal root: no. of canals	Number of teeth	Prevalence
2 (n = 775)	1	1	10	1.24%
	2	1	506	62.7%
	2	2	119	14.8%
	2	3	1	0.1%
	3	1	92	11.4%
	3	2	45	5.6%
	3	3	2	0.3%
3 (n = 32)	2	1	21	2.6%
	2	3	0	0.1%
	3	1	1	0.1%
	3	2	1	0.1%

one located in the distal root. This is in agreement with previous studies. Although the presence of one sole root with only one canal was not detected in this study, it has been reported earlier.^[27] The maximum number of canals per root was observed to be three for the mesial root, three for the distal root, and one for the extra third root. However, the presence of four canals in the mesial root and three canals in the distal root has previously been reported.^[34,35] Thus, the number of canals in FPLMs may range from one to seven for two-rooted FPLMs.^[34] This emphasizes the importance of searching for additional canals during RCT of mandibular first molars.

The prevalence of four canals in this study population was slightly higher (28.7%) in comparison to that in the East Coast Malaysian study population (22.2%).^[27] However, it was much lower than a studied Sudanese population (59%).^[31] The higher percentage of four canals cases (50.3%) was observed in FPLMs with two mesial and two distal canals, the next most prevalent was FPLMs with three mesial and one distal canal (39.7%). The lowest number of canals (9%) was found in three-rooted FPLMs with two mesial and one distal canals. The occurrence of two canals in our study (1.2%) was similar to a study conducted on Western China population (1.4%),^[33] but lower than that in a study conducted on Kuwaiti (6.1%),^[36] or Indian (6.45%)^[37] populations. This is also much lower than that reported for the East Coast Malaysian population (23.3%),^[27] where the sample size used in the study was significantly lower than that used for this study.

The presence of an MM canal was observed in 17.5% of cases. Interestingly, it was elucidated that the percentage of an MM canal increased gradually by age to reach 26.3% for 31–40 years age group. It then decreased gradually for the older age groups [Figure 2]. This may suggest that the presence of the MM canal is a temporary stage. It might be developed through the deposition of secondary or tertiary dentin in the wide communication area between the two mesial canals. Later, with the progress of dentin deposition, the MM canal will be obliterated and will disappear and thus the prevalence of MM canal tends to decrease in older ages. However, further investigations need to be undertaken to confirm this suggestion. No association was observed for the occurrence of MM canal in FPLMs with gender or side of the mandible.

CLINICAL SIGNIFICANCE

The number of roots and root canals and their variety should always be carefully considered when evaluating a preoperative radiograph before RCT procedures.

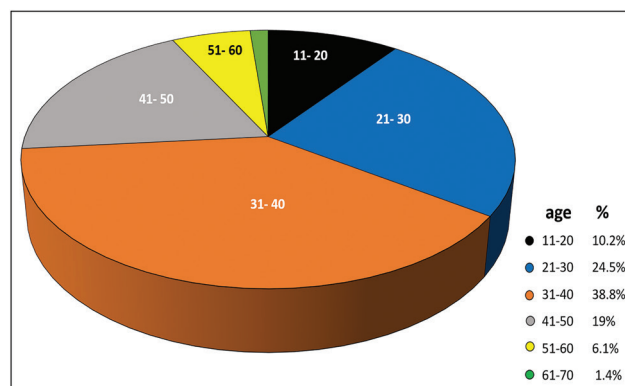


Figure 2: Middle Mesial (MM) canal relationship to age. The percentage of observed MM canals increased gradually and reached the highest percentage in the 31–40 years age group, then decreased gradually for older age groups

It is very useful to check the dentin map carefully under good illumination to detect any possible extra canals.

If the patient complains of “spontaneous pain” at any time after root canal pulp extirpation session, the first thing to consider is the presence of an extra root or canal.

CONCLUSION

- CBCT is a valuable tool to identify additional roots and/or root canals in mandibular molars.
- Dental clinicians should be aware of the presence of an extra root in 4% of the FPLMs.
- Approximately a quarter of the cases (27%) have an extra MM canal in the mesial root.
- The extra MM canal in the mesial root was found to be more prevalent in the middle-aged groups.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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