

DETERMINATION OF NUMBER AND CONFIGURATION OF CANALS IN PERMANENT LOWER FIRST MOLAR BY CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

OBJECTIVE: To determine the number and configuration of canals in permanent lower first molar by cone beam computed tomography (CBCT).

METHODS: This cross-sectional study was conducted at Sardar Begum Dental College, Peshawar, using 334 good quality CBCT images of mandibular first molar with intact pulp, closed apices from both genders using previous records. CBCT images were analyzed using Scanora software version 3D. All the images were studied at axial and coronal planes by continuously moving the tool bar from the floor of pulp chamber to root apices.

RESULTS: Out of 334 patients, 210 (62.9%) were males and 124 (37.1%) were females. Three-canals were the most frequent (n=167; 50%) canals in permanent lower first molar followed by four-canals (n=141; 42.2%) and two-canals (n=26; 7.8%). In males, four-canals pattern was most common (51.4%) while in females three-canals pattern was most frequent (57.3%) [P=0.000]. Type II was the common (n=203; 60.78%) configuration in mesial root of mandibular first permanent molar followed by type IV (n=116; 34.7%) and type I (n=15; 4.5%). In distal root of mandibular first permanent molar, 180 (53.9%) cases had type I canal configuration followed by type IV (n=92; 27.5%) and type II (n=62; 18.6%). Gender stratified data was significant for distal root while insignificant for mesial root.

CONCLUSION: Males had common patterns of four-canals while females had three-canals. Canal configuration in mesial root was type II followed by type IV and distal root was type I followed by type IV and II.

KEY WORDS: Molar (MeSH); Cone Beam Computed Tomography (MeSH); Canal Configuration (MeSH).

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INTRODUCTION

Permanent mandibular first molar erupt at the age of six to seven years and its root completion occurs after two to three years. Lower first molar has five cusps and has a root trunk which divides into mesial and distal roots. Rarely, it exhibits three roots where the mesial root has buccal and lingual branches.¹ Among all human teeth, the lower first permanent molar is commonly affected

by caries and usually needs restoration and root canal treatment at early age.² The incidence of caries in first molar is 55.6%.³ This is due to the early eruption of mandibular first permanent molar. This is first one in permanent dentition to erupt and that's why more prone to cariogenic insults.² There are different causes of root canal treatment failure which include deficient cleaning and sealing of canals, inadequate coronal restoration and missing of canal due to

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two dimensional images. Various procedures were undertaken to find out the number of root canals e.g. decalcification method, periapical radiograph, spiral computed tomography, scanning electron microscopy, cone beam computed tomography (CBCT). The disadvantage of decalcification method is formation of opaque area owing to incomplete dehydration and air drying. Periapical radiographs are two dimensional images.⁴ The spiral computed tomography method provides three dimensional image but the major limitation of this method is high radiation dose (1.34mSv).⁵ The limitation of scanning electron microscopy is the potential for artifact production during specimen's preparation.⁶ CBCT images are three dimensional and provide more image accuracy. It has rapid scanning time (10-70 sec) and radiation dose is low (0.034-0.102mSv).⁷

Different previous investigations have documented variations in root canal systems in different races.⁸ The lower molars with two roots usually have three canals but the incidence of fourth canal is also high.^{2,8-10} Mesial root has two canals and the distal root has one or two canals.⁴ A study in Iran declared that 6% of teeth had three roots, 50% had four canals and 42% had three canals.⁸ In a study in Turkey evaluated configuration of root canal in lower first permanent molar with the help of CBCT, they reported that type IV configuration was the most numerous 59.8%, type II was the second most common 32.5% in mesial root while type I was found in 73.5% cases and in 12.9% cases was type II in distal root for which Vertucci's classification was used.⁷ Zhang R, et al.⁴

TABLE I: STRATIFICATION OF CANAL NUMBERS WITH GENDER

Number of Canals	Gender of Patients			x ²	df	*p-value
	Male	Female	Total			
	n (%)	n (%)	n (%)			
2	6 (2.9)	20 (16.1)	26 (7.8)	31.092	2	.000
3	96 (45.7)	71 (57.3)	167 (50)			
4	108 (51.4)	33 (26.6)	141 (42.2)			
Total	210 (100)	124 (100)	334 (100)			

*Chi-Square applied.

TABLE II: STRATIFICATION OF CANAL CONFIGURATION (MESIAL ROOT) WITH GENDER

Number of Canals (Mesial Root)	Gender of Patients			x ²	df	*p-value
	Male	Female	Total			
	n (%)	n (%)	n (%)			
I	6 (2.9)	9 (7.3)	15 (4.5)	4.535	7	.104
II	134 (63.8)	69 (55.6)	203 (60.8)			
III	0	0	0			
IV	70 (33)	46 (37.1)	116 (34.7)			
V	0	0	0			
VI	0	0	0			
VII	0	0	0			
VIII	0	0	0			
Total	210 (100)	124 (100)	334 (100)			

*Chi-Square applied.

TABLE III: STRATIFICATION OF CANAL CONFIGURATION (DISTAL ROOT) WITH GENDER

Number of Canals (Distal Roots)	Gender of Patients			x ²	df	*p-value
	Male	Female	Total			
	n (%)	n (%)	n (%)			
I	102 (48.6)	78 (62.9)	180 (53.9%)	7.846	7	.020
II	40 (19)	22 (17.7)	62 (18.6%)			
III	0	0	0			
IV	68 (32.4)	24 (19.4)	92 (27.5%)			
V	0	0	0			
VI	0	0	0			
VII	0	0	0			
VIII	0	0	0			
Total	210 (100)	124 (100)	334			

*Chi-Square applied.

evaluated lower permanent 1st and 2nd molar's root canal configuration in subpopulation of China using CBCT on 389 Chinese individuals. Their results showed that in 70% of lower first molars and 76% of lower 2nd molars cases had two isolated roots. In 29%, first molars were tri-rooted. In 29% of second molars, roots canal were C-shaped. Three canals frequency was 56% and four canal frequencies was 43% in lower 1st molar while in 2nd molar and was 46% and 38% respectively. Vertucci type I configuration was most

common in distal root. The root canal systems were more intricate in mesial root. Seven variants of morphology of root canal were found in lower 1st molar and eight in lower 2nd molars.

A local study was done in 2015 by decalcification method. They have shown that 100% of permanent lower first molar are two rooted. They also revealed that prevalence of three canals was 65.8% and four canals were 34.2% (two in each root). They also concluded that mesial root was dominated by type

IV configuration (70.7%) followed by type II (26.8%).⁵

For successful root canal treatment, dentists must know the number of root canals, cleaned and irrigated them properly, and after that, fill the root canals with non reactive obturating material. If canal is missed during root canal treatment it will lead to failure of root canal treatment because it will be a source of infection.^{5,6} Furthermore, there is also variation in root anatomy of permanent lower first molar in different races. So this current study aims to evaluate canal numbers and configuration of lower first molar by CBCT method.

METHODS

This retrospective study was conducted at Department of Oral Diagnosis and Department of Radiology, Sardar Begum Dental College, Peshawar, Pakistan after taking prior permission from Ethical Review Committee of Gandhara University, Peshawar, Pakistan. CBCT images, scanned from March 2015 to April 2016, were collected from the said departments and analyzed during the study duration.

CBCT images were analyzed using Scanora software version 3D. The contrast and brightness of the images were adjusted using the imaging process tool in the software to ensure optimal visualization. All the images were studied at axial and coronal planes by continuously moving the tool bar from the floor of pulp chamber to root apexes. The data collected were strictly used for research purpose and will be kept confidential. The canal numbers and configuration were assessed and charted down in a predesigned check list according to the classification by Vertucci.⁸ Sample size of 334 was taken for the study. All good quality CBCT images of permanent mandibular first molar with intact pulp chamber, having close root apices in both genders were included in the study, while all with any treatment history, artificial crown, fractured, sclerosed roots and three rooted permanent mandibular first molars were excluded. Data was collected and analyzed using SPSS version 20. Means and standard

deviations were calculated for number of canals. Percentage was calculated for canal configuration. Post stratification for genders were carried out for number of canals and configuration of canals using Chi-square test. $P < 0.05$ was considered significant.

RESULTS

Of total 334 patients, 210 (62.9%) were males and 124 (37.1%) were females. The male to female ratio was 1.6:1. Frequencies and percentages of canals' number in mandibular first permanent molar shows that three-canals were the most frequent (50%) canals in permanent lower first molar followed by four-canals (42.2%) and two-canals (7.8%). Stratified gender distribution in comparison with number of root canals is shown in Table I.

Type II was the common ($n=203$; 60.78%) configuration in mesial root of mandibular first permanent molar followed by type IV ($n=116$; 34.7%) and type I ($n=15$; 4.5%). The stratified data for configuration of canal (mesial root) in comparison with gender is as per Table II.

In distal root of mandibular first permanent molar, 180 (53.9%) cases had type I canal configuration followed by type IV ($n=92$; 27.5%) and type II ($n=62$; 18.6%). The stratified data for configuration of canal (distal root) in comparison with gender is as per Table III.

DISCUSSION

The most common cause of root canal failure is to explore and debride the whole canal.¹¹ Undetected extra canal is also major cause for endodontic treatment failure.¹² A precise and accurate radiography is essential for diagnosis. Radiograph taken at different angles are required for evaluation of root canal morphology and anatomy.¹³

In the current study males were outnumbered than females. In our country, males are dominant, more outgoing and more visitors for endodontic treatment. The second reason that the female are more cautious about their oral hygiene and hence less prone to carious lesion.

Hussain U, et al.⁹ carried out a study on incidence of fourth canal in mandibular first molars in Khyber College of Dentistry, Peshawar, their study shows similar to current study being males were more than females.

In current study CBCT was used to determine number and configuration of canals in permanent mandibular first molar at Peshawar. Mokhtari H, et al.¹⁴ in vitro study compared the accuracy of CBCT and with staining and clearing technique in determining root canal morphology of lower first molars. They reported that clearing technique had more accuracy than cone beam CT because more accurate anatomy of the root canal system of lower first molars can be obtained. But this study has limitation because it was in vitro. In vitro study, the clearing technique can be performed more easily as compared to in vivo. CBCT can reconstruct the 3-D structure of the entire root canal system to offer the dental specialist with a precise image of root canal.¹⁵ CBCT is simple and non-invasive technique and can be done in any sort of clinical settings. The plus points of Cone Beam CT is; it is non-invasive, providing three-dimensional reconstruction for the whole canal system, radiation dose is much less, limiting imaging field is feasible, an increase in image precision and resolution and a reduction in artifacts.¹⁶

Most of studies carried out in Pakistan only determined number of canals in first permanent molars and based on conventional X-ray (SLOB rule) and decalcification method.^{5,9,17} The current study addressed the number of canal as well as configuration based on CBCT method. In the present study three canals were the most numerous (50%) followed by four canals (42.2%). Two canals were found in (7.8%) cases only. Shahi S, et al.⁸ conducted a study on Iranian population using extracted first permanent molars and they reported that out of 209 teeth studied, 137 teeth (65.56%) had three canals, 66 teeth (31.57%) had four and 6 teeth (2.87%) had two canals.

Hussain U, et al.⁹ reported in a study on a sample of Peshawar population based on conventional X-ray (SLOB rule) that mandibular first molar have three canals

in 60% and four canals 40%. The small difference in frequencies of canal patterns is due to the fact in Hussain U, et al.⁹ study, canal's frequencies were determined by house surgeons which have less experience. The second reason may be the lack of accurate diagnostic tool (e.g. CBCT). Another study conducted in Hyderabad, Pakistan, using SLOB rule showed that 36% of the mandibular first molars have four canals.¹⁷

Huang CC, et al.¹⁸ used CBCT to determine the number of roots and canals in lower first molars in 151 patients of Taiwan population. They reported that 56.1% had three canals, 40.5% had four, and 3.4% had two canals. These results are in consistence to the current study with same methodology used.

Nur BG, et al.¹⁹ determined the number of root canals and configuration of canals in lower first permanent molar in Turkish population of south-eastern area with help of CBCT of 966 samples. They reported that 49.8% had four canals, 49.8% had three canals and 0.4% had five canals. In contrast to this study, Nur BG, et al.¹⁹ found fifth canal in Turkish population as well. This may be due to genetic, environmental and ethnic variation. Accordingly in the current study about 7% patients had two canals while the Nur BG, et al.¹⁹ reported none for two canals.

In the current study gender wise distribution for number of canals shows that in males, four canals patterns were the most common (51.4%) followed by three canals (45.7%) while in females three canals was most numerous (57.3%) followed by four canals (26.6%). This difference in frequencies of canals in both genders were statistically significant ($P=0.000$). This unique difference may shows that number of canals is influenced by X-linked genetics.²⁰ Miloglu O, et al.⁷ while evaluating root and canal configuration of mandibular first molars with cone beam computed tomography in a Turkish population reported a non-significant difference for number of roots among males and females but not provided any data regarding canal variation stratified by gender. No study has been traced in which comparison

among genders for number of canals in mandibular first molar was done.

In the present study Vertucci classification was used for studying root canal morphology. The distribution of canals in mesial roots mandibular first molar shows that type II was the common configuration (60.78%). Fifteen cases (4.49%) had type I canal configuration, 203 cases had type II canal configuration and 116 (34.74%) cases had type IV canal configuration. Shahi S, et al.⁸ reported that type IV type was the most common in Iranian population. They reported that out of 206 two-rooted mandibular first molars, mesial roots with two canals were of type II (41.87%), type III (0.49%), type IV (53.69%) or type V (3.94%) canal configuration. It looks that race and ethnicity are imperative factors in differences perceived in root canal configuration between others in present study.

In current study, both males and females, type II canal configuration was most common in mesial root. In male 63.8% and in females 55.6% have type II configuration. In both genders, type II was most numerous followed by type IV and then type I. This difference was not statistically significant ($P=0.104$) The research of Wasti, et al.²¹ and Gulabivala, et al.²² Sertet, et al.²³ also concluded that both gender and ethnic origin should be given due consideration during preoperative evaluation of endodontic therapy. Therefore, further studies are needed in different regions of the world to prove that there is a relationship between the racial and ethnic differences and the anatomic differences in the lower first permanent molars.

Torres A, et al.²⁴ studied root canal configuration in mandibular first molar in sample of Belgium and Chilean population using CBCT images of 515 mandibular molars. They determined the root canal configuration on basis of Vertucci classification. They reported that the most common configurations in the mesial root of both molars were type V (42%) and type III (33%). These results are different from the current study. The difference may due to genetic and ethnic variation. In contrast to our study, Nur BG, et al.¹⁹ CBCT

based study found type IV followed by type I canal to be the most numerous in mesial root of mandibular first molars in Iran population.

In present study the distal root of mandibular first permanent molar, 180 cases (53.89%) had type I canal configuration, 62(18.56%) had type II and 92(27.54%) had type IV canal configuration. Similar to the current study, Torres A, et al.²⁴ in a study on sample of Belgium and Chilean population reported type I canal configuration to be most numerous in distal root of mandibular first molar. However, simultaneously, in contrast to the present results, in their study the second most common configuration in distal root was type III. This shows that how much variability exist in different population for canal configuration.

Nur BG, et al.¹⁹ in a study on south-eastern Turkish population reported that the most common configuration in distal root of mandibular first molar was type I followed by type II. These results are consistence with the current study. In current study no statistical difference was found for distal root canal configuration between males and females. Similar results has been reported by others.^{21,24}

CONCLUSION

Half of mandibular first molar had three-canals. More males have common patterns of four canals while in female three canal was the commonest pattern. More males have common patterns of four-canals while in female three-canal was the commonest pattern. Mesial and distal roots have different patterns of canal configuration. Mesial root has type II most common canal configuration and distal root has type I most common canal configuration.

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AUTHORS' CONTRIBUTIONS

Following authors have made substantial contributions to the manuscript as under:

TM: Concept & study design, acquisition of data, drafting the manuscript, critical review, final approval of the version to be published.

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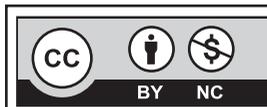
Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

CONFLICT OF INTEREST

Authors declared no conflict of interest

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