



ORIGINAL ARTICLE

Anatomical variations and bilateral symmetry of roots and root canal system of mandibular first permanent molars in Saudi Arabian population utilizing cone- beam computed tomography



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Abstract *Aim:* The aim of the study was to evaluate the anatomical variations of the roots and root canal system, and to determine the symmetry between right and left sides of mandibular first permanent molars in Saudi Arabian population using images derived from cone beam computed tomography (CBCT) scans.

Methods: The CBCT scans (with the following parameters: FOV 170 × 120 mm, 90 Kv, 5–8 mA, 17.5 s exposure time and 0.25 mm voxel size) were retrieved from the database and axial, coronal and sagittal sections of mandibular first molars were examined. The number of roots, canals and type of canal configuration based on Vertucci's classification were recorded. Bilateral symmetry between right and left side of the same individuals and differences between genders were investigated.

Results: Out of 174 mandibular first molars, 97.1% were two rooted and 2.9% were three rooted (distolingual root). In regards to the number of canals, 73% had three, 25.3% had four and 1.7% had two root canals. In teeth with four root canals, 90.9% of the extra canal was in the distal root, while 9.1% in the extra distolingual root. The most common canal configuration in mesial and distal root were type IV (64.9%) and type I (77%), respectively. Symmetrical analysis revealed 100% symmetry in number of roots and 56.4% in number of canals between right and left teeth in the same individual.

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Conclusions: Within the limitation of this study, wide range of canals configurations were noted in mandibular first molars among the Saudi Arabian population. The prevalence of three rooted mandibular first molars was relatively low. Three canals were most commonly seen in mandibular first molars. Bilateral symmetry was varied in number of canals and canals configurations, which could be of clinical significance while performing root canal treatment on both side mandibular first permanent molars.

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1. Introduction

Chemo-mechanical cleaning and shaping of the root canal system and three-dimensional obturation are mandatory to fulfill the main aim of root canal treatment (RCT) that is preventing and/or treating apical periodontitis (Schilder, 1967; Schilder, 1974). Presence of anatomical difficulties will affect the process of chemo-mechanical cleaning and shaping which ends up in a potential reduction in the success rate of RCT (Peters, 2004). Therefore, clinicians should be thoroughly aware of the common root canal morphology and their possible variations in order to improve the predictability of RCT. In this context, the past few decades witnessed development of many techniques that implemented to evaluate anatomy of the teeth and their root canal systems including injection of plastic resin, conventional radiograph, histological examination, clearing and dye injection, conventional and micro-computed tomography (de Pablo et al., 2010; Harris et al., 2013). Certainly, these methodological approaches provided very useful information to the practitioners. However, essential limitations of these techniques inspired us to search for newer methods that help in depicting the anatomy more accurately. Recently, cone beam computed tomography (CBCT) has been widely used with a wide range of applications in dental practice. Briefly, CBCT enables the clinicians to observe the three dimensions of the relevant area. The use of CBCT in the analysis of root canal morphology has been supported by number of studies (Huang et al., 2010; Kim and Yang, 2012; Kim et al., 2012; Tu et al., 2009). In fact, root morphology including number of root canals can be visualized well in three dimensions (Patel et al., 2007).

Mandibular first molar is the first permanent tooth to erupt, most often affected by caries and frequently undergoes endodontic treatment with a complex morphology of its canal system especially in the mesial root (de Pablo et al., 2012, 2010, Vertucci, 1984). The mesial root is characterized by wide buccolingual and narrow mesiodistal dimension, whereas the distal root is mostly conical (Skidmore and Bjorndal, 1971). However, the occurrence of three rooted mandibular first molar, is the most frequently encountered variability, although linked to specific ethnic groups (Rodrigues et al., 2016). Limited studies have reported root and canal morphology among Saudi population (Ahmad, 2015), and no single study have been published on mandibular first molar by utilizing the three dimensional modality. Thus, the present study was designed to evaluate the number of roots, canal morphology, bilateral symmetry and gender differences of mandibular first permanent molars in Saudi Arabian population by means of CBCT images.

2. Material and method

A total of 174 CBCT scans of mandibular first permanent molars were acquired from ninety eight Saudi Arabian patients from the southern region, with an age range between 15 and 50 years. The study sample included 61 males with 111 mandibular first molars, and 37 females with 63 mandibular first molar. The institutional review board (CODJU-1811F) approved the study plan and the study was conducted following the guidelines. CBCT scans were retrieved from the database of the institution. Teeth with fully developed roots and closed apices were included in the study. Previously treated-root canal or root canal treatment initiated teeth; teeth with periapical lesions, calcification or resorption; and distorted CBCT images were excluded. Out of 98 patients, 77 patients were having both right and left sided mandibular first molars (154 mandibular first molars), and were subjected for bilateral symmetrical analysis. The CBCT machine used in this retrospective cross-sectional study was 3D Accuitomo 170 (MORITA, Japan) and the scanning parameters were constant for all patients as follows: FOV 170 × 120 mm, 90 kv, 5–8 mA, 17.5 s exposure time and 0.25 mm voxel size. All CBCT images were processed and reconstructed using Morita's i-Dixel 3D imaging software. Axial, coronal and sagittal serial sections were acquired to evaluate number of roots and canals and to classify the root canal system on the basis of classification given by Vertucci (1984) (Fig. 1). First, the sectioning was oriented to be parallel to long axis of root canal with 1 mm slice thickness. Then the projections were examined by scrolling the images in coronal-apical direction for axial sections and from mesial to distal for parasagittal sections. A careful examination was obtained by optimal visualization using all the software features, such as zooming, change in contrast and brightness. The CBCT images were accessed and evaluated by two endodontists and one oral and maxillofacial radiologist. The examiners independently assessed each tooth in two sessions with a two-week interval. Any disagreement in assessment was resolved by consensus. Data were tabulated and analyzed using Chi square and Kappa tests, as appropriate. SPSS software version 22 (SPSS Inc., Chicago, IL, USA) was used to analyze the data. Following parameters were evaluated: number of roots, number of root canals, and classification of canals based on Vertucci's classification. Furthermore, comparisons between males and females, and right and left side symmetrical analysis of the same individuals were performed.

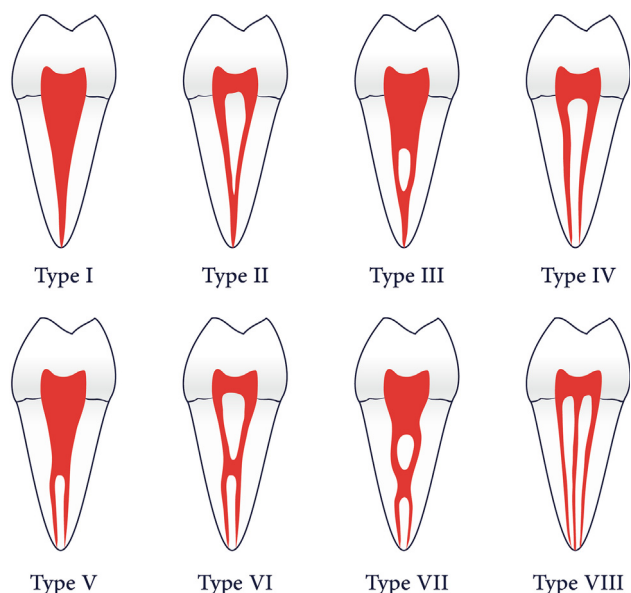


Fig. 1 Diagrammatic illustration of Vertucci's classification used in the present study.

3. Results

3.1. Anatomical variations

Out of 174 mandibular first molars, 169 (97.1%) were two rooted, and 5 (2.9%) had extra (distolingual) root. With regard to number of canals, three canals were the most predominant (73%) followed by four canals (25.3%) and two canals (1.7%). In teeth with 4 canals (44 out of 174), 90.9% of the extra canal was in the distal root, while 9.1% in the extra distolingual root (Table 1). Both roots, mesial and distal showed wide range of variations of canal system according to Vertucci classification (Fig. 2); type IV (64.9%) was the most prevalent configuration in the mesial root and type I (77%) in distal roots. One interesting variation, type I in mesial roots was noted with a prevalence rate of 1.7%. In addition, all distolingual roots (100%) were of type I canal's configuration (Table 2).

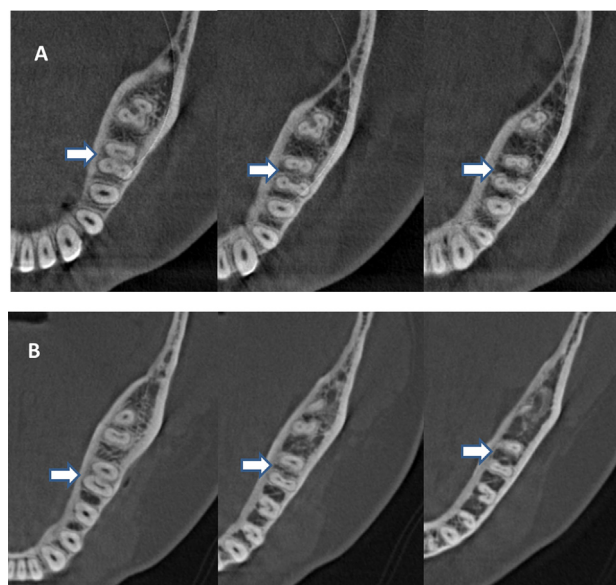


Fig. 2 Axial sections of mandibular first permanent molars at coronal, middle and apical third levels; the white arrow indicates variations in canal configurations of the examined tooth. (A) Mesial root with type IV (2-2) and distal root with type V (1-2) configuration. (B) Mesial root with type V (1-2) and distal root with type I (1) configuration.

3.1.1. Comparison between males and females:

There were no associations of number of roots, canals and configuration of canal with gender ($P > 0.5$) (Tables 1 and 2).

3.1.2. Symmetrical analysis between right and left sides:

Out of 98 patients 77 had both sided right and left first mandibular molars. Configuration of canals in the right and left sides were compared. The mesial roots showed an overall canal system symmetry in 54.1% of cases, with the most common configuration were type VI representing 40/48 of cases (83.3%) and type II representing 16/24 of cases (64%). Distal root showed an overall symmetry in 47.6% of cases with the most common configuration was type I representing 55/61 of cases.

	Right			Left			No. of teeth, N (%)
	Male, n	Female, n	No. of teeth, n (%)	Male, n	Female, n	No. of teeth, n (%)	
No. of roots	$P = 1$			$P = 0.538$			
One	0	0	0 (0)	0	0	0 (0)	0 (0)
Two	52	31	83 (96.5)	55	31	86 (97.7)	169 (97.1)
Three	2	1	3 (3.5)	2	0	2 (2.3)	5 (2.9)
No. of root canals	$P = 0.134$			$P = 0.752$			
Two	1	1	2 (2.3)	1	0	1 (1.1)	3 (1.7)
Three	44	21	65 (75.6)	40	22	62 (70.5)	127 (73)
Four	9	10	19 (22.1)	16	9	25 (28.4)	44 (25.3)
Molars with 4 canals	$P = 1$			$P = 0.52$			
Two-rooted	8	9	17 (89.5)	14	9	23 (92)	40 (90.9)
Three-rooted	1	1	2 (10.5)	2	0	2 (8)	4 (9.1)

Table 2 The distribution of the canal system types (Vertucci) by location and gender.

Classification of the canal system based on Vertucci*	Mesial			Distal		
	Male, n	Female, n	No. of teeth, n (%)	Male, n	Female, n	No. of teeth, n (%)
Type I	2	1	3 (1.7)	89	45	135 (77)
Type II	29	23	52 (29.9)	6	5	11 (6.32)
Type III	0	3	3 (1.7)	6	5	11 (6.32)
Type IV	77	36	113 (64.9)	4	2	6 (3.45)
Type V	2	0	2 (1.1)	4	6	10 (5.75)
Type VI	1	0	1 (0.6)	2	0	2 (1.15)
Type VII	0	0	0 (0)	0	0	0 (0)
Type VIII	0	0	0 (0)	0	0	0 (0)
Total No. of teeth, n	111	63	174	111	63	174

* Mesial for both sides were combined together, as similarly done for distal; $P > 0.05$ for all individual Vertucci distribution by gender (Chi square test).

Table 3 Symmetry of Distal and mesial canal configuration in the Right and Left sides.

		Left distal canal Vertucci's classification						Total	Kappa and P value
		I	II	III	IV	V	VI		
Right distal canal Vertucci's classification	I	55	2	2	0	1	1	61	0.476 (P < 0.001)
	II	1	2	0	0	1	0	4	
	III	3	0	1	0	0	0	4	
	IV	0	1	0	2	0	0	3	
	V	1	0	2	0	2	0	5	
Total		60	5	5	2	4	1	77	
		Left mesial canal Vertucci's classification						Total	Kappa and P value
		I	II	III	IV	V	VI		
Right mesial canal Vertucci's classification	I	1	1	0	0	0	0	2	0.541 (P < 0.001)
	II	1	16	0	7	0	0	24	
	III	0	0	1	0	0	0	1	
	IV	0	8	0	40	0	0	48	
	V	0	0	0	0	1	0	1	
	VI	0	0	0	1	0	0	1	
Total		2	25	1	48	1	0	77	

Table 4 Symmetry of numbers of roots and canals in right and left sides.

		Left Tooth Roots Number		Total	Kappa and P value	
		2	3			
Right tooth roots number	2	75	0	75	1 (P < 0.001)	
	3	0	2	2		
Total		75	2	77		
		Left tooth canals number			Total	Kappa and P value
		2	3	4		
Right tooth canals number	2	1	1	0	2	0.564 (P < 0.001)
	3	0	51	7	58	
	4	0	5	12	17	
Total		1	57	19	77	

cases (90.2%) (Table 3). With regard to number of roots and canals, the right and left sides showed 100% symmetry in number of roots and 56.4% symmetry in number of canals with the most frequent symmetry and also the most common was three canals representing 51/58 (87.9%) (Table 4).

4. Discussion

In the present study, the anatomy and canals morphology of mandibular first permanent molars were investigated by means of CBCT. The tooth along with the adjacent anatomical

structures are best visualized when a 3D modality like CBCT is applied. It not only overcomes the limitations of 2-dimensional x-ray, but also changes the way endodontics is practiced today (Lam, 2012; Patel et al., 2007). Many studies were carried out to study the root canal anatomy of mandibular first molar by using variety of methods which showed great variability among different populations.

In the present study majority of mandibular first molars were two-rooted, similar to the systematic review by de Pablo et al. (2010), findings of al-Nazhan (1999) on Saudi sub-population and Chourasia et al. (2012) on Indian population. Three rooted mandibular first molar prevalence was 2.9% in the present study lower than the findings of de Pablo et al. (2010), who reported an average prevalence of 13% in different populations with wide range from 0.2% to 25.82% (al-Nazhan, 1999; Chourasia et al., 2012; Kim et al., 2013; Younes et al., 1990).

The global estimation of the number of root canals showed a prevalence rate of 61.3% for three root canals, followed by 35.7% for four canals (de Pablo et al., 2010). The radiographic and clinical study by al-Nazhan (1999) on Saudi subpopulation reported the prevalence of three and four canals as 42% and 58% respectively. Chourasia et al. (2012) in an Indian population using cleared tooth techniques found 64% three canals and 36% four canals of the sample. The present study revealed a slightly higher prevalence of three root canals (72.4%) and lower prevalence of four canals (25.3%).

Mesial root showed type IV canal as the most prevalent (64.9) followed by type II (29.9%), similar to the findings of previous studies (Chourasia et al., 2012; de Pablo et al., 2010). In a recent CBCT based study on an Italian population, Gambarini et al. (2018) reported type IV and type II canal configurations as 59% and 41% respectively. In a large CBCT study among Korean population with a sample size of 1952 mandibular first molars, Kim et al. (2013) reported type IV canals in 76.86% followed by type II in 20.21% in mesial root of mandibular first molar. One canal with type I Vertucci classification in mesial root was seen in 1.7% cases, similar to the findings of Kim et al. (2013) who reported a prevalence of 1.81% mesial root among Korean population. Zafar and Alrahabi (2015) reported much higher (7.5%) prevalence of type I configuration in mesial root of mandibular first molar among Saudi Arabian population recruited from the Western region in *ex vivo* CBCT based study. These variations in the findings may be attributed to the differences of the studied populations.

With regard to distal root canal configuration, the present study revealed 77% for type I and 6.3% for both type II and type III configuration, similar to the findings of Zafar and Alrahabi (2015) among Saudi population, and a systematic review by de Pablo et al. (2010). Other study showed type I configuration to be most prevalent (65.3%) followed by type II (20.6%) in a distal root of mandibular first molar (Chourasia et al., 2012). A CBCT based study in a Korean population (Kim et al., 2013) showed the most prevalent canal configuration in distal roots was type I canals (66.62%), followed by type II (19.02%).

Although C-shaped canals configuration was reported by Alfawaz, Alqedairi et al. (2019) in mandibular first molar of Saudi population with a prevalence of 0.19%, it was not seen in the present study.

Comparisons between males and females were addressed in the current work, which revealed non-significant differences in distribution of roots, canals and canal configurations. These findings are consistent with al-Nazhan (1999) in a Saudi population, Sert and Bayirli (2004) in a Turkish population, and Martins, Marques et al. (2018) in a Portuguese population.

Symmetry between left and right mandibular first molars in the same individual with regard to number of roots and canals, and canals configuration were investigated in the present study. Our study showed 100% symmetry in number of roots and 56.4% in number of canals. Regarding canals configuration, results showed symmetries in 54.1% in mesial roots and 47.6% in distal roots. The CBCT based study on Italian population by Plotino et al. (2013) reported 70.6% symmetry in number of roots and canal on right and left sided first mandibular molars. Another publication by Felsypremila et al. (2015) in Indian population examined 131 patients with right and left mandibular first molars, reported 78.6% symmetry in regards to number of roots and canals. Although with slight variations, the findings of present study go within the main stream of the global estimation of root canal anatomy of permanent mandibular first molar.

5. Conclusion

Within the limitation of this study, extra root was seen in few cases of mandibular first molars of a Saudi population from the southern region. A wide range of canals configurations were noted with high prevalence of type IV in mesial root and type I in distal root. No associations between gender and root anatomy and canals morphology were reported. Although high bilateral symmetry was found in number of roots, it varied with regards to number of canals and canals configurations in the same individuals.

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed were in accordance with the ethical. Standards of the local institutional review board (CODJU-1811F).

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