ORIGINAL RESEARCH

Ethnical Anatomical Differences in Mandibular First Permanent Molars between Indian and Saudi Arabian Subpopulations: A Retrospective Cross-sectional Study

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Abstract

Aim and objective: The variation in the anatomy of the root canal system has anthropological and demographic significances. The aim of this study was to compare the number of roots, root canals, and internal canal morphology of permanent mandibular first molars between Indian and Saudi Arabian populations.

Materials and methods: A total of 523 (255 teeth of Indian sample and 268 teeth of Saudi Arabian sample) mandibular first molar (M1) were included for comparative analysis using cone-beam computed tomography images based on the inclusion criteria. The external and internal morphologies were assessed and compared by trained endodontist and the data was recorded.

Results: M1 with three roots were found in 3.9% of the Indian population and 6% of the Saudi population. Overall, high prevalence was observed in two roots (95.0%), three canals (70.4%), Vertucci type IV of the mesial root (56.0%), and Vertucci type I of the distal root (76.7%). Comparison between Indian and Saudi Arabian molars revealed significant differences in relation to the number of canals (p <0.001), Vertucci types of the mesial root (p = 0.008), and Vertucci types of the distal root (p <0.001). Differences between genders for the whole sample revealed significant differences in relation to Vertucci types of the distal root (p = 0.025) with a relatively high male prevalence of type I (54.4%) and type IV (57.1%).

Conclusion: The predominant parameters of M1 were two roots, three canals, Vertucci type II and IV mesial root configuration, and type I distal root configuration irrespective of both populations. The root canal morphology of Indian and Saudi Arabian populations shares a common trait of Asian origin.

Clinical significance: The likelihood of predicting the complex system of the root canal with marked preference to ethnic identity would be a clinical benefit for the dentist performing root canal treatment.

Keywords: Cone-beam computed tomography, Dental pulp cavity, Ethnic groups, Mandibular first molar, Retrospective studies.

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Introduction

The pre-eminence of scrutinizing the morphological variation of the root canal system (RCS) is to accomplish complete debridement, disinfection, and complete obturation of the same. The variation in the anatomy of the RCS has anthropological[1] and demographic[2,3] significances. Numeral swats have shown inconsistent patterns in the number and shape of the roots and canals among divergent denizens.[4-6] These discrepancies seem to be genetically determined and are fundamental in discerning the etymology of the human race.[7,8] Disparate techniques have been used for studying the morphology and anatomy of the RCS, namely, invasive cross-sectional examination,[9] staining and tooth clearing,[5] conventional radiography,[10] radiographic assessment enhanced with contrast media,[11] microcomputed tomography,[12] and cone-beam computed tomography (CBCT).[13] An ample number of researches have implicated the use of CBCT technique to be more precise in evaluating the root canal number and shape *in vivo*.[13,14]

The first to erupt and the frequent tooth to be affected by caries is the mandibular first permanent molar (M_1) with a complex RCS.[15] These teeth display a range of variations in terms of shape, number of roots, root canals, and internal anatomy, thereby rendering itself a significant entity in the field of endodontics.[4,16,17] For example, the prevalence of radix entomolaris (RE) in M_1 was different for Indian,[18]

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Malaysian,[19] Saudi,[3,20] and Taiwanese Han Chinese[21] populations. These variations seem to have clinical significance during endodontic therapy. They also have a genetic penetrance which plays a vital role in tracking the origin of population based on the ethnic background.[22]Two studies have compared the RCS of M_1 among different ethnic backgrounds.[2,22] Torres et al. observed variations in root canal morphology, curvature in the distal canal, and C-shaped canal of mandibular molars between the Chilean and Belgian populations using CBCT.[23] The root canal morphology of mandibular second molars from nine different geographic locations worldwide was screened for the prevalence of C-shaped canal using CBCT.[24]

Although India and Saudi Arabia are part of the same Asian continent, the ethnic anatomical differences between the two populations of South Asian and West Asian geographic locations, respectively, remain unanswered in the literature. The likelihood of predicting the complexity of RCS with marked preference to ethnic identity would be of a clinical benefit for the dentist performing the root canal treatment. Moreover, comparing the morphological alteration of root canal between racial profiles will be obliging for the operator in enhancing the key traits to remember. The classification of human-kind by Scott and Turner states that the majority of people from the Indian subcontinent belong to the Asiatic Indian group of the Western Eurasia origin.[25] Another school of thought says that the origin is Indo-European.[26] Whereas, the people of Saudi Arabia, being a part of Arab nations, are commonly called as Middle Eastern population.[27]

Therefore, the purpose of the study was to comparatively analyze the number of roots, root canals, and root canal morphology of M_1 among Indian and Saudi Arabian populations. The null hypothesis tested was that there is no difference in the prevalence of root and root canal morphology between the two populations based on geographic location.

Materials and Methods

The present study was approved by the Standing Committee for Scientific Research Ethics, Jazan University (REC41/4/088). A retrospective cross-sectional observational design was employed for the time period from January 2019 to December 2019. The sample size was not calculated because the previous literature comparing the two chosen populations was not available. Hence, this investigation was conducted as a preliminary study on the representative subpopulations to obtain the data for future investigations on a larger scale.

Study Sample

A total of 300 patients (150 each) from two countries were selected from the archives according to the following eligibility criteria and were involved in the study. The patients having at least one noncarious M_1 without endodontic restoration who required diagnostic CBCT investigation for preoperative assessment for multiple implants, endodontic management of any other teeth with unusual root canal morphology, facial trauma, maxillary sinusitis, or orthodontic treatment were included in the study. CBCT images of 150 patients representing the Indian population were retrieved from the archives of a private diagnostic imaging center in India. There were 84 (56%) images for males and 66 (44%) images for females with a mean age of 33.64 ± 14.03 years ranging from 10 to 72 years. Similarly, CBCT images of 150 patients representing the Saudi population were retrieved from the database of the College of Dentistry, Jazan University. The study samples consist of 71 (47.3%) males and 79 (52.7%) females with a mean age of 28.95 ± 9.80 years ranging from 17 to 59 years.

Cone-beam Computed Tomography Image Acquisition and Analysis

Cone-beam computed tomography images of Indian patients were obtained by Kodak 9500 cone beam 3D (Carestream Health Inc., Rochester, New York, USA) equipment with the following technical parameters: field of view 18 cm × 20 cm, 10.8 seconds exposure time (pulsated), tube voltage 60–90 kV, 2 to 15 mA (pulsated mode) and slice thickness of 0.25 mm. CBCT images were analyzed using 3D module version 2.4 Kodak Dental Imaging software (Carestream Health Inc.). The CBCT unit used for Saudi patients was 3D Accuitomo 170 (J. Morita Mfg. Corp., Kyoto, Japan) with the following scanning parameters: field of view 17 cm × 12 cm, tube voltage 90 Kv, 5–8 mA, effective exposure time of 17.5 seconds, and 0.25 mm voxel size. Processing and reconstruction of all CBCT images were performed using 3D imaging software (i-Dixel version 2.0; J. Morita Mfg. Corp.). Three serial sections (axial, coronal, and sagittal) were acquired to evaluate external and internal morphologies. Although the two CBCT units and the corresponding visualization software were different, the voxel size and other technical parameters were the same to standardize the images.

Two endodontists (M.M., V.T.) were trained to work with the CBCT in identifying the root canal morphology; one blinded investigator per subpopulation was asked to observe the CBCT images retrospectively to avoid bias. In case of complex RCS, where confirmation could not be obtained, a third endodontist (M.A.) was consulted to arrive at the consensus. Moreover, each investigator was asked to reassess 10% of their respective samples after 3 weeks interval period for comparison in order to measure the data reliability. CBCT images in all the three planes were observed for two times to get a detailed view of the RCS (Fig. 1). M_1 with fully developed roots and closed apices were included in the study. Treated root canal, calcified, resorbed, or distorted teeth on CBCT images were excluded. The following parameters were evaluated: number of roots, number of canals, and canal configurations according to Vertucci classification.[8]

Statistical Analysis

The collected data were coded and entered into an Excel worksheet (Microsoft Excel 2010, Microsoft, Redmond, Washington, USA) for the statistical analysis. The IBM SPSS Statistics for Windows software program, version 25.0 (IBM Corp., Armonk, New York, USA) was used. Descriptive statistics in terms of frequencies and percentages were presented. Comparison between the groups based on country and gender was performed using chi-square or Fisher's test as appropriate. The contingency coefficient was selected for variables with more than two categories. *p*-value <0.05 was considered significant for all tests.

Results

A total of 524 teeth were included in the study based on the inclusion criteria mentioned vide supra. A left M_1 in an Indian female was excluded from the study as there was only one tooth with C-shaped configuration. Finally, 523 (255 Indian and 268 Saudi) teeth were available for the comparative analysis. Cohen's Kappa was to test the reliability of measurements. The result revealed a

Figs 1A to D: Mandibular first molars from the whole population representing the highly prevalent two roots (A), three canals (A), Vertucci type II of mesial root (B), type IV of mesial root (C), and type I of distal root (D)

Table 1: Characteristics of mandibular first molar for whole sample and by country

	Overall (N = 523; %↓)	*Indian (N = 255; %↔)*	*Saudi (N = 268; %↔)*	*p value**
Number of roots				
Two roots	497 (95.0)	245 (49.3)	252 (50.7)	0.319
Three roots	26 (5.0)	10 (38.5)	16 (61.5)	
Number of canals				
Two canals	10 (1.9)	9 (90.0)	1 (10.0)	<0.001
Three canals	368 (70.4)	194 (52.7)	174 (47.3)	
Four canals	145 (27.7)	52 (35.9)	93 (64.1)	
Vertucci mesial root				
Type I	11 (2.1)	9 (81.8)	2 (18.2)	0.008
Type II	204 (39.0)	103 (50.5)	101 (49.5)	
Type III	6 (1.1)	3 (50.0)	3 (50.0)	
Type IV	293 (56.0)	140 (47.8)	153 (52.2)	
Type V	9 (1.7)	0 (0.0)	9 (100.0)	
Vertucci distal root				
Type I	401 (76.7)	215 (53.6)	186 (46.4)	<0.001
Type II	34 (6.5)	25 (73.5)	9 (26.5)	
Type III	49 (9.4)	3 (6.1)	46 (93.9)	
Type IV	14 (2.7)	12 (85.7)	2 (14.3)	
Type V	25 (4.8)	0 (0.0)	25 (100.0)	

The symbol "%↓" indicates that the percentage has to read vertically and "%↔" horizontally;

*Statistically significant at (p <0.05)

κ value of 0.938 (p <0.001) for the Saudi sample and 0.928 for the Indian sample.

Table 1 shows the comparative prevalence of root canal anatomy features of M_1 for the whole sample and the individual countries. The parameters with maximum prevalence for the whole sample (Fig. 1) were two roots (95.0%), three canals (70.4%), Vertucci type IV of the mesial root (56.0%) and Vertucci type I of the distal root (76.7%). Comparison between Indian and Saudi samples revealed significant differences between the samples in relation to the number of canals (p <0.001), Vertucci types of the mesial root (p = 0.008), Vertucci types of the distal root (p <0.001). It can be noticed that Vertucci type V was not found in the Indian sample. No significant differences were found between both samples in relation to the number of roots (p = 0.319). It is evident from Table 1 that relatively high prevalence was observed in the Saudi population for four canals (64.1%), Vertucci type IV of the mesial root (52.2%), and Vertucci type III of the distal root (93.9%). Vertucci type III of the mesial root was having an equal prevalence in both subpopulations.

Differences between genders for the whole sample revealed significant differences in relation to Vertucci types of the distal root (p = 0.025) with a relatively high male prevalence of type I (54.4%) and type IV (57.1%) as shown in Table 2. Similar significant gender differences were observed in Saudi samples for Vertucci types of the distal root (p <0.014) with a relatively high female prevalence of type I (51.6%), type II (88.9%), type III (52.2%), and type IV (100%). There was no significant difference between the genders as far as the number of roots, the number of canals, and Vertucci types of the mesial root are concerned (p >0.05). In Indian samples, significant gender differences were observed for Vertucci types of the mesial root (p = 0.049) and distal roots (p = 0.047) with a high male prevalence of type I (88.9%), II (55.3%), and IV (57.9%) and of type I (59.5) and IV (66.7), respectively.

The differences between Indian and Saudi samples for both genders are shown in Table 3. Significant ethnic differences were found among males for the number of canals (p <0.001), Vertucci types of mesial (p = 0.015) and distal (p <0.001) roots. However, the ethnic differences among the females were found significant only in relation to Vertucci types of the distal root (p <0.001). In the male samples, relatively high Indian prevalence was seen for two canals (100%), three canals (56.8%), Vertucci types of mesial root [type I (88.9%), type II (56.4%), and type IV (50.3%)] and Vertucci types of distal root [type I (58.7%), type II (90.9), and type IV(100%)]. In the female samples, relatively high Indian prevalence was seen for Vertucci type II (65.2) and type IV (66.7%) of the distal root.

Discussion

The understanding of the internal anatomy of RCS is of utmost importance before commencing the endodontic therapy to ensure complete three-dimensional cleaning and shaping.[8] Given this, the comparison of root canal morphology between two

Table 2: Differences in canal configuration between males and females for the whole sample and by country

	Overall (N = 523; %↔)			*Indian (N = 255; %↔)*			*Saudi (N = 268; %↔)*		
	Male	*Female*	*p value*	*Male*	*Female*	*p value*	*Male*	*Female*	*p value*
Number of roots									
Two roots	265 (53.3)	232 (46.7)	0.548	140 (57.1)	105 (42.9)	1	125 (49.6)	127 (50.4)	0.442
Three roots	12 (46.2)	14 (53.8)		6 (60.0)	4 (40.0)		6 (37.5)	10 (62.5)	
Number of canals									
Two canals	8 (80.0)	2 (20.0)	0.111	8 (88.9)	1 (11.1)	0.062	0 (0.0)	1 (100.0)	0.611
Three canals	199 (54.1)	169 (45.9)		113 (58.2)	81 (41.8)		86 (49.4)	88 (50.6)	
Four canals	70 (48.3)	75 (51.7)		25 (48.1)	27 (51.9)		45 (48.4)	48 (51.6)	
Vertucci mesial root									
Type I	9 (81.8)	2 (18.2)	0.177	8 (88.9)	1 (11.1)	0.049	1 (50.0)	1 (50.0)	0.68
Type II	101 (49.5)	103 (50.5)		57 (55.3)	46 (44.7)		44 (43.6)	57 (56.4)	
Type III	2 (33.3)	4 (66.7)		0 (0.0)	3 (100.0)		2 (66.7)	1 (33.3)	
Type IV	161 (54.9)	132 (45.1)		81 (57.9)	59 (42.1)		80 (52.3)	73 (47.7)	
Type V	4 (44.4)	5 (55.6)		0 (0.0)	0 (0.0)		4 (44.4)	5 (55.6)	
Vertucci distal root									
Type I	218 (54.4)	183 (45.6)	0.025	128 (59.5)	87 (40.5)	0.047	90 (48.4)	96 (51.6)	0.014
Type II	11 (32.4)	23 (67.6)		10 (40.0)	15 (60.0)		1 (11.1)	8 (88.9)	
Type III	22 (44.9)	27 (55.1)		0 (0.0)	3 (100.0)		22 (47.8)	24 (52.2)	
Type IV	8 (57.1)	6 (42.9)		8 (66.7)	4 (33.3)		0 (0.0)	2 (100.0)	
Type V	18 (72.0)	7 (28.0)		0 (0.0)	0 (0.0)		18 (72.0)	7 (28.0)	

The symbol "%↔" indicates that the percentage has to read horizontally;

*Statistically significant at ($p < 0.05$)

different populations would be guidance for the clinician performing the endodontic therapy.[2] Various factors affecting the prevalence of root canal morphology are age, gender, type of teeth (anterior/posterior), sample size, geographic location, ethnicity, research method, and the particular examination tool used.[1,10,18,28]

Martin et al.[2] stressed the importance of comparing the population of similar age-group. Accordingly, the average age of patients in both Indian and Saudi populations was approximating, thereby nullifying the influence of age on the prevalence of canal configurations. Careful observation of gender differences in the present data revealed that the characteristic trait of Indian males were two canals, Saudi males had Vertucci type III and V configurations of the mesial root, and Saudi females had Vertucci type V of the distal root. Although micro-CT, the golden standard in three-dimensional imaging, has a high resolution, CBCT plays an important role as it has reliable accuracy in diagnosing the internal anatomy of RCS allowing *in vivo* examination in a noninvasive and expedite manner.[29] The existing CBCT databases were retrospectively analyzed to avoid subjecting the patient to radiation.[30]

In the current study, M_1 with three roots was found in 3.9% of the Indian population and 6% of the Saudi population, which is close to the previous reports.[4,31] Globally, the prevalence of three-rooted M_1 was varying in different parts of the world as follows: 25.9% in Asians,[2] 22.7% in Japanese,[32] 15% in Hongkongers,[33] and 1% in European and African groups.[28] According to Scott and Turner,[25] the prevalence of M_1 with three roots was less than 5% in the populations of European origin, Africans, Eurasians, and Indians in contrast to the Asians races (5–40%). Hence, it is logical to presume that both the Indian and Saudi Arabian populations are sharing a common trait of European ancestry.[22,26]

Generally, there are two types of M_1 with three roots categorized based on the location and morphology as RE and radix paramolaris.[34] All the M_1 which had three roots were RE in both Indian and Saudi populations which is in complete agreement with the previous studies.[3,31] On the other hand, the prevalence of radix paramolaris for M_1 in the previous studies was 0.3% in Saudi[20] and 0.7% in Indian population[18] as compared to complete absence in the present study. This could be attributed to the regional variations among different subpopulations as such, and the convenient sampling chosen for the study. Interpopulation and intrapopulation comparisons of the presence of three roots between both genders were not statistically significant, which is similar to the studies conducted in India[35] and Germany.[36] Therefore, it is recommended to search for the additional orifice of the third root irrespective of the gender, especially for the distolingual canal when the initial preparation and debridement of the pulp chamber has been completed.

In the present investigation, of all M_1 with four canals, the prevalence among Saudi population was 64.1% (representing 34.7% of the individual country) which was significantly more than that of the Indian population (35.9%, representing 20.4% of the individual country). This result is in complete agreement with the previous reports.[4,31] However, the prevalence of this trait was 1.9% in Malaysian,[37] 28.7% in Turkish,[38] 43% in Chinese,[13] and 50.36% in Korean populations.[39] Numerous variations in the position of four canals in mandibular first molars irrespective of the number of roots make it difficult to compare and correlate the prevalence and ethnic origin among the various populations of the world. The prevalence of four canals was found to be equally present between

Table 3: Differences in canal configuration for males and females between Indian and Saudi Arabian subpopulations

	Indian males (N = 146; %↔)	*Saudi males (N = 131; %↔)*	*p value*	*Indian females (N = 109; %↔)*	*Saudi females (N = 137; %↔)*	*p value**
Number of roots						
Two roots	140 (52.8)	125 (47.2)	1	105 (45.3)	127 (54.7)	0.275
Three roots	6 (50.0)	6 (50.0)		4 (28.6)	10 (71.4)	
Number of canals						
Two canals	8 (100.0)	0 (0.0)	<0.001	1 (50.0)	1 (50.0)	0.221
Three canals	113 (56.8)	86 (43.2)		81 (47.9)	88 (52.1)	
Four canals	25 (35.7)	45 (64.3)		27 (36.0)	48 (64.0)	
Vertucci mesial root						
Type I	8 (88.9)	1 (11.1)	0.015	1 (50.0)	1 (50.0)	0.236
Type II	57 (56.4)	44 (43.6)		46 (44.7)	57 (55.3)	
Type III	0 (0.0)	2 (100.0)		3 (75.0)	1 (25.0)	
Type IV	81 (50.3)	80 (49.7)		59 (44.7)	73 (55.3)	
Type V	0 (0.0)	4 (100.0)		0 (0.0)	5 (100.0)	
Vertucci distal root						
Type I	128 (58.7)	90 (41.3)	<0.001	87 (47.5)	96 (52.5)	<0.001
Type II	10 (90.9)	1 (9.1)		15 (65.2)	8 (34.8)	
Type III	0 (0.0)	22 (100.0)		3 (11.1)	24 (88.9)	
Type IV	8 (100.0)	0 (0.0)		4 (66.7)	2 (33.3)	
Type V	0 (0.0)	18 (100.0)		0 (0.0)	7 (100.0)	

The symbol "%↔" indicates that the percentage has to read horizontally;

*Statistically significant at (p <0.05)

the genders of whole and individual populations. In contrast, they were predominantly occurring in Saudi group than the Indian subjects when the males were separately analyzed.

Although various classifications exist, the comprehensive classification introduced by Vertucci in 1984 has been widely acknowledged and used frequently by the researchers for examining the RCS.[1,15] On comparing the Vertucci types of the mesial root, the most common canal configuration was type IV (Indian, 54.9%; Saudi, 57.1%) followed by type II (Indian, 40.4%; Saudi, 37.7%), whereas the similar comparison of Vertucci types of distal root revealed type I (Saudi, 69.4%; Indian, 84.3%) dominance in both the populations. A similar finding was observed in mesial roots of M_1 samples from Asian ethnic groups (Chinese) and the Turkish population.[2,38] Although there were similarities in Vertucci type IV prevalence of mesial root between the current study and other Asian groups such as Malaysian,[37] Chinese,[13] and Korean[39] populations of Mongolian trait, the Vertucci type II prevalence of mesial root in these studies were negligible and contradicting with our study. Nevertheless, the prevalence of distal root Vertucci type I in our study was unprejudiced and matching with most of the global populations.[2,13,38,40] Therefore, by correlating the above reasons, it can be argued that the Vertucci parameters of both mesial and distal roots had a close resemblance with the Asian trait. Although C-shaped canals are more common in the Asian group than the Caucasians,[8] we encountered only one such canal configuration in our investigation.

The nonseparated root-like formations during the process of root formation are called radicals.[25] When the inter-radicular process incompletely penetrates the radicals, the superficial developmental grooves are formed on the root surface. Although the roots are not divided completely from the surface, the RCS is divided internally, which is highly influenced by the genetic composition.[25,26] This explains the significant variation that was predominantly observed in Vertucci types of mesial and distal roots (internal anatomy) than that of the number of roots (external morphology) between the Indian and Saudi populations as well as the genders. Moreover, the internal anatomy is a reliable parameter in tracing the key traits of the population belonging to different ethnic groups apart from its benefit during the endodontic treatment.[22, 26] Hence, our previous argument stating the possibility of European influence on the traits of Indian and Saudi populations based on three roots parameter could be overlooked. Besides, the geographic location does not seem to influence the root canal configuration of South Asian and West Asian subpopulations in this study. Therefore, the tested hypothesis was rejected.

The knowledge of RCS for various populations of different ethnic origin would not reduce the complexity of the endodontic procedure. However, clinicians with such ethnic information would have an edge over their ignorant counterpart.

Limitations

Although the samples from the selected subpopulation of two ethnic origins represent the original population, larger samples are required from different geographic regions of respective countries to arrive at clinically significant findings. Moreover, further investigations are required on the canal configurations of the entire teeth to have a complete understanding of the anatomical differences between the two populations concerning their ethnic origin.

Conclusion

Under the conditions of this investigation, the following conclusions were made with reference to permanent mandibular first molars:

- Based on the canal configurations, the Indian and Saudi populations share the common trait of Asian origin despite different ethnic and geographic locations.
- The predominant parameters were two roots, three canals, Vertucci type II and type IV mesial root configurations and type I distal root configuration in both Indian and Saudi Arabian populations.
- The unique feature of Indian males was two canals, Saudi males were Vertucci type III and type V configurations of mesial root and Saudi females was Vertucci type V configuration of distal root.
- The clinicians should be familiar with such anatomical differences as they have both clinical and anthropological significances.

Clinical Significance

Comparing the morphological alteration of root canal between racial profiles will be obliging in enhancing the key traits to be remembered by the dentist on accomplishing the accurate root canal procedure.

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