

Original Article

Root Morphology of Mandibular Anterior Teeth in Mecca, Saudi Arabia

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Abstract

Background: Root canal morphology is of utmost importance to the success of root canal treatment. The present study aim is to determine the variation in root canal morphology of the mandibular anterior permanent teeth using cone-beam computed tomography (CBCT) in a Saudi population in Mecca.

Methodology: This is a cross-sectional study which was conducted using CBCT images of 388 patients. Patients were included according to a specific criterion to evaluate the number of canals and their configuration according to the Vertucci's classification.

Results: The prevalence of the second canal of mandibular canine was 11% (11.3 in male and 10.7 in female), for mandibular lateral incisor was 22.3% (28.5 for male and 16.7 for female) and mandibular central incisor represented 21% (22% for male 20.1% for female). These differences were non-significant for canine and central incisor but was significant for lateral incisor ($p=0.028$). There were no significant differences regarding teeth position. According to Vertucci's classification, type I was the most prevalent followed by type III, II and V for lateral and central incisors while type III, V and II were most prevalent in canines. There were statistically significant differences between male and female for lateral and central incisors morphology ($p=0.003$ and $p=0.013$, respectively) while the difference was non-significant for canine ($p=0.303$).

Conclusion: Type I Vertucci's classification was the most common configuration in all mandibular anterior teeth. The presence of second canal is more prevalent in mandibular lateral and central incisors and the morphology of their root canals is significantly different between males and females.

Keywords: CBCT, cone-beam computed tomography, root canal morphology, mandibular anterior teeth.

Introduction

One of the most common causes of root canal treatment failure is intraradicular infection due to untreated canal anatomy (1). Since unfilled canals are thought to be a potential reason for contamination and can promote periapical disease after treatment, their exact recognition would be fundamental (2). The knowledge about root canal morphology is of utmost importance to the success of root canal treatment (3). It was previously assumed that mandibular anterior teeth had only one root canal (4).

Root canal morphology of permanent mandibular anterior teeth may be compromised by the involvement of the second canal, lateral canal, and apical deltas (5). For permanent mandibular anterior teeth, one of the most prevalent canal morphology is a single root having a single canal (4). However, there is a difference between the numbers of canals among the different populations (6).

In China, the prevalence of the second canal in central incisors was 9.8%, lateral incisors 21.5% while canines was 9.2% (7). Furthermore, in India, 18.63% had two root canals in canine and 28.43% had two root canals in central and lateral incisor (8). Cone-beam computed tomography (CBCT) provides a three-dimensional image in three different planes. Detection of the configuration and root canal convergence and divergence can be viewed (9). Mecca city have diverse population with expected variation in root canal morphology of mandibular anterior teeth, thus the current study was designed to determine the root canal morphology of the mandibular permanent anterior teeth using CBCT in Mecca city population.

Methodology

Study design

This study is a cross-sectional study using electronic health records (EHR) at Umm Al-Qura University, in Mecca, Saudi Arabia. The sample size was calculated by the following equation $(s = \frac{N}{1+Ne^2})$ (10). Where S = sample size, N = number of population, e = level of precision, calculated with 5% margin error acceptance and 95% confidence level. Accordingly, the required sample was determined as 388 participants.

Sample selection

The sample was selected after applying the inclusion/exclusion criteria to 966 EHR. The focus group is Saudi population in Mecca city included according to the following inclusion criteria: Unrestored lower anterior teeth, complete root formation with closed apex, Saudi people. Patients with deep caries, Crown or bridge, Periapical lesion and root resorption, Posts and root canal fillings, missing anterior teeth were excluded from our study.

Root canal evaluation

CBCT images were used to evaluate the root canal morphology of lower anterior teeth. Using CBCT dental imaging system (iCAT visionQ, Imaging Sciences International, Hatfield, PA, USA) operates at 120 kVp and 3-7 mA. The study was conducted on 388 CBCT images of lower anterior teeth to estimate the number of root canals and their types. CBCT images evaluated 1,552 permanent mandibular incisors, 776 permanent mandibular canines, Configuration of the canal was categorized according to the method of Vertucci's (3) (**Figure 1**).

Type I: A single canal extends from the pulp chamber to the canal terminus.

Type II: two separate canals depart the pulp chamber and connect each other to create one canal at the canal terminus.

Type III: one canal departs the pulp chamber, split into two canals then merging each other to create one canal at the apex.

Type IV: Two separate canals present from the pulp chamber to the canal terminus.

Type V: One canal departs the pulp chamber, split into two separate canals with two apical foramina.

Type VI: Two separate canals depart the pulp chamber, connect each other in the body of the root, and separate short of the apex to exit as two distinct canals.

Type VII: One canal departs the pulp chamber, divides and then reconnect in the body of the root, and at the end separates into two distinct canals short of the apex.

Type VIII: Three separate and well-defined canals extend from the pulp chamber to the apex.

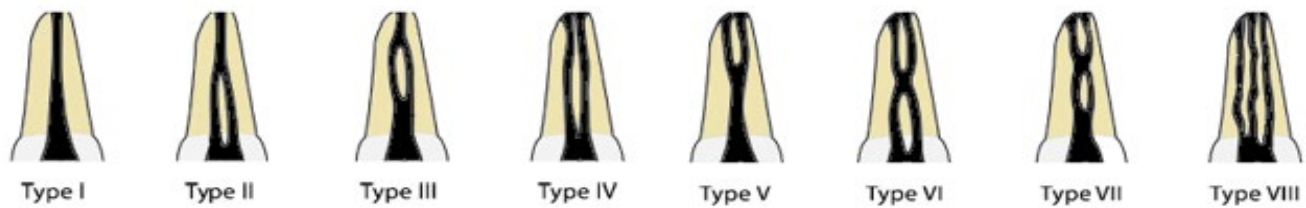


Figure 1: Eight types of Vertucci's classification of mandibular anterior teeth (Vertucci, 2005).

The number of canals and root canal configuration of mandibular permanent anterior teeth were examined in three dimensions by three researchers after training and measurement of intra and inter examiner consistency. Kapa test results was 86% for intra examiner and 91 % for inter examiner stability.

Result

The prevalence of two canals was 11% for canine, 22.3% for lateral and 21% for central incisor. According to

position, there were no significant differences between right and left side for #3 ($p=0.517$), #2 ($p=0.657$) and #1 ($p=0.507$). On comparison between male and female, there were no significant differences between them for #3 ($p=0.454$) and #1 ($p=0.277$) while there was significant difference between #2 ($p=0.028^*$) (Table 1).

Table 1: Comparison between root canal number of mandibular anterior teeth in relation to gender and position

Tooth	Number of canals	Gender		p-value	Position		p-value	Total No (%)
		Male No (%)	Female No (%)		Right No (%)	Left No (%)		
#3	1	323 (88.7)	368 (89.3)	0.454	348 (89.7)	343 (88.4)	0.517	691 (89.0)
	2	41 (11.3)	44 (10.7)		40 (10.3)	45 (11.6)		85 (11.0)
	Total	364 (100)	412 (100)		388 (100)	388 (100)		776 (100)
#2	1	260 (71.5)	343 (83.3)	0.028*	305 (78.6)	298 (76.4)	0.657	603 (77.7)
	2	104 (28.5)	69 (16.7)		83 (21.4)	90 (23.2)		173 (22.3)
	Total	364 (100)	412 (100)		388 (100)	388 (100)		776 (100)
#1	1	284 (78.0)	329 (79.9)	0.277	306 (78.8)	307 (79.2)	0.507	613 (79.0)
	2	80 (22.0)	83 (20.1)		82 (21.2)	81 (20.8)		163 (21.0)
	Total	364 (100)	412 (100)		388 (100)	388 (100)		776 (100)

#3, #2 and #1 = lower canine, lateral incisor and central incisor respectively.

p-value calculated by Chi square test comparing between root canal number of mandibular anterior teeth of right and left side as well as between male and female.

* If p-value < 0.05 it is statistically significant

Table 2: Comparison between root canal number of mandibular anterior teeth in relation to position for male and female.

Tooth	Number of canals	Male		p-value	Female		p-value
		Right No (%)	Left No (%)		Right No (%)	Left No (%)	
#3	1	162 (89.0)	161 (88.4)	0.751	186 (90.2)	182 (88.4)	0.611
	2	20 (11.0)	21 (11.6)		20 (9.8)	24 (11.6)	
	Total	182 (100)	182 (100)		206 (100)	206 (100)	
#2	1	132 (72.6)	128 (70.4)	0.311	173 (84.0)	170 (82.6)	0.378
	2	50 (27.4)	54 (29.6)		33 (16.0)	36 (17.4)	
	Total	182 (100)	182 (100)		206 (100)	206 (100)	
#1	1	142 (78.0)	142 (78.0)	0.500	164 (79.6)	165 (80.2)	0.638
	2	40 (22.0)	40 (22.0)		42 (20.4)	41 (19.8)	
	Total	182 (100)	182 (100)		206 (100)	206 (100)	
Total #2+#1	1	274 (75.2)	270 (74.2)	0.369	337 (81.8)	335 (81.4)	0.591
	2	90 (24.8)	94 (25.8)		75 (18.2)	77 (18.6)	
	Total	364 (100)	364 (100)		412 (100)	412 (100)	

#3, #2 and #1 = lower canine, lateral incisor and central incisor respectively.

p-value calculated by Chi square test comparing between right and left side root canal number of mandibular anterior teeth for male and female separately.

There were no significant differences between right and left side of both male [#3 (p=0.751), #2 (p=0.311), #1 (p=0.500) and total of #2 + #1 (p=0.369)] as well as female participants [#3 (p=0.611), #2 (p=0.378), #1 (p=0.638) and total of #2 + #1 (p=0.591)] (Table 2).

According to Vertucci's classes, there was no significant difference between male and female for #3 (p=0.303) while there were statistically significant differences between them for #2 (p=0.003*) and #1 (p=0.013*). There were no significant differences between right and left side for #3 (p=0.476), #2 (p=0.707) and #1 (p=0.362) (Table 3).

Table 3: Comparison between root canal types of mandibular anterior teeth in relation to gender and position

Tooth	Canal types	Gender		p-value	Position		p-value	Total No (%)
		Male No (%)	Female No (%)		Right No (%)	Left No (%)		
#3	I	329 (90.4)	368 (89.3)	0.303	354 (91.2)	343 (88.4)	0.476	697 (89.8)
	II	3 (0.8)	0 (0)		1 (0.3)	2 (0.6)		3 (0.4)
	III	23 (6.3)	28 (6.8)		22 (5.6)	29 (7.4)		51 (6.6)
	IV	0 (0)	0 (0)		0 (0)	0 (0)		0 (0.0)
	V	8 (2.2)	15 (3.6)		11 (2.8)	12 (3.0)		23 (3.0)
	VI	1 (0.3)	1 (0.2)		0 (0)	2 (0.6)		2 (0.3)
	VII	0 (0)	0 (0)		0 (0)	0 (0)		0 (0.0)
	Total	364 (100)	412 (100)		388 (100)	388 (100)		776 (100)
#2	I	260 (71.4)	343 (83.2)	0.003*	305 (78.6)	298 (76.8)	0.707	603 (77.7)
	II	13 (3.6)	8 (1.9)		12 (3.0)	9 (2.2)		21 (2.7)
	III	86 (23.6)	58 (14.1)		68 (17.6)	76 (19.5)		144 (18.6)
	IV	0 (0)	1 (0.2)		0 (0)	1 (0.4)		1 (0.1)
	V	4 (1.1)	2 (0.5)		3 (0.8)	3 (0.8)		6 (0.8)
	VI	0 (0)	0 (0)		0 (0)	0 (0)		0 (0.0)
	VII	1 (0.3)	0 (0)		0 (0)	1 (0.3)		1 (0.1)
	Total	364 (100)	412 (100)		388 (100)	388 (100)		776 (100)
#1	I	281 (77.2)	353 (85.7)	0.013*	319 (41.1)	315 (40.6)	0.362	634 (81.7)
	II	7 (1.9)	2 (0.5)		4 (0.5)	5 (0.6)		9 (1.2)
	III	70 (19.2)	53 (12.9)		57 (7.3)	66 (8.5)		123 (15.9)
	IV	0 (0)	1 (0.2)		1 (0.2)	0 (0)		1 (0.1)
	V	3 (0.9)	1 (0.2)		4 (0.5)	2 (0.3)		6 (0.8)
	VI	0 (0)	0 (0)		0 (0)	0 (0)		0 (0.0)
	VII	3 (0.8)	2 (0.5)		3 (0.4)	0 (0)		3 (0.4)
	Total	364 (100)	412 (100)		388 (100)	388 (100)		776 (100)

#3, #2 and #1 = lower canine, lateral incisor and central incisor respectively.

P-value calculated by Chi square test comparing between root canal types of mandibular anterior teeth of right and left side as well as between male and female.

* If p-value < 0.05 it is statistically significant.

There were no significant differences between right and left side root canal types of both male [#3 (p=0.667), #2 (p=0.857) and #1 (p=0.844)] and female participants [#3 (p=0.641), #2 (p=0.772) and #1 (p=0.221)] (Table 4).

Table 4: Comparison between right and left root canal types of mandibular anterior teeth for male and female.

Tooth	Canal types	Male		P	Female		P	Grand total No (%)
		Right No (%)	Left No (%)		Right No (%)	Left No (%)		
#3	I	168 (46.2)	161 (44.2)	0.667	186 (45.1)	182 (44.2)	0.641	697 (89.8)
	II	1 (0.3)	2 (0.6)		0 (0)	0 (0)		3 (0.4)
	III	10 (2.7)	13 (3.6)		12 (2.9)	16 (3.9)		51 (6.6)
	IV	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)
	V	3 (0.8)	5 (1.4)		8 (2.0)	7 (1.7)		23 (2.9)
	VI	0 (0)	1 (0.3)		0 (0)	1 (0.2)		2 (0.3)
	VII	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)
	Total	182 (50)	182 (50)		206 (50)	206 (50)		776 (100)
#2	I	132 (36.3)	128 (35.2)	0.857	173 (42.0)	170 (41.2)	0.772	603 (77.7)
	II	7 (1.9)	6 (1.6)		5 (1.2)	3 (0.7)		21 (2.7)
	III	41 (11.3)	45 (12.4)		27 (6.6)	31 (7.5)		144 (18.6)
	IV	0 (0)	0 (0)		0 (0)	1 (0.2)		1 (0.1)
	V	2 (0.5)	2 (0.5)		1 (0.2)	1 (0.2)		6 (0.8)
	VI	0 (0)	0 (0)		0 (0)	0 (0)		0 (0.0)
	VII	0 (0)	1 (0.3)		0 (0)	0 (0)		1 (0.1)
	Total	182 (50.0)	182 (50.0)		206 (50.0)	206 (50.0)		776 (100)
#1	I	140 (38.5)	141 (38.7)	0.844	179 (43.4)	174 (42.2)	0.221	634 (81.7)
	II	4 (1.1)	3 (0.8)		0 (0)	2 (0.5)		9 (1.2)
	III	34 (9.3)	36 (9.9)		23 (5.6)	30 (7.3)		123 (15.9)
	IV	0 (0)	0 (0)		1 (0.2)	0 (0)		1 (0.1)
	V	2 (0.6)	1 (0.3)		1 (0.2)	0 (0)		4 (0.5)
	VI	0 (0)	0 (0)		0 (0)	0 (0)		0 (0.0)
	VII	2 (0.6)	1 (0.3)		2 (0.5)	0 (0)		5 (0.6)
	Total	182 (50.0)	182 (50.0)		206 (50.0)	206 (50.0)		776 (100)

#3, #2 and #1 = lower canine, lateral incisor and central incisor respectively.

P-value calculated by Chi square test comparing between right and left side root canal types of mandibular anterior teeth for male and female separately.

Discussion

Many reasons are leading to endodontic treatment failure, one of the most common causes is missed canal due to improper diagnosis, other causes include ledges, transportations, perforations, separated instruments. Any of these influences the result of root canal therapy. These operational errors are not specifically responsible for endodontic failure. These mistakes negatively affect the proper cleaning, shaping, and obturation of the root canal, which in turn inhibits the prevention of endodontic infection (11, 12).

CBCT used in different branches of dentistry, in endodontic treatment like surgical apexification, root hemisection, and root morphology. The key benefit of

CBCT imaging is non-harmful for the patient and allowing to clarify the image from sagittal, axial, and coronal dimensions and provide imagining for anatomical structures inside and outside the tooth and underlying bone structures (13-15). The most important advantages of CBCT are lower radiation dose, accurate measurement, and lower cost relative to traditional CT (16, 17). The results of the current study indicated that, all the lower permanent incisors have one root, the prevalence of the second canal in permanent mandibular incisors was 21.6% (22.3% for lateral and 21% for central). The prevalence of two canals in lower incisors of Mecca city populations was within the range recorded by previous literature review where it was from 11.6% to 65.3% (12). The present results were higher than the

prevalence obtained by Madeira and Hetem et al 1973 (11.6%) (18), Miyashita et al. 1997 (12.4%) (19) and Liu et al. 2014 (13.2%) (20). The current prevalence was agreed with that reported by Green 1956 (20%) (21) and Han et al 2014 (21.55%) (12). On the other hand, the reported prevalence in the present study was less than that reported by Benjamin and Dowson 1974 (41.4%) (22), Vertucci 1974 (27.5%) (23), Kartal et al. 1992 (45%) (24), Caliskan et al. 1995 (31.37%) (25), Al-Qudah and Awawdeh 2006 (26.2%) (26), Aminsobani et al. 2013 (29%) (27), Rahimi et al. 2013 (36.62%) (4) and Kamtane et al. 2016 (36%) (8).

The prevalence of the second canal in permanent mandibular canine teeth of Mecca city population was (11%) which was higher than the prevalence reported by Zhao et al. 2014 (3%) (7), Zhengyan et al. 2015 (4.2%) (28), Al-Dahman et al. 2019 (4.6%) (29), Rahimi et al. 2013 (8.4%) (4), Han et al. 2014 (6.7%) (12) and Haghanifar et al. 2017 (9.4%) (30). On the other hand, the prevalence was less than that obtained by Vertucci 1974 (22%) (23) and Sert et al. 2004 (24%) (31).

In this study, the prevalence of the second canal in lower permanent mandibular incisors in male was 25.3 % (right side is 24.8% and 25.8% in left side) and the difference was non-significant ($p=0.369$). For female, the prevalence was 18.4% (right side is 18.2% and 18.6% in left side) and the difference was non-significant ($p=0.591$), these findings were higher than that reported by Green 1956. The prevalence of the second canal in lower permanent mandibular canine in male was 11.3% (right side is 11% and 11.6% in left side) and the difference was non-significant ($p=0.751$). For female, the prevalence was 10.7% (right side is 9.8% and 11.6% in left side) and the difference was non-significant ($p=0.611$), these results were closed to the results reported by Rahimi et al. (4).

Totally, there were no differences between right and left side regarding lower mandibular permanent teeth (Table 1, 2). The intermediate prevalence of two root canals in Mecca population may be due to diversity of its population and may be due to special characteristics of Mecca population that different races had inter-married and stayed there due to the holy nature of Makkah to all Muslim population. The findings of the present study showed that, Vertucci's Type I is the most prevalent type (89.8% for canine, 77.7% for lateral and 81.7 for central incisor) followed by type III (6.6% for #3, 18.6% for #2 and 15.9% for #1), type II (0.4% for #3, 2.7% for #2 and 1.2% for #1) and type V (2.9% for #3, 0.8% for #2 and 0.5% for #1). These findings were agreed with the results

obtained by numerous researches showed that Vertucci's type I is the most prevalent type (32-34).

It has shown that, among double root canals, Vertucci's type III was the most prevalent for mandibular anterior teeth (12). The highest prevalence of the various types of canals associated with Vertucci's classification were types I, III, II and V which differ than that obtained by Sobhani et al. who reported that, the prevalence was types I, II, IV, III and V, respectively (27). The present findings showed that, Vertucci's type III has the highest prevalence as a two canaled mandibular incisors and this not agreed with results reported by Altunsoy et al where they found Vertucci's type V had the highest prevalence in double root canals (32). Another study showed that the highest prevalence was the type's I, II, III, and IV, respectively reported by Rahimi et al. (4). The prevalence of Vertucci's types were I, III, V, respectively reported by Silva et al. (35). These differences may be due to different ethnicity of the participants. The present results indicated that, the endodontists should take care during treatment of lateral and/or central incisors as there were significant differences between male and female ($p=0.003$ and $p=0.013$). Also, the results indicated that, there were no specific precautions during treating right or left side either for male or female as there were no significant differences among them (table 4).

CBCT has limitations like image artifact and, it is sensitive to technique errors, so it needs special training for interpretation. Moreover, CBCT is not a substitution for periapical, bitewing, and panoramic x-rays it is used only for a particular diagnosis. There is a restricted usage of CBCT in endodontics for the evaluation of complex root canal morphology, root resorption, and related conditions (17).

Conclusion

Type I Vertucci's classification was the most common configuration in all mandibular anterior teeth. Type IV and VII Vertucci canal configuration were the least prevalent type in canine. Type IV, VI and VII were the least prevalent in lateral incisor. Type IV, V and VII were the least prevalent in mandibular central incisors. The presence of the second canal and Type III Vertucci's classification was relatively high in mandibular lateral and central incisors so more attention should be given for these teeth during endodontic treatment. The Prevalence of the second canal in mandibular right and left canines was the lowest, and mandibular right and left lateral incisors was the highest. The configuration of double

rooted lateral and central incisors is significantly differed in males than females.

Disclosure

Statement

The authors declare no conflict of interest.

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Ethical consideration

Ethical approval was obtained from Umm Al-Qura University institutional review board with approval number: Ref #161-19.

Author contribution

All authors contributed to conceptualizing, data collecting, image interpretation, data drafting and filtration and final writing of the manuscript.

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