Evaluating Root Canal Configuration of Permanent Mandibular Incisors Using CBCT in an Iraqi Subpopulation (Middle Euphrates Region)

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Abstract:

Background/purpose: The purpose of this study was to determine the morphology of root canal space of permanent mandibular incisors in a sample of population of Karbala governorate in Iraq using cone-beam computed tomography images.

Materials and methods: A total of (263) CBCT images including (980) mandibular incisors were included in this study. Number of roots, root canals and root canal configuration according to Vertucci classification were evaluated and analyzed statistically. Gender prevalence of root canal configuration was also evaluated.

Results: All the examined incisors had a single root. About 66.43% had single root canal, while two canals were found in 33.57% of the teeth. The differences between males and female and between central and lateral incisors were statistically insignificant ($p < 0.05$). Vertucci canal configuration types I, II, III, and V were detected, type I was the most prevalent (66.43%) followed by type III (30.2%), then type II (3.27%), and type V was found in only one case (0.1%). There was high degree of bilateral symmetry regarding canal number (89.12%) for central incisors and (88.84%) for lateral incisors.

Conclusion: In Karbala governorate, bouts 1/3 of mandibular incisors have two root canals with different configurations. These findings are comparable to those reported in Iraqi-Kurdistan region.

Keyword: CBCT; mandibular incisors; root canal morphology; symmetry; Vertucci classification.
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1. Introduction

Studying the anatomy of root canal system (RCS) have direct influence on clinical practice of endodontics. The ultimate goal of endodontists is to achieve a hermetic seal of the RCS after complete removal of vital or necrotic tissue, microorganisms, and their byproducts. However, this task could be difficult to accomplish in reality because of the complexity of the RCS. Many studies have shown that RCS comprise very complex passageways for pulp tissue that split and unite together during its course from orifice to root apex [1-4]. A detailed information about the number of roots, number of canals, inner canals morphology as well as the possible variations in all groups of teeth is a prerequisite for a successful root canal treatment outcome [5, 6]. Studies have shown a significant variation in the root canal morphology of the human teeth among different populations [2, 6].

In the past, several methods have been performed to study the morphology of RCS in human teeth mostly on extracted teeth using techniques like tooth clearing [7,8], cross-sectioning[9] and radiographs with intracanal contrast medium[10] . Recent technological advances have allowed the production of high resolution three-dimensional (3D) tomographic images of the teeth and surrounding structures. Cone-beam computed tomography (CBCT) is a noninvasive technique that allow studies to be done using a larger sample of population[6], and is considered as appropriate as the canal staining and tooth clearing technique in categorizing root canal systems[11] .

Mandibular incisors mostly own a single root with what radiographically seems to be a long, narrow canal. But, on occasion one canal branches into two canals, which subsequently rejoin into a single canal before reaching the apex, or they may persist as two separate canals[12] . Although there are studies using CBCT assessing root canal morphology of mandibular permanent anterior teeth in an Iraqi-Kurdistan subpopulation [13-15], to the best of our knowledge, there is no available study assessing root canal morphology of mandibular permanent incisors in other regions of Iraq. Therefore, this study was conducted to determine the prevalence of the number of roots, root canals, and root canal configuration of mandibular incisors in the Iraqi Middle Euphrates subpopulation using CBCT.

2. Materials And Methods

The patient's sample

This cross sectional retrospective study was conducted on CBCT images of (263) patients (113 males and 150 females) obtained from private oral and maxillofacial radiology clinic in Karbala governorate. The age of the patients ranged from 14 to 65 years old. All CBCT scans were requested for variable surgical,

orthodontic, endodontic, restorative, and prosthetic treatment purposes during the period from 1st January 2019 to 31st December 2021.

Authorization to use the CBCT images in this study was collected from the director of the radiology clinic and ethical permission was attained from the ethical committee at the college of medicine/university of Karbala. All image data sets were obscured to keep the identity of the patients trustworthy.

Images included in this study were those containing at a minimum one mandibular incisor (central or lateral), the teeth must be sound with fully developed roots and no previous endodontic treatment or pathologies.

CBCT examination

All CBCT scans were operated by a specialized oral and maxillofacial radiologist. The CBCT images were obtained using a Hyperion X5® (Myray, Imola (Bo), Italy) operating at 8 mA and 90 kV, with variant Fields of View (FOV), according to the needs of the case, extending from 40 × 40 mm to 80 × 80 mm. The voxel size was 0.125 mm.

Image analysis

Each image was assessed by two examiners (radiologist and endodontist) using MyRay iRYS software viewer program utilizing all software enhancement, such as zooming and changing brightness and contrast. Each tooth evaluated in axial, coronal and sagittal planes with a cutting interval of 0.125mm to get final result of canal morphology. In cases where an agreement was not reached, a third opinion from specialized oral radiologist was requested to reach a decisive assessment regarding canal configuration. Canal configuration was classified according to the following criteria of Vertucci[16] (Figure 1):

1. Type I: There is one pulp canal extends from the pulp chamber to the root apex.
2. Type II: There are two distinct pulp canals extend from the pulp chamber but they unite into one before reaching the root apex.
3. Type III: One pulp canal extends from the pulp chamber, splits into two within the root, and then unite into one before reaching the root apex.
4. Type IV: There are two distinct pulp canals extend from the pulp chamber to the root apex.
5. Type V: One pulp canal extends from the pulp chamber but it splits into two before reaching the root apex.
6. Type VI: Two distinct pulp canals extend from the pulp chamber, unite into one within the root, and then splits into two before reaching the root apex.

7. Type VII: One pulp canal extends from the pulp chamber, splits and reunites within the root, and finally splits again into two distinct canals before reaching the root apex.
8. Type VIII: Three distinct pulp canals extend from the pulp chamber to the root apex.

Figure 1: Vertucci's classification of root canal configuration

3. Results

After scrutinizing a total of 263 patient's CBCT scans (113 males and 150 females) there was non-significant difference between two genders (The t-value was 0.19702. The p-value was 0.43101 at $p < .05$). With a total of 483 mandibular central incisors and 497 mandibular lateral incisors were individually evaluated, all these teeth were with single roots.

Concerning number of canals, 651 (66.43%) teeth were with a single canal (265 males and 386 females) and distributed as (321 in mandibular central incisors 330 mandibular lateral incisors), 329 (33,57%) teeth had two canals (144 males and 185 females) and distributed as (163 in mandibular central incisors and 166 in mandibular lateral incisors) as shown in **Table 1**. The difference between the central and lateral incisors regarding the presence of two canals was non-significant (The t-value was -0.04127. The p-value was 0.485415 at $p < .05$).

Table 1: Canal numbers in mandibular incisors in CBCT scans according to tooth type and patient gender.

Tooth/Gender	Canals number		
	One canal	Two canals	Total
Central incisors	321 (66.32%)	163 (33.68%)	484
Lateral incisors	330 (66.53%)	166 (33.47%)	496
Total	651 (66.43%)	329 (33.57%)	980 (100 %)
Male	265 (64.8%)	144 (35.2%)	409
Female	386 (67.6%)	185 (32.4%)	571
Total	651 (66.43 %)	329 (33.57 %)	980 (100 %)

Concerning Vertucci's classification, type I (described well above), type II shown in 32 cases (14 cases in central incisors and 18 cases in lateral incisors, 18 of cases were males and 14 of them were females). Vertucci classification type III appeared in 296 of cases (149 in central incisors and 147 in lateral incisors, 125 of them were males and 171 of them were females). Vertucci classification type V in this study was seen just in one mandibular lateral incisor male person as shown in Figure 2 and Table 2.

Figure 2: CBCT Sagittal view of mandibular incisors: (A) type I; (B) type II; (C) type III; (D) type V Vertucci classification.

Table 2: Distribution of Vertucci classification

Vertucci's classification	Central incisors		Lateral incisors		Total	
Type I	321 (66.32%)	M[a] 124 (62.95%) F[b] 197 (68.64%)	330 (66.53%)	M 141 (66.51%) F 189 (66.55%)	651 (66.43%)	M 265 (64.79%) F 386 (67.6%)
Type II	14 (2.89%)	M 8 (4.06%) F 6 (2.09%)	18 (3.63%)	M 10 (4.72%) F 8 (2.82%)	32 (3.27%)	M 18 (4.4%) F 14 (2.45%)
Type III	149 (30.79%)	M 65 (32.99%) F 84 (29.27%)	147 (29.64%)	M 60 (28.3%) F 87 (30.63%)	296 (30.2%)	M 125 (30.56%) F 171 (29.95%)
Type V	0 (0%)	M 0 (0%) F 0 (0%)	1 (0.2%)	M 1 (0.47%) F 0 (0%)	1 (0.1%)	M 1 (0.24%) F 0 (0%)
Total	484 (100%)	M 197 F 287	496 (100%)	M 212 F 284	980 (100%)	M 409 F 571

[a] Male [b] Female

Regarding the similarity between right and left mandibular incisors, only patients having bilateral teeth were included in the comparison. Central incisors showed (89.12%) symmetry in root canal configuration, while lateral incisors showed (88.84%) symmetry in root canal configuration as shown in **Table 3**.

Table 3: Numbers and percentages of symmetry of root canals configuration in mandibular incisors.

Tooth	Number of symmetrical cases	Total cases
Central incisors	213(89.12%)	239
Lateral incisors	215 (88.84%)	242

4. Discussion

Investigators have shown anatomical variation among different populations regarding pulp space configurations of mandibular anterior teeth[3, 13-28]. as shown in **Table 4**. These differences could be attributed to racial and ethnic origins[29-31]. Awareness of the common morphology of the RCS among

people in each geographical region can decrease the errors during root canal procedures. This study was conducted to explore root canal morphology and the presence of second canal in permanent mandibular incisors amongst residents of the Middle Euphrates region in Iraq.

Different studies have confirmed that missed canals have a detrimental effect on the outcome of endodontic treatment[32, 33]. The RCS of the permanent mandibular incisors are so comparable to that they are examined together. These teeth often have two canals that are located labially and lingually, and the lingual canal most often is missed[12]. If a single of the present two canals is treated, pulp tissue of the additional canal becomes necrotic and yields toxic agents, which can spread to the periodontal ligament through main, lateral and an accessory canal. CBCT has been commonly used to identify the canals' morphologies in several studies because it is precise and noninvasive method allowing examination of larger number of people[34, 35].

Table 4 : Percentages of root canal configurations found in permanent mandibular incisors in previous studies assessed by CBCT.

Author Year	Country	Tooth	Sample size	Percentage of canal configuration								
				I	II	III	IV	V	VI	VII	VIII	🌀
Aminsobhani et al.[18] 2013	Iran	Central incisor	632	72.7	11.3	4.7	7.7	3.6	0	0	0	–
		Lateral incisor	614	70.6	7.1	3.7	15.4	3.2	0	0	0	–
Liu et al.[19] 2014	China	Central incisor	768	91.1	2	5.3	1.3	0.3	0	0	0	–
		Lateral incisor	785	82.5	3.9	10.4	2.8	0.3	0	0	0	–
Leoni et al.[20] 2014	Brazil	Central incisor	50	50	0	28	0	0	–	4	0	18
		Lateral incisor	50	62	0	28	0	0	–	2	0	8
Lin et al.[21] 2014	China	Central incisor	706	89.1	2.4	6.2	1.7	0.6	0	0	0	–
		Lateral incisor	706	74.5	3.7	19.3	2.1	0.4	0	0	0	–

Arslan et al.[22] 2015	Turkey	Central incisor	185		51.9	4.3	41.6	0	0.5	0	0	0	1.6
		Lateral incisor	189		52.9	2.6	42.3	0	1.6	0	0	0	0.5
Kamtane & Ghodke[24] 2016	India	Mandibular incisors	102		64.71	23.53	8.82	2.94	0	0	0	0	–
Basha[25] 2018	Egypt	Central incisor	200	M[a]	76	0	17	0	7	0	0	0	–
				F[b]	95	0	5	0	0	0	0	0	–
		Lateral incisor	200	M	88	0	7	0	5	0	0	0	–
				F	91	0	9	0	0	0	0	0	–
Popovic et al.[26] 2018	Serbia	Central incisor	296		73	4.7	21.6	0	0.7	0	0	0	–
		Lateral incisor	294		73.5	5.4	18.4	0.7	2	0	0	0	–
Valenti-Obino et al.[27] 2019	Italy	Central incisor	487		55	34,3	9.3	0.6	0	0	0.8	0	–
		Lateral incisor	491		57	35.7	6.9	0	0	0	0.4	0	–
Mirhosseini et al.[3] 2019	Iran	Central incisor	330		76.1	0	15.8	0.6	7.6	0	0	0	–
		Lateral incisor	351		65	0.6	15.7	0.9	17.9	0	0	0	–
Ghabbani et al.[28] 2021	Saudi Arabia	Mandibular incisors	1624		50.3	0	42.3	0.2	5.3	0	1.6	0	–
Dizayee & Selman[14] 2019	Iraq Kurdistan	Mandibular incisors	1716		79.254	0.466	20.279	0	0	0	0	0	–
Goran & Rofoo[15] 2020	Iraq Kurdistan	Central incisor	388		67	1	22.6	0	7.7	0	1.8	0	0
		Lateral incisor	388		67	0.5	18	0	13.9	0	0.7	0	0

Talabani[16] 2021	Iraq Kurdistan	Central incisor	597	73.8	18	8	0	0	0	0	0	–
		Lateral incisor	599	71.2	12.8	6.8	0	0	0	0	0	–
Present study	Iraq Kerbala	Central incisor	484	66.32	2.89	30.79	0	0	0	0	0	–
		Lateral incisor	496	66.53	3.63	29.64	0	0.2	0	0	0	–

֍ New root canal configuration that are not included in Vertucci's classification.[21, 23]

[a]Male [b]Female

In the current study, Vertucci classification was used because it is reasonably inclusive, easy to apply and it was most commonly used in previous studies (Table 4).

In this research, just the Vertucci types I, II, III, and V canal configuration were noticed in mandibular incisors. Vertucci type I was the most dominant canal configuration, which was in harmony with previous studies in Iraq[13-25] and in different countries of the world [3, 19, 21, 24-26]. The presence of two canals in mandibular incisors according to the findings of current study was 33, 57%. These findings are very similar to those of **Goran & Rofoo**[14] (33.1%) who conducted their study in Kurdistan region in Iraq, while they differ slightly from the findings of two studies of **Dizayee & Selman**[13] (20.75%) and **Talabani**[15] (26.1-30.4%) which were conducted in the same region.

The next most common canal configuration was Vertucci type III, while type V was the slightest common. This is in accordance with the **Liu et al**[19]., **Lin et al**[21]., **Arslan et al**[22]. studies and in partial agreement with the **Popovic et al**[26]., **Mirhosseini et al**[3]., **Dizayee & Selman**[13], **Goran & Rofoo**[14], **Ghabbani et al**[28]. studies, while in contrast to the Aminsobhani et al[18]., **Kamtane & Ghodke**[24], **Valenti-Obino et al**[27]., **Talabani**[15] studies.

Studying bilateral symmetry in root canal configuration has clinical importance as it may help the clinician to predict, with high probability, the corresponding teeth configuration on the contralateral side[28, 36, 37]. Among the population of the current study, the overall symmetry in the configuration of the root canal was more common in central incisors (89.12%) than in lateral incisors (88.84%). These result came in agreement with **Lin et al.** where they found that the overall symmetry in the root canal configuration was (92.7%) for central incisors and (89.2%) for lateral incisors, nevertheless, several studies showed a high degree of

variation with low or high percentage of symmetry in configuration of corresponding teeth on the contralateral side [16,27], These differences could be attributed to ethnic differences or a variable sample size.

5. CONCLUSIONS

All mandibular permanent incisors have single root but 33.57% of them have two root canals with non-significant difference between central and lateral incisors, or between males and females. Vertucci type I canal configuration was the most predominant and the least one was type V, while type IV was not found at all. Finally, there was high degree of bilateral symmetry for the presence of two root canals.

6. CONFLICTS OF INTEREST

The authors have no conflicts of interest related to this study.

7. ACKNOWLEDGMENTS

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