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Original Article

Assessment of root canal anatomy of mandibular incisors using cone-beam computed tomography in a Turkish subpopulation

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Abstract

Aim: The success of a root canal treatment is influenced by the status of the root canals. The aim of this study was to investigate the frequency of second root canals in mandibular incisors and the prevalence of root canal separation in the cervical, middle, and apical thirds in cases with two root canals.

Methodology: Retrospective cone-beam computed tomography (CBCT) data from 500 patients seen between 2016 and 2018 was evaluated. A total of 300 patients—134 male and 166 female—aged 13-71 years (mean age 39.34 ± 13.44) were included in this study. A total of 587 central mandibular incisors and 582 lateral mandibular incisors were examined. The number of roots and the root canal morphology, based on Vertucci's classification, were analyzed. The effect of gender on the prevalence of root canal anatomy was also evaluated.

Results: The occurrences of more than one root canal in the mandibular lateral and mandibular central were 41.2% and 40.4%, respectively, and all teeth had a single root. Type I (59.2%) was the most common type, followed by Type III (31.4%), Type II (5.8%), Type VII (2.1 %), Type VI (0.8%), and Type V (0.7%). Type IV and Type VIII were not observed. Root canal separation in the two root canals of the central and lateral mandibular incisors was found in the middle third of the root in 65.4% and 74.6% of cases, respectively. The incidence of Type III in males (39%) was higher than in females (25.4%), while the incidence of Type I in females (67.7%) was significantly higher than in males (48.3%). Second canals in the mandibular incisors were detected more frequently in men than in women.

Conclusion: The overall prevalence of second canals in the mandibular incisors was 40.8%; Type III was observed most frequently. CBCT is an appropriate method for identifying the canal morphologies of mandibular incisors.

Keywords: Central mandibular incisor, cone-beam computed tomography, lateral mandibular incisor, root canal morphology

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Introduction

Knowledge of root canal anatomy, tooth morphology, and their variations is important for the success of root canal treatment (1, 2). The appropriate cavity access, biomechanical clearing of the canals, and effective chemical debridement and filling of the canals are essential for the success of endodontic treatment (3). Awareness of root canal anatomy and its variations can avoid endodontic treatment failure and help to determine the best treatment plan (3). Due to variations in the root canal morphologies of different populations, it is necessary to define the anatomy of root canals by population (4, 5). Mandibular incisors mostly have one root, but often have roots in two canals (6). These two canals may merge together to form an apex in a single apical foramen or may be bifurcated from each other all the way to the end; in such cases, the inability to find the lingual root canal leads to failure of the endodontic treatment.

Conventional radiography, root canal staining methods, clearing methods, tooth sectioning, microscopic observation, and cone-beam computed tomography (CBCT) have been used in previous investigations (7-13). Although the root canal staining and clearing technique are the gold standard for evaluating the anatomy of a root canal, it is only performable on extracted teeth.

CBCT has been used in recent years to evaluate the morphology of root canals in dentistry. The data acquired by CBCT presents coronal, sagittal, and axial sections, decreasing the superposition of anatomical structures. This helps the clinician to understand the three-dimensional morphological features (14-16).

The aim of this study was to investigate the number of roots and root canals in the mandibular incisor teeth in the Turkish population and the bifurcation point in the cervical, middle, and apical thirds in cases with two canals.

Materials and Methods

In this retrospective study, 500 randomized scans were assessed, of which 300 that imaged the lower incisor region were included in the study. The ethical approval had obtained from the Clinical Research Ethics Committee of Altınbaş University (approval number: 2020/23). Informed consent had routinely been obtained from all patients before radiographic examination. A total of 1,169 mandibular incisors were examined using CBCT images. The CBCT scans had been taken for a variety of reasons, including dental implant planning, jaw lesions, dental trauma, and orthodontic anomalies. Inclusion criteria were patients with at least one mandibular anterior tooth; without root canal fillings, coronal and post restorations, periapical lesions, fixed crown restorations, or orthodontic braces; and with high-quality CBCT images. After excluding images that did not meet the inclusion criteria, 300 were included in the study.

The same technician produced all the CBCT images using the same radiographic equipment (Morita Veraviewepocs 3D R100, Kyoto, Japan, with 90 kV and 5 mA, 80 × 80 mm FOV). One Volume Viewer (J. Morita Mfg. Corp, Kyoto, Japan) was used for reconstruction and evaluation of all projections. The brightness and contrast of the images were adjusted to ensure optimal visualization. An oral radiologist (OO) and an endodontist (ANK) reviewed the records. Cases of disagreement were discussed to achieve a consensus.

The mandibular incisor teeth were evaluated for the number of roots, root canals, and canal morphology based on Vertucci's method (17). All root canal configurations were recorded as two root canals, except Type I (single canal) and Type VIII (three canals). The beginning and end points of the separation in cases with more than one canal were also analyzed.

The canal configuration was classified based on the following criteria of Vertucci's method (17):

1. Type I: Only one canal extending from the pulp chamber to the apex.
2. Type II: Two canals that leave the pulp chamber separately, are joined in the apical region, and terminate as a single canal.
3. Type III: A single canal that leaves the pulp chamber, is divided into two, and then ends up as a single canal in the apical region.
4. Type IV: Two separate canals that leave the pulp chamber and terminate in two separate canals in the apical region.
5. Type V: A single canal that leaves the pulp chamber and terminates by dividing into two canals.
6. Type VI: Two distinct canals that leave the pulp chamber, merge into a single canal, and separate again in the apical region, ending in two separate canals.
7. Type VII: A single canal that leaves the pulp chamber, divides into two, rejoins to form a single canal, and then re-divides at the apical region to terminate with two separate foramens.
8. Type VIII: Three distinct canals that leave the pulp chamber and terminate separately.

The root canal separation was grouped by the cervical, middle, and apical third of the root in cases of Type II–Type VII.

Statistical Analysis

The statistical software SPSS software was used to analyze the data (IBM SPSS Statistics for Windows, V22, Armonk, NY, USA).

Chi-squared test, Fisher Freeman Halton test, and Yates's continuity correction were used to compare qualitative data, together with descriptive statistical methods (mean, standard deviation (SD), and frequency). P-values of less than 0.05 were considered to be statistically significant ($p<0.05$).

Results

Having started with 500 patients, we evaluated 1,169 mandibular incisors from 300 of them who matched our inclusion criteria; 134 (44.5%) were male and 166 (55.5%) female. The age range was 13–71 years (mean age ± SD: 39.34 ± 13.44 years).

A total of 582 lateral mandibular incisors and 587 central mandibular incisors were evaluated. All the mandibular incisors had a single root, and the incidence of second canals in the mandibular lateral and mandibular central were 41.2% and 40.4%, respectively.

The overall incidence of a second canal was 40.8% (Type III was observed most frequently).

Type I (59.2%) was the most prevalent configuration of root canal, followed by Type III (31.4%), Type II (5.8%), Type VII (2.1 %), Type VI (0.8%), and Type V (0.7%) (Table 1; Figure 1).

Type I was found in 350 teeth (59.6%), and Type III was found in 169 teeth (28.8%) (Table 2) in the central mandibular incisors. Type I was found in 342 teeth (58.8%), and Type III was found in 198 teeth (34%) (Table 3) in the lateral mandibular incisors. In all incisors, Types II, V, VI, and VII were rare, and Types IV and VIII were not detected.

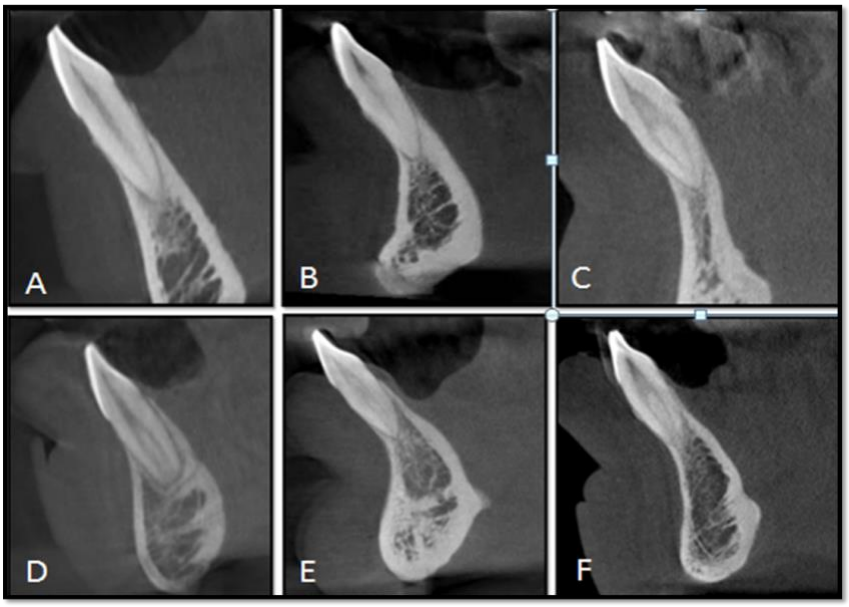

Figure 1. CBCT images of mandibular incisors (A) Type I, (B) Type II, (C) Type III, (D) Type V, (E) Type VI, (F) Type VII

Table 1. Root canal classification of total mandibular incisors

		n	%
Vertucci classification (n=1169)	Type I	692	59,2
	Type II	68	5,8
	Type III	367	31,4
	Type V	8	0,7
	Type VI	9	0,8
	Type VII	25	2,1
Root canal number (n=1169)	Single canal	692	59,2
	Double canal	477	40,8
Root canal separation (n=477)	Middle	334	70,0
	Cervikal	143	30,0

Table 2. Root canal classification of central mandibular incisors

		n	%
Vertucci classification (n=587)	Type I	350	59,6
	Type II	41	7
	Type III	169	28,8
	Type V	5	0,9
	Type VI	8	1,4
	Type VII	14	2,4
Root canal number (n=587)	Single canal	350	59,6
	Double canal	237	40,4
Root canal separation (n=237)	Middle	155	65,4
	Cervikal	82	34,6

Table 3. Root canal classification of lateral mandibular incisors

		n	%
Vertucci classification (n=582)	Type I	342	58,8
	Type II	27	4,6
	Type III	198	34
	Type V	3	0,5
	Type VI	1	0,2
	Type VII	11	1,9
Root canal number (n=582)	Single canal	342	58,8
	Double canal	240	41,2
Root canal separation (n=240)	Middle	179	74,6
	Cervikal	61	25,4

Root canal separation in double root canals of the central incisors was detected in the middle third of the root of cases in 65.4% and in the cervical third of the root in 34.6% of cases. Root canal separation in double root canals of the lateral incisors was detected in the middle third of the root in 74.6% of cases and in the cervical third of the root in 25.4% of cases.

There was a statistically significant difference between the Vertucci classifications by gender ($p<0.05$). The incidence of Type III in males (39%) was higher than in females (25.4%), while the incidence of Type I in females (67.7%) was significantly higher than in males (48.3%). There was also a statistically significant difference between the root canal numbers by gender ($p<0.05$). The occurrence of additional canals in the mandibular central and lateral incisors was more frequent in males (51.7%) than in females (32.3%). There was no statistically significant difference between genders in root canal separation distribution (Table 4).

Table 4. Distribution of mandibular incisor teeth by gender

		Lateral			Central			Total		
		Male	Female	p	Male	Female	p	Male	Female	p
		n (%)	n (%)		n (%)	n (%)		n (%)	n (%)	
Vertucci classification	Type I	125 (%49)	217 (%66,4)	[1]0,000*	124 (%47,7)	226 (%69,1)	[1]0,000*	249 (%48,3)	443 (%67,7)	[1]0,000*
	Type II	15 (%5,9)	12 (%3,7)		24 (%9,2)	17 (%5,2)		39 (%7,6)	29 (%4,4)	
	Type III	108 (%42,4)	90 (%27,5)		93 (%35,8)	76 (%23,2)		201 (%39)	166 (%25,4)	
	Type V	2 (%0,8)	1 (%0,3)		3 (%1,2)	2 (%0,6)		5 (%1,0)	3 (%0,5)	
	Type VI	0 (%0)	1 (%0,3)		6 (%2,3)	2 (%0,6)		6 (%1,2)	3 (%0,5)	
	Type VII	5 (%2)	6 (%1,8)		10 (%3,8)	4 (%1,2)		15 (%2,9)	10 (%1,5)	
Root canal number	Single canal	126 (%49,2)	217 (%66,4)	[2]0,000*	123(%47,5)	226 (%69,1)	[2]0,000*	249 (%48,3)	443 (%67,7)	[2]0,000*
	Double canal	130 (%50,8)	110 (%33,6)		136 (%52,5)	101 (%30,9)		266 (%51,7)	211 (%32,3)	
Root canal separation	Middle	103 (%79,2)	76 (%69,1)	[2]0,072	88 (%65,2)	66 (%65,3)	[2]0,979	191 (%72,1)	142 (%67,3)	[2]0,259
	Cervical	27 (%20,8)	34 (%30,9)		47 (%34,8)	35 (%34,7)		74 (%27,9)	69 (%32,7)	

[1]Fisher Freeman Halton Test [2]Chi-Square Test * p<0.05

Table 5. Prevalence of a additional canal in anterior incisors

Previous Studies	Population	Technique	Year	Number of Teeth	%
Vertucci	USA	Staining and Clearing	1974	200	27.5
Benjamin & Dowson	USA	Radiography	1974	464	41.4
Kartal & Yanikoglu	Turkey	Staining and Clearing	1992	100	45
Caliskan et al.	Turkey	Staining and Clearing	1995	200	31.37
Miyashita et al.	Japan	Staining and Clearing	1997	1085	12.4
Sert et al.	Turkey	Staining and Clearing	2004	401	65.3
Al-Qudah & Awawdeh	Jordan	Clearing and staining	2006	450	26.2
Rahimi et al.	Iran	Staining and Clearing	2013	314	36.62
Liu et al.	China	CBCT	2014	1571	13.2
Han	China	CBCT	2014	3871	21.55
Verma et al.	India	CBCT	2017	800	33.5
Shemesh et al.	Israel	CBCT	2018	2980	39.07

Discussion

In endodontic treatment, inadequate debridement may lead to failure. Studies have shown that the staining and clearing technique (17-23) and micro-computed tomographic imaging (24), which can only be used on extracted teeth, can supply definite knowledge of root canal morphology. The most commonly used technique to differentiate tooth morphology in clinical situations is conventional radiography. CBCT is a technique with a low radiation dose that has been demonstrated to be accurate in assessing root canal systems (5, 25, 26).

The prevalence of an additional canal in mandibular incisors in this study was 40.8%, which was higher than the findings of Shemesh et al. (39.07%) (2), Rahimi et al. (36.62%) (11), Liu et al. (13.2%) (13), Madeira and Hetem (11.6%) (18), Vertucci (27.5%) (19), Caliskan et al. (31.37%) (20), Miyashita et al. (12.4%) (21), Al-Qudah and Awawdeh (26.2%) (23), Han (21.55%) (27), and Verma et al. (33.5%) (28) but lower than those of Benjamin and Dowson (41.4%) (6), Sert et al. (65.3%) (22), and Kartal and Yanikoglu (45%) (29) (Table 5). In most of these previous studies, the staining and clearing technique was used to evaluate the root canal morphology, and few studies in the literature have used CBCT to assess the root canal morphology of mandibular incisors (2, 13, 27, 28).

Most of the mandibular anterior teeth had the same pattern, with a single root and a single canal. Type III was observed most frequently among teeth with two root canals, followed by Types II and VII; Type IV was not observed and Types V and VI only seldom. Most of the additional canals did not course along the root length; in most cases, the canals began at the orifice and then divided into two, which might then remain separate or fuse to form one or two root foramens. However, in some cases, two canals began from two orifices and either fused into one and then separated or continued as a single canal. Dentists in clinical practice should therefore take into account the position of all root canals to debride and remove pulp tissue.

The results of this study indicate that Vertucci Type I (59.2%) was the most prevalent, then Type III (31.4%), Type II (5.8%), Type VII (2.1%), Type VI (0.8%), and Type V (0.7%). In all other studies, Vertucci Type I has been observed as the most prevalent, as in our study. Of the double root canals, Types II and III were the most observed canal types in previous studies. In studies conducted with CBCT (2, 13, 24, 28), the most common type of double root canal was Type III, as in our study. In the present study, the root canal separation in the mandibular incisors was located in the middle third of the root in almost 70% of cases, and the findings of Shemesh et al. (80%) (2) are quite similar to ours. Awareness of additional canals and the point of the separation is important for dentists as missed canals have been shown to be related to endodontic treatment failure (30).

Gender was partially related to the presence of double root canals. The frequency of two root canals in incisors was significantly higher in males, and this finding is similar to that of previous studies (13, 31), although some have reported similar numbers in males and females (22, 32) and Verma et al. (28) reported higher prevalence in females.

Conclusions

The following conclusions may be reached from this retrospective study:

- The prevalence of two root canals in the mandibular central and mandibular lateral incisors was 40.4% and 41.2%, respectively.
- The overall incidence of two root canals in the mandibular incisors was significantly higher in males.
- In the mandibular incisors, the root canal separation was located in the middle third of the root in almost 70% of cases.

Ethical Approval: Ethics committee approval was received for this study from Altınbaş University, Ethics Committee in accordance the World Medical Association Declaration of Helsinki, with the approval number: 2020/23.

Peer-review: Externally peer-reviewed.

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