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Assessment of the Canal Anatomy of the Mandibular Molars in a Group of Turkish Patients: A Cone-Beam Computed Tomography Study

Bir Grup Türk Hastada Alt Çene Azı Dişlerinin Anatomisinin İncelenmesi:Bir Konik Işınlı Bilgisayarlı Tomografi Çalışması

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Abstract

Objective: The mandibular molars represent one of the most common dental groups in which root canal treatments fail due to their complex anatomical structure and presence of the radix entomolaris or c-shaped root canals. For the long-term successful treatment of these teeth, all anatomical variations should be well known. The aim of this study was to evaluate the number of roots and root canal anatomy of mandibular molars in a group of Turkish patients by examining cone-beam computed tomography (CBCT) images.

Material and Method: The CBCT images of 936 mandibular first and second molars of a total of 280 patients were evaluated, and the number of roots, root canal anatomy, and incidence of the radix entomolaris and c-shaped root canals in these teeth. The patients' gender and age were also recorded, and their possible correlation with the dental data was investigated.

Results: Among the total 936 mandibular molars, 98.8% had two roots, and the radix entomolaris was present in 1%. The number of root canals was 3 in 79.7% of the teeth, 4 in 17.7%, and 2 in 2.7%. Of the mandibular second molars, 6.6% showed C-shaped root canal formation. The rate of a single canal (Vertucci type I) was 4.7% for the mesial roots of the second molars, while the distal roots of the mandibular first molars showed type IV formation at a rate of 30.3%.

Conclusion: Considering the contribution of our findings to clinical practice, the incidence of C-shaped canals in the mandibular second molars was 6.6%. Radix entomolaris was present in 1% of all the teeth. Four root canals were detected in 17.7% of the mandibular molars.

Keywords: *Mandibular molar teeth, Cone-beam CT, Root canal morphology*

Özet

Amaç: Alt çene azı dişleri, karmaşık radix entomolaris veya c şeklindeki kök kanallarının varlığı gibi karmaşık anatomik yapıları nedeniyle kök kanal tedavilerinin başarısız olduğu en yaygın diş gruplarından biridir. Bu dişlerin uzun dönem başarısı için tüm anatomik varyasyonların iyi bilinmesi gerekir. Bu çalışmanın amacı, bir grup Türk hastada konik ışınlı bilgisayarlı tomografi (KIBT) görüntülerini inceleyerek alt çene azı dişlerinin kök sayısını ve kök kanal anatomisini değerlendirmektir**.**

Materyal ve Metod: Toplam 280 hastanın 936 alt birinci ve ikinci azı dişlerinin KIBT görüntüleri değerlendirildi ve bu dişlerde kök sayısı, kök kanal anatomisi, radix entomolaris ve c şekilli kök kanallarının görülme sıklığı değerlendirildi. Hastaların cinsiyeti ve yaşı da kaydedilerek aralarındaki olası korelasyonlar araştırıldı.

Bulgular: Toplam 936 alt azı dişinin %98.8' inde iki kök vardı ve %1'inde radix entomolaris mevcuttu. Dişlerin %79.7' sinde 3, %17.7'sinde 4 ve %2.7'sinde 2 kök kanalı vardı. Alt ikinci azı dişlerinin %6,6'sında C-şekilli kök kanal oluşumu görüldü. Alt ikinci azı dişlerinin mezyal kökleri için tek kanal (Vertucci tip I) görülme oranı %4,7 iken, alt birinci azı dişlerinin distal kökleri %30,3 oranında tip IV oluşum gösterdi.

Sonuç: Bulgularımızın klinik pratiğe katkısı göz önüne alındığında, alt ikinci azı dişlerinde C şeklindeki kanalların görülme sıklığı %6,6 idi. Radix entomolaris, tüm dişlerin %1'inde mevcuttu. Alt azı dişlerinin %17.7' sinde dört kök kanalı tespit edildi**.**

Anahtar kelimeler: A*lt azı dişleri, Konik ışınlı BT, Kök kanal morfolojisi*

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INTRODUCTION

The biomechanical disinfection of root canals is essential for the long-term success of endodontic treatment (Vertucci, 1984). Insufficient knowledge concerning the root canal complex of the molars to be treated may cause some root canals to be overlooked. Inaccessible root canals may cause secondary infection and the loss of the tooth (Siqueira et al., 2001).

The permanent lower first molars are the first teeth to erupt in the posterior oral cavity. From a young age, carious lesions can be seen in these teeth, often requiring root canal treatment (Zaatar et al 1997; Scavo et al 2011). The percentage of extracting the number of mandibular molars lost as a result of the failure of root canal treatment is also very high (Touré et al., 2011). Anatomical alterations in the lower second molar teeth, such as the radix entomolaris and C-shaped root canals, as well as, mid-mesial canals may complicate successful endodontic treatment in these teeth(Tahmasbi et al., 2017; De Moor et al., 2004; Cooke et al., 1979). In many studies on this subject, varying numbers of root canals and anatomical variations have been reported depending on racial differences (Caliskan et al., 2004; Sert et al., 2004; Celikten et al., 2016; Pawar et al., 2017; Shemesh et al., 2017; Kim et al., 2018; Kantilieraki et al., 2019)

Although many techniques have been described in the definition of root canal complex, clearing and staining techniques have provided reliable data on this subject to date. However, the applicability of this technique only to extracted teeth can be considered as a disadvantage (Caliskan et al., 2004; Sert et al., 2004; Celikten et al., 2016; Shemesh et al., 2017; Kantilieraki et al., 2019). Due to the two-dimensional nature and limitations of conventional radiography techniques, CBCT imaging methods come to the fore in the definition of the root canal complex in three dimensions (Neelakantan et al., 2010; Special Committee to Revise the Joint AAE/AAOMR Position Statement (2015). Use of CBCT in Endodontics). According to the status report of the European Union of Endodontists (2019), CBCT imaging can be safely used in making an accurate diagnosis, solving endodontic problems, and identifying anatomical variations (Patel et al.,2019).

The aim of the present study is to clarify the anatomy of the mandibular molar teeth in selected Turkish participants, thus emphasizing the importance of anatomical structure in increasing the long-term success of root canal treatment and creating references for relevant research.

MATERIAL and METHODS

This exploration was ratified by the ethics committee of the university (approval number: E-10840098-772.02-193.856) on 11.01.2022. The CBCT images of 936 molar teeth were examined in a total of 280 patients who underwent treatment planning and dental treatments at the faculty of dentistry between 2012 and 2017. The patient's age and gender were also recorded. A criterion for the teeth to be included in the study was that they had fully erupted in the mouth and completed their root development. Teeth with a previous root canal treatment and filling or periapical lesions in the root were not included in the sample. In addition, cases in which there were deviations from normal image quality were eliminated from the investigation.

The radiographic images were taken using the i-CAT17–19 (Imaging Sciences Int. Inc. USA) imaging system following a standardized scanning protocol (voxel size of 0.25 mm) due to the manufacturer's recommendation. All images were obtained at 120 kVp and 20.27 mAs using a 16 cm × 11 cm field of view.

The displays were scored by an oral radiologist and two endodontists, all with at least 10 years of experience. In order to calibrate the observers, 10 of the obtained data were randomly selected and examined by two endodontists twice at 10-day intervals. In cases where a common decision was not made, the final result was agreed upon by consulting an oral diagnosis and radiology specialist. Cohen's kappa coefficient for the interobserver agreement was determined as 0.75.

A series of axial and cross-section CBCT images were examined to determine the root canal complex. The root canals were evaluated according to the Vertucci (1) classification. This classification basically defines eight different anatomical morphologies (Figure 1):

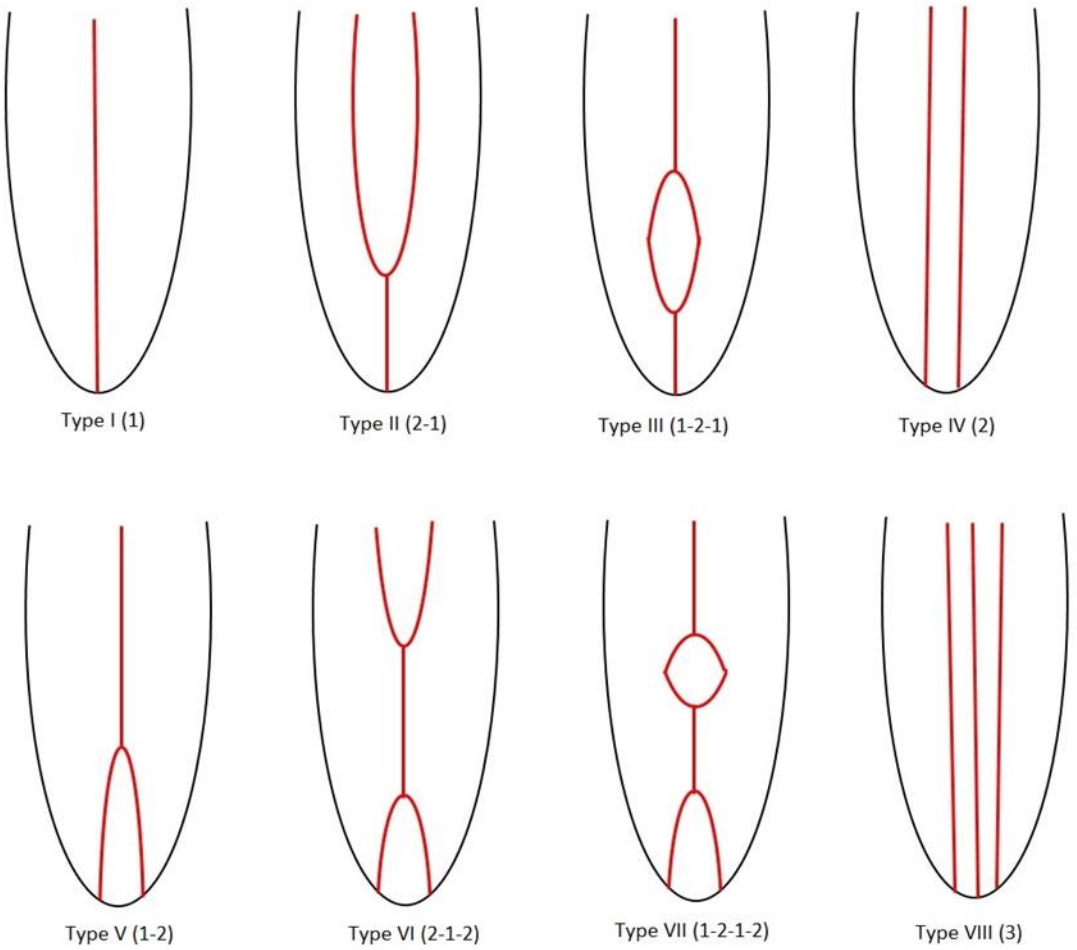

Figure 1: Basic root Canal Morphology Types by Vertucci

Statistical Analysis

The findings gained from the study were evaluated with SPSS Statistics 22 software (IBM SPSS, Turkey).In order to evaluate the data, the chi-square, continuity (Yates) correction, and Fisher-Freeman-Halton exact tests were used to compare qualitative data and descriptive statistics were also used (mean, standard deviation, and frequency). Significance was evaluated at the $p < 0.05$ level.

RESULTS

Our study was conducted by examining 936 permanent mandibular first and second molars of 280 patients, of whom 116 were male (41.4%) and 164 were female (58.6%), with an age range of 13-81 years. Of these teeth, 390 were mandibular first molars (41.7%), and 546 were mandibular second molars (58.3%). The majority (98.8%) of the teeth had two roots. The radix entomolaris was present in 1%. Regarding the mandibular second molars, 6.6% showed a C-shaped formation (Figure 2).

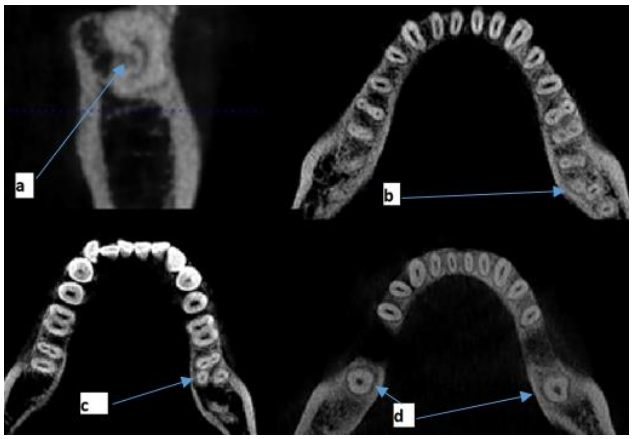

Figure 2 : a) c-shaped root canal at horizontal plane, b,c) radix entomolaris at horizontal plane, d) one-root canal formation of second molar teeth at CBCT axial section

The number of root canals was 3 in 79.7% of the teeth, 4 in 17.7% and 2 in 2.7% (Table 1).

Table 1: Number of roots and root canals in the lower molar teeth

		First molar n (%)	Second molar n (%)	Total n (%)	p
Number of root canals	2	0 (0%)	24 (4.7%)	24 (2.7%)	[1]0.000*
	3	241 (61.8%)	476 (93.3%)	717 (79.7%)	
	4	149 (38.2%)	10 (2%)	159 (17.7%)	
Number of roots	1	0 (0%)	4 (0.8%)	4 (0.4%)	[2]0.215
	2	387 (99.2%)	502 (98.4%)	889 (98.8%)	
	3	3 (0.8%)	4 (0.8%)	7 (0.8%)	

[1]*Chi-square test* [2]*Fisher-Freeman-Halton exact test* *$p < 0.05$

The incidence of Vertucci type II formation in the mesial roots of the mandibular second molars was significantly higher among the males (7%) compared to the females (2.4%). When the mesial roots of the mandibular molar teeth were examined, the rate of a single canal formation in the second molars (Vertucci type I) was 4.7%, and the distal roots were 30.3% of the mandibular first molars occurred type IV formation (Table 2).

Table 2: Study outcomes regarding classification of the mesial and distal roots of the mandibular molar teeth

	Vertucci Classification	First molar n (%)	Second molar n (%)	Total n (%)	p
Mesial root	Type I	0 (0%)	24 (4.7%)	24 (2.7%)	[1]0.000*
	Type II	16 (4.1%)	22 (4.3%)	38 (4.2%)	
	Type III	0 (0%)	4 (0.8%)	4 (0.4%)	
	Type IV	374 (95.9%)	460 (90.2%)	834 (92.7%)	
Distal root	Type I	241 (61.8%)	501 (98.2%)	742 (82.4%)	0.000*
	Type II	15 (3.8%)	3 (0.6%)	18 (2%)	
	Type III	14 (3.6%)	1 (0.2%)	15 (1.7%)	
	Type IV	118 (30.3%)	5 (1%)	123 (13.7%)	
	Type V	2 (0.5%)	0 (0%)	2 (0.2%)	

Fisher-Freeman-Halton exact test *$p < 0.05$

DISCUSSION

According to data from the present study, the formation of a C-shaped root canal type in the mandibular second molars was calculated as 6.6% (n = 36). This value is similar to Weine et al (2012) (7.6%), Peiris et al (2008) (6%), Shahi et al (2008) (7.2%), and Neelakantan et al (2010) (7.5%), but it is lower compared to the percentages presented by Kotoku (1985) (28.4%), Yang et al (1988) (31.5%), Madani et al (2017) (26%), Gulabivala et al (2001) (22.4%), Al-Qudah and Awawdeh (2009) (21.6), Zheng et al (2011) (39%), Zhang et al (2011) (29%), Wang et al (2012) (34.64%), and Kim et al (2016) (40%) and higher compared to those determined by Silva et al (2013) (3.5%) and Jahromi et al (2013) (3%). Accordingly, when all the data are evaluated, it is not possible to state that C-shaped formation is more or less common in a certain geography or race considering that even different studies conducted in the same country may not provide similar results (Madami et al. 2017; Jahromi et al, 2013). For example, when publications originating from Turkey are examined, the incidence of C-shaped root canals in the mandibular molars was reported as 4.1% by Demirbuga et al (2013), 1.9% by Çelikten et al (2016), 10.6% by Tassoker and Sener (2018), and 8.9% by Helvacioglu-Yigit and Sinanoglu (2013). On the other hand, when the findings of our study are compared with similar studies in the world, they seem to be closer to the European geography, as well as the rates found in studies from Turkey (Khawaja et al., 2021). In the current study, no C-shaped canal formation was present among the mandibular first molars.

When the number of roots of the mandibular first molar teeth was evaluated in our study, 99.2% were found to have two roots. The percentage of visible samples of the radix entomolaris was only 1%. When compared to their counterparts in the world, the data obtained from the Far East and Asia (25% by Kim et al., 2013 and 29% by Zhang et al., 2011) are much higher. Our findings are consistent with previous studies conducted in Turkey, with the incidence of the radix entomolaris being reported as 2% by Demirbuga et al (2013) and 0.5% by Nur et al (2014).

Concerning the root canal numbers of the mandibular first molars, 61.8% of the samples had three canals and 38.2% had four canals in these teeth. When our results are compared with studies from different countries and Turkey, they are very similar to those presented by Chourasia et al (3 canals in 64%, and 4 canals in 36%) (2012), Mirzaie et al (3 canals in 63%, and 4 canals in 37%) (2018), and Nur et al (3 canals in 63%/4 canals in 37%) (2014). However, there are also publications reporting very different results from Turkey and other parts of the world (Choupani et al., 2018). When we evaluated the number of roots of the mandibular second molars, we observed that 98.4% had two separate roots (n = 502). In previous studies, the incidence of the formation of two separate roots was reported as 79.2% by Janani et al (2018), 81.6% by Madani et al (2017), 85.4% by Demirbuga et al (2013), 90% by Nur

et al (2014), and 83.93% (Belgium) and 86.61% (Chile) by Torres et al (2015).

In the present study, 0.8% of the mandibular second molars were single-rooted (n = 4) and 0.8% had three roots (n = 4). Similarly, the incidence of single-root formation was determined as 0.8% by Senan et al (2021) and 1.29% by Demirbuga et al (2013). However, this rate differed in other studies: 19.8% in a study by de Janani et al (2018), 8.7% by Felsypremilla et al (2015), 8.93% (Chile) and 14.29% (Belgium) by Torres et al (2015), and 22% by Zhang et al (2011). The incidence of three-root formation was determined to be 0.6% by Senan et al (2021), 0.6% by Madani et al (2017), 0.89% (Belgium) and 3.57% (Chile) by Torres et al (2015), 0.3% by Choi et al (2015), 1.2% by Gulabivala et al (2002), 3.45% by Demirbuga et al (2013), and 3.5% by Silva et al (2013). As can be seen from the differences in these results, it is very difficult to categorize these rates based on geographical or ethnic characteristics.

Table 3. Root canal configuration of the mesial canals of the mandibular first molars

Authors	Country/ Nationality	Number of samples	Mesial root type / %	Distal root type / %
Demirbuğa et al. (34)	Turkey	1,748	IV / 68,II / 30	I / 82, II / 6, IV / 5.6
Nur et al. (39)	Turkey	966	IV / 92, II / 5	I / 60, II / 12, IV / 20, V / 7
Chourasia et al. (40)	India	150	IV / 54,II / 36.6	I / 65.3, II / 20.6, IV / 9.3
Al-Qudah and Awawdeh (27)	Jordan	330	IV / 53, II / 36	I /54, II / 17, IV / 9, V / 11
Dastgerdi et al. (42)	Iran	312	IV / 40, II / 21.1	I / 43.6, II / 17.6, V / 15
Madani et al. (25)	Iran	154	IV / 57, II / 31.5	I / 79.8, II / 10.7, III / 4.6, IV / 3.3
Kim et al. (38)	Korea	1,952	IV / 71, II / 20	I / 66, II / 19, IV / 12
Zhang et al. (29)	China	232	IV / 81, V / 15	-
Chen et al. ((49)	Taiwanese-China	183	IV / 55.2, II / 29.5	I /54, II / 12, III / 7, IV / 25, V / 2
De Pablo et al.(50)	Spain	18,781	IV / 52.3, II / 35	I / 63, II / 14, IV / 12.4
Ahmed et al. (51)	Sudan	100	IV / 73, II / 14	I / 38, II / 28, V / 22
Gulabivala et al. (26)	Burmese	139	IV / 38.1, II / 28.8	I / 60.6, IV / 13.4
Gulabivala et al. (48)	Thailand	139	IV / 58.3, II / 22.3	I / 67.9, IV / 16.5

Tables 3 and 4 present the results of studies in which the mesial and distal root anatomy of the mandibular first and second molars were evaluated according to the Vertucci classification. Accordingly, the dominant canal type in the mesial roots of the mandibular first molars is type IV at varying rates (40%-81%). In our study, we calculated this rate to be 95.9%, which is very high. In the distal roots, the most common canal type in the studies examined is type I (38%-82%). We also found type I structure at a rate of 61.8% in the samples we examined. We consider that there is a need for further research to evaluate the data obtained from this group of randomly selected and evaluated patients in a more homogeneous way.

Table 4. Mesial and distal canal configuration of the of the mandibular second molar teeth

Authors	Country/ Nationality	Number of samples	Root	Type I %	Type II %	Type III %	Type IV %	Type V %	Type VI %	Type VII %	Type VIII %
Calıskan et al. (13)	Turkey	100	M	9.8	19.2	-	52.94	-	3.92	-	1.96
			D	70.2	14.41	11.65	-	3.92	-	-	-
Sert et al. (9)	Turkey	200	M	12.5	31.5	21.5	28	2	-	-	-
			D	76	5.5	13	2	2.5	-	-	-
Gulabivala et al. (26)	Burmese	134	M	30.8	35.9	3.8	26.9	1.3	-	-	-
			D	89.7	5.1	1.3	1.3	1.3	-	-	-
Gulabivala et al. (48)	Thai	60	M	14.8	20.4	-	57.4	1.9	1.9	-	-
			D	70.4	9.3	3.7	11.1	3.7	-	-	-
Ahmed et al.	Sudan	100	M	5	18		63		3	1	
			D	65	11		10	1	2	1	

(51)											
			M	18.1	28	5.7	42.9	3.3	0.8		
Madani et al. (25)	Iran	147	D	91.7	3.3	0.8	1.6	1.6	0		
			M	16	54.7	0	28.6	0.7			
Donyavi et al. (52)	Iran	447	D	97.54	1.23	0	1.23	0			
			M	3	78.2	0	14.9				
Pérez-Heredia et al. (53)	Spain	222	D	92.1	2	3	3				
			M	8.4	2.02	1.44	63.1	5.2			
Neelkanthan et al. (22)	India	345	D	64.9	4.63	0.57	11	1.73			0.57
			M	7.23	32.55	0.91	45.17	1.02			
Pawar et al. (15)	India	983	D	61.14	18.21		7.53				
			M	4	56.9	15.6	18.8	1.1	1.1		
Senan et al. (45)	Yemen	500	D	91.3	0	7.8	0	0.9			
			M	11.7	5.32	37.23	14.89	28.72		2.13	
Torres et al. (44)	Belgium	112	D	98.94	0	0	0	1.06			
			M	17.53	7.22	48.45	4.12	20.62		2.06	
Torres et al. (44)	Chile	112	D	98.97				1.03			
			M	13.88	37.75	1.18	44.46	2.63			
Kim et al. (31)	Korea	1,102	D	96.55	2.09		0.91	0.45			
			M	20	11	42	5	15	2	3	
Peiris et al. (54)	Sri Lanka	100	D	93		2	1	3			

When the mandibular second molars were evaluated, it was seen that the most common canal structure was type IV at mesial root canals. Only Pérez–Heredia et al (2017) reported type II structures at a rate of 78.2%. In our study, we found that the highest rate belonged to type IV at 90.2%. When the distal roots were examined, type I configuration was the most common morphology in the literature, which is consistent with our study (98.2%).

The incidence of type II roots among the mesial roots of the mandibular second molars was found to be significantly higher in men (7%) than in women (2.4%). Although there were 164 female patients versus 116 male patients in the analyzed samples, there is a striking difference in the results. However, more studies should be undertaken to reach a definite conclusion. When evaluated together with other studies on this subject, the existence of highly variable rates between geographical regions is remarkable and is largely due to racial differences, as well as the number of samples evaluated. In order to choose the ideal root canal treatment and achieve long-term success, it is necessary to perform a comprehensive examination of the canal structure with modern imaging techniques.

Although many techniques have been used in the examination of root canal complexes over the years, it is clear that high-quality data flow can be achieved with the CBCT imaging method (Neelakantan et al 2010). Nevertheless, the micro-computed tomography (μCT) method, which can offer a more detailed examination, is accepted as the gold standard in this regard (Ordinola-Zapata et al 2017). However, one disadvantage of μCT is that it only allows for the examination of extracted teeth. Therefore, retrospective CBCT scans could provide more detailed findings on this subject.

CONCLUSION

Within the limitations of our study, CBCT imaging before the root canal treatment is strongly recommended if it's possible for preventing missing extra root canals and rare anatomical structures at the root canal complex. In addition, CBCT is currently used in the diagnosis and treatment planning of tooth resorption, pathological lesions, and detection of perforations in endodontics. We believe that our study is a guide for clinicians and a good reference for academics on the subject.

In conclusion, we consider that our results concerning the root anatomy provide wide information about the root canal complex of the Turkish population and present data that can be compared to other populations.

Conflict of Interest

The authors deny any conflicts of interest directed to this study.

Ethics Approval

The present study with the recordings of the participants has been approved by The Ethical Board of the University (approval number: E-10840098-772.02-193.856 on 11.01.2022).

Author Contributions

The images were collected by EE and the data analysis was performed by EE, KO, and TFE. EE and EŞ wrote the manuscript. MG achieved the final read and corrections of the manuscript.

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