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ORIGINAL ARTICLE

A cone-beam computed tomography study of root canal morphology of maxillary and mandibular premolars in a Turkish population

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Abstract

Aim. The aim of this study was to evaluate the root canal number and configuration of maxillary and mandibular premolar teeth by gender, intervals for decades, tooth position and unilateral or bilateral occurrence in a Turkish population using Cone Beam Computed Tomography(CBCT) scanning. ***Methodology.*** CBCT images of 5496 maxillary and mandibular premolars from 849 patients were evaluated. The following was evaluated in all the images: numbers of roots and root canals, the morphology of the root canal configuration according to the Vertucci classification, male–female differences in the tooth position and male–female differences in unilateral or bilateral occurrence. The reliability data were analyzed with a chi-square test. ***Results.*** The most prevalent root canal frequency was the two canals (86.2%) and type IV (76.9%) configuration for maxillary first premolar, one canal (59.7%) and type I (54.5%) canal configuration for second premolar. The incidence of one canal was higher in females and the occurrence of two or three canals was more common in males. The incidence of one canal was higher on the left side of maxillary premolars and the incidence of two canals was higher on the right side. Most mandibular first (93.5%) and second (98.5%) premolars had one canal. In general, females had one root canal of the mandibular premolar, whereas males had two or three canals. The type I configuration was most common and the incidence was higher on the right side. There were some differences found in the frequency distribution of the number of root canals and configuration of maxillary and mandibular premolar teeth according to intervals for decades. ***Conclusion.*** CBCT scanning provides comprehensive information about the root canal morphology of maxillary and mandibular premolar teeth. These data may help clinicians in root canal treatment of premolar teeth.

Key Words: *cone beam computed tomography, maxillary premolars, mandibular premolars, root canal anatomy, root canal configuration*

Introduction

A thorough knowledge of root canal morphology and configuration plays an important role in the success of endodontic treatment [1]. Failure to detect additional canals and incomplete instrumentation are the most likely reasons for endodontic flare-ups and failures [2–4].

Maxillary premolars pose challenges for endodontic treatment because of the number of roots and canals and the variations in the configurations of the pulp cavity [5]. Different studies have reported substantial variation in the number of roots and canals of maxillary premolars [5–9]. The type of roots and the morphology of the canals of maxillary and mandibular premolar teeth can also be extremely complex and highly variable [3,7,9,10]. Therefore, they are probably the most difficult teeth for endodontic treatment [2]. Factors that can contribute to differences in the internal complexities of the root canal anatomy include ethnic differences and origin [10,11], age [9], gender [12] and study design.

Studies of the root canal anatomy of premolar teeth have used the canal staining and clearing technique [1], the cross-sectioning technique [13] and radiographic examination [9]. However, these studies have been based on extracted teeth. In addition, the canal staining and clearing technique [1] and the

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cross-sectioning technique [13] are invasive and result in irreversible damage to samples. Radiographic examinations also provide only two-dimensional images, and anatomic structures can be superimposed in these images. Therefore, they do not reflect the complete morphology of root canals.

Recently, cone-beam computed tomography (CBCT) has been used to evaluate endodontic applications [14]. CBCT facilitates diagnosis and provides clinicians with three-dimensional information about the morphology of the roots and their divergence [15]. The images obtained by CBCT display axial, sagittal and coronal sections and reduce the superimposition of anatomic structures [14]. These advantages facilitate the clinician's understanding of the thorough morphology of root canals.

Many studies have evaluated the root canal morphology of maxillary and mandibular premolar teeth [3,5–7,11,12,16,17]. However, to the best of our knowledge, there have been no CBCT studies of the root canal configuration of maxillary and mandibular premolar teeth by gender or by tooth position in a Turkish population. The aim of this study was to evaluate the root canal anatomy, number and configuration of maxillary and mandibular premolar teeth by gender, intervals for decades, tooth position and unilateral or bilateral occurrence in a Turkish population using CBCT scanning.

Materials and methods

CBCT images of maxillary and mandibular premolars were obtained from patients who visited the Faculty of Dentistry, Dicle University, Diyarbakir, Turkey, for various purposes between 2009 and 2011. We evaluated a database of 5496 (2,680 maxillary premolars, 2816 mandibular premolars) CBCT scans obtained from 849 patients according to (a) gender (females, n = 421; males, n = 428 males); (b) age (between 14–84 years); (c) presence of maxillary and mandibular permanent premolar teeth on scans; and (d) fully erupted teeth, fully formed apexes and no root canal fillings, posts and crown restorations.

The CBCT images were obtained using a CBCT scanner (I-CAT vision TM Imaging Science International, Hatfield, USA, 2008) at 120 kVp, 18.54 mA, with an exposure time of 8–9 s. The voxel size of the images was 0.3 mm. The acquisition process was performed by an experienced radiologist according to the manufacturer's recommendation protocol, with the minimum exposure necessary for adequate image quality. Intra-examiner calibration of the CBCT images was first performed to evaluate the reliability of the assessment. All the images were assessed separately twice by two examiners (one endodontist and one maxilla facial radiologist) with a 2-week interval between the assessments. In the event of disagreements between the pair, these were discussed with another radiologist until a consensus was reached (especially for type VII and VIII configurations). The following was evaluated in all the images: the numbers of roots and canals, the morphology of the root canal configuration according to the Vertucci classification (Figure 1), differences in the tooth position of males and females, intervals for decades, and unilateral or bilateral occurrence. The reliability of the data was analyzed with a chi-square test.

Results

Number of the root canals and canal configuration of maxillary premolars

Table I shows the frequency distribution of the root canals of maxillary premolar teeth. Most maxillary first premolars (86.2%) had two root canals, whereas most second premolars (59.7%) had one canal. The numbers of root canals and the tooth position were different in males and females (Table II). When the maxillary first and second premolars were evaluated unilaterally, the incidence of canals varied between the males and females, with the incidence of one-canalled maxillary first and second premolars higher in females and the incidence of two and three-canalled maxillary first and second premolars higher in males.

The frequency distribution of the different canal configurations of the maxillary premolars is shown in Table I. Overall, the type IV canal configuration was most prevalent in first premolars (76.9%) and the type I canal configuration was most prevalent in second premolars (54.5%), regardless of gender. The type VII canal configuration was not found in all teeth. Three-canalled teeth were observed in less than 1% of cases and were classified as type VIII. There were variations in the root canal configurations of the maxillary first premolars between the left and right side of both males and females (Table II). When the teeth were evaluated unilaterally, the numbers of canals and the configuration of the canals were different between males and females.

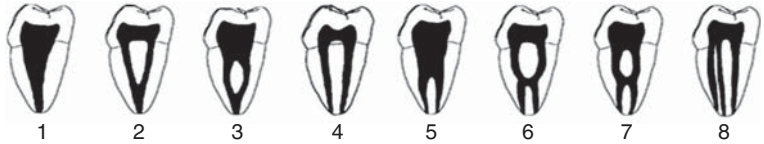

Figure 1. Vertucci classification of root canal configuration.

Table I. The frequency distribution and percentage of the number of root canals and the configuration of maxillary and mandibular premolar teeth.

	Maxillary		Mandibular	
No of canals (%)	1. Premolar	2. Premolar	1. Premolar	2. Premolar
1 canal	173 (12.5)	776 (59.7)	1375 (93,5)	1325 (98.5)
2 canal	1189 (86.2)	521 (40)	95 (6,5)	17 (1.3)
3 canal	17 (1.2)	4 (0.30)	1 (0,06)	3 (0.2)
No of canal Config (%)				
Type 1	132 (9.57)	709 (54.50)	1366 (92.8)	1325 (98.5)
Type 2	89 (6.46)	115 (8.84)	4 (0.3)	1 (0.07)
Type 3	19 (1.38)	47 (3.61)	14 (1)	1 (0.07)
Type 4	1061 (76.94)	285 (21.91)	21 (1.4)	8 (0.6)
Type 5	63 (4.57)	141 (10.84)	65 (4.4)	7 (0.5)
Type 6	1 (0.07)	0	0	0
Type 7	0	0	0	0
Type 8	14 (1.01)	4 (0.30)	1 (0.06)	3 (0.2)

Number of the root canals and canal configuration of mandibular premolars

Table I shows the frequency distribution of the number of root canals of mandibular premolar teeth. Most mandibular first premolars (93.5%) had one root canal and most second premolars (98.5%) had one canal. The overall occurrence of canals on the left side and on the right side was different, regardless of gender (Table III). The incidence of two canals of the mandibular left first premolar was higher on the left side (9.5%) than on the right side (5.9%) in males. The incidence of one-canalled mandibular premolars was higher in females and the frequency of two and three-canalled mandibular premolars were higher in males.

Table I shows the frequency distribution of the different canal configurations of the mandibular premolar teeth. The type I canal configuration was most prevalent in mandibular first (92.8%) and second (98.5%) premolar teeth. The type VIII canal configuration was least prevalent and the type VI and VII canal configurations were not found in all teeth. The incidences of varying root canal configurations did not differ between the left and the right side of both males and females (Table III). However, when the teeth were evaluated unilaterally, the number of

Table II. The frequency distribution of the number of root canals and the configuration of maxillary premolar teeth according to tooth position and gender.

	Maxillary 1. Premolar				Maxillary 2. Premolar			
	Right		Left		Right		Left	
No of canal, %	Male	Female	Male	Female	Male	Female	Male	Female
1 canal	8.1	15.2	9.7	17.3	50.9	68	51.9	68.1
2 canal	89.1	84.5	88.8	82.5	48.8	32	47.2	31.9
3 canal	2.8	0.3	1.5	0.3	0.3	0	0.9	0
No of canal Config, %								
Type 1	5.3	11.5	7.7	14	44.9	63.4	46.3	63.7
Type 2	6.2	7.5	5.6	6.5	9.3	8.5	9.3	8.2
Type 3	0.8	1.7	1.2	1.8	3.3	4	3.1	4.1
Type 4	80.4	75	78.7	73.5	29.3	16.2	25.2	16.7
Type 5	4.5	4.3	5.3	4.2	12.9	7.9	15.2	7.3
Type 6	0.3	0	0	0	0	0	0	0
Type 7	0	0	0	0	0	0	0	0
Type 8	2.5	0	1.5	0	0.3	0	0.9	0

Table III. The frequency distribution of the number of root canals and the configuration of mandibular premolar teeth according to tooth position and gender.

	Mandibular 1. Premolar				Mandibular 2. Premolar			
	Right		Left		Right		Left	
No of canal, %	Male	Female	Male	Female	Male	Female	Male	Female
1 canal	93.8	95.6	90.5	94.1	97.3	99.7	97.4	99.7
2 canal	5.9	4.4	9.5	5.9	2.7	0.3	1.7	0.3
3 canal	0.3	0	0	0	0	0	0.9	0
No of canal Config, %								
Type 1	93.2	95.6	89.2	93.5	97.3	99.7	97.4	99.7
Type 2	0.2	0	0.5	0.3	0.3	0	0	0
Type 3	0.5	0.6	1.9	0.8	0.3	0	0	0
Type 4	1.4	1.1	1.6	1.6	0.9	0.3	0.9	0.3
Type 5	4.3	2.8	6.8	3.8	1.2	0	0.9	0
Type 6	0	0	0	0	0	0	0	0
Type 7	0	0	0	0	0	0	0	0
Type 8	0.3	0	0	0	0	0	0.9	0

canals and the configuration of the canals were different between males and females.

Number of the root canals and canal configuration of premolar intervals for decades

Table IV shows the frequency distribution of the number of root canals and configuration of maxillary and mandibular premolar teeth according to intervals for decades. There were some differences found, especially in the first, fourth and fifth decade (Figure 2).

Discussion

This study provides a comprehensive account of the root canal number and the configuration of mandibular and maxillary premolars in a Turkish population. Studies have reported that variations in root canal anatomy are very common [18]. Vertucci [1] classified the anatomy of root canals into eight types. We used this classification in the present study.

Past studies of the numbers of root canals of maxillary first premolars reported the percentage of one-canalled as 3.92–26.2%, two-canalled as 73.3–97% and three-canalled as 0–5% [9,17,19,20]. In the present study, the percentage of one-canalled maxillary first premolars was 12.5%. This is higher than that reported in earlier studies of a Turkish population [17,19]. An interesting observation is that the percentage of two-canalled maxillary first premolars in this study was 86.2%, which is slightly lower than the percentage reported in these previous studies [17,19]. The percentage of three-canalled (1.2%) maxillary first premolars was higher than that observed by Çalişkan et al. [17] (0) and lower than that found by Kartal et al. [19] (1.6%). In other studies of the root canal morphology of maxillary second premolars, the percentage of one-canalled maxillary second premolars was 44–55%, two-canalled was 45–56% and three-canalled was 0–1% [9,17,19,21]. In the present study, the percentage of one-canalled (59.7%) maxillary second premolars was higher and the percentage of two- (40%) and three-canalled (0.3%) maxillary second premolars was lower than that found in several earlier studies of a Turkish population [17,19].

In the present study, the number of canals was associated with the tooth position, regardless of the gender. The incidence of one canal was higher on the left side and the incidence of two canals was higher on the right side. When the teeth were evaluated

Table IV. The frequency distribution of the number of root canals and configuration of maxillary and mandibular premolar teeth according to decades for intervals.

	10–20	20–30	30–40	40–50	50–60	60 and upper
10–20				[b]	[a,b]	
20–30			[c]	[b]	[a,b]	
30–40	[b]	[c]			[a,b]	
40–50		[b]				
50–60	[a,b]	[a,b]	[a,b]			
60 and upper						

[a] $p < 0.05$ mandibular first premolar; [b] $p < 0.05$ mandibular second premolar; [c] $p < 0.05$ maxillary first premolar; [d] $p < 0.05$ maxillary second premolar.

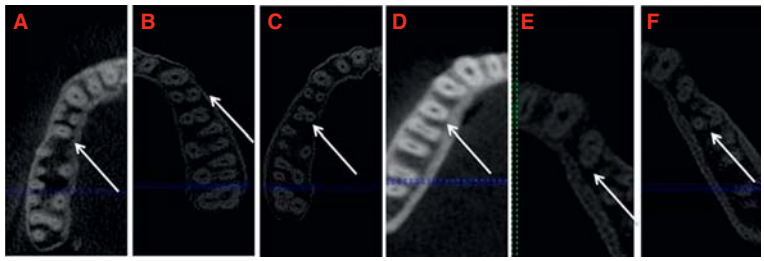

Figure 2. Root canal configuration of maxillary premolars (A) Type I; (B) type IV; (C) Type VIII, Root canal configuration of mandibular premolars (D) Type I; (E) Type IV; (F) Type VIII.

unilaterally, differences were found, with the incidence of one canal of the maxillary first and second premolars higher in females and the incidence of two and three canals higher in males. Awareness of the clinician of this difference before the preoperative evaluation might increase the success of root canal treatment. In addition, the clinician should take care when opening the access cavity of the premolar teeth not to miss out the additional canal.

In the present study, the type IV canal configuration was most prevalent (76.9%) in the maxillary first premolar teeth, followed by type I, type II and type V. Other studies of a Turkish population reported that the percentage of the type IV canal configuration was 60–78% [12,17,19]. Our findings were similar with Çalışkan et al. [17] and higher than those of Sert et al. [16]. and Kartal et al. [19]. The percentages of type I, type II and type III canal configurations were higher than those reported by Çalişkan et al. [17] and Kartal et al. [19] and lower than those reported by Sert et al. [12].

The present study observed differences in the types of canal configurations between the right and the left sides of maxillary first premolar teeth. The type I and type III canal configurations were higher on the left side and the type II and type IV were higher on the right side, regardless of gender. Differences were also found when the teeth were evaluated unilaterally. Compared to findings presented by Sert et al. [12], the type II and type III canal configurations in the present study were higher in females in the maxillary first premolar teeth and the type IV was higher in males.

In the maxillary second premolar teeth, the type I canal configuration was most prevalent (54.50%), followed by type IV, type V and type II. In the present study, the percentage of the type I canal configuration was higher than that reported in earlier studies (32–48%) for a Turkish population [12,17,19]. There were no differences between the right and left sides of maxillary second premolar teeth, regardless of gender. However, when the teeth were evaluated unilaterally, the type I and type III were higher in males and the type IV and type V were higher in females on both the left and right sides of the second premolars compared to findings reported by Sert et al. [12].

The root canal number and the canal configuration of the mandibular premolar teeth were evaluated in this study. In the literature, the incidence of one canal in the mandibular first premolar was reported to be 60.5–70% and 71–98.8% for the second premolar [9,12,16,17,22]. In the present study, the percentage of mandibular first (93.5%) and second premolars (98.5%) with one canal was higher than that found in several earlier studies of a Turkish population [12,16,17]. The incidence of mandibular first and second premolars with two and more canals was 30–39.5% and 1.2–29%, respectively, in the literature [9,12,16,17,22]. The number of canals of the first and second premolar in the present study was lower than that found in previous studies of a Turkish population [12,16,17].

In the present study, the number of canals of mandibular premolars was associated with tooth position and gender. The incidence of one-canalled mandibular premolars was higher in females, whereas the incidence of two and three canals was higher in males. The incidence of two canals was higher on the left side for first premolars in males. Clinicians should be aware of these differences in preoperative evaluations of mandibular premolar teeth.

The type I configuration was most prevalent in mandibular first (92.8%) and second premolar (98.5%) teeth. In the literature, the incidence of one canal in the apex of mandibular first and second premolars were reported to be 74–89.5% and 81.5–98.8%, respectively [9,12,16,17,22]. The incidences of mandibular first (94.1%) and second (98.64%) premolars with one canal in the apex were higher than those found in previous studies of a Turkish population [12,16,17]. The type I canal configuration in both the first and second premolars was higher in females. The type I configuration was higher at the right side, regardless of gender. Sert et al. [12] found that the type I canal configuration of mandibular first premolar teeth was higher in males, whereas it was higher in the second premolar teeth in females. Our results were different in the first premolar from Sert et al. [12].

In the present study, the frequency distribution of the number of root canals and configuration of maxillary and mandibular premolar teeth according to intervals for decades were evaluated. Although there were some differences found, especially in the first,

fourth and fifth decade, it indicates the root canal configuration did not effect from decades for intervals.

The differences in the maxillary and mandibular premolars in the current study compared to those of previous studies of a Turkish population [12,16,17,19] may be related to various factors, with ethnic differences [10] and ethnic origins [11] the prime reasons for the variations in the canal configurations. The previous studies of a Turkish population were carried out in the north-west and western regions of Turkey. In contrast, the data in the current study were obtained from patients living in the south-west of the country. We might say that ethnic differences between populations may influence the configuration of the root canals. In addition, the previous studies did not compare the right and left side unilaterally and bilaterally by gender. The studies of the root canal configurations of the Turkish population [12,16,17,19] were also based on a small number of subjects. The present study was comprehensive and included a large number of teeth (2680 maxillary premolar teeth and 2816 mandibular premolar teeth). These differences may explain the variations between the present study and the previous ones. We also used CBCT image analysis in this study. CBCT is more accurate, more reliable and leads to clearer determinations than canal staining and the clearing technique [14]. Therefore, the present study may represent the true variation in the Turkish population.

Conclusions

Within the limitations of this study, it can be concluded that there was a higher prevalence of two-canalled maxillary first premolars with a type IV canal configuration and that this configuration was higher on the right side in males. The maxillary second premolars were mostly one canalled. They showed a type I configuration, which was higher on the left side of males and females. The mandibular premolars were mostly one canalled, with a type I canal configuration, which was higher on the right side of females. This study provides comprehensive information for dentists on the root canal morphology of maxillary and mandibular premolar teeth in a Turkish population.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984;58:589–99.
[2] Slowey RR. Root canal anatomy. Road map to successful endodontics. Dent Clin North Am 1979;23:555–73.
[3] England MC Jr, Hartwell GR, Lance JR. Detection and treatment of multiple canals in mandibular premolars. J Endod 1991;17:174–8.
[4] Barbizam JV, Ribeiro RG, Tanomaru FM. Unusual anatomy of permanent maxillary molars. J Endod 2004;30:668–71.
[5] Pecora JD, Saquy PC, Sousa Neto MD, Woelfel JB. Root form and canal anatomy of maxillary first premolars. Braz Dent J 1992;2:87–94.
[6] Carns EJ, Skidmore AE. Configurations and deviations of root canals of maxillary first premolars. Oral Surg Oral Med Oral Pathol 1973;36:880–6.
[7] Loh HS. Root morphology of the maxillary first premolar in Singaporeans. Aust Dent J 1998;43:399–402.
[8] Green D. Double canals in single roots. Oral Surg Oral Med Oral Pathol 1973;35:689–96.
[9] Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. Oral Surg Oral Med Oral Pathol 1972;33:101–10.
[10] Trope M, Elfenbein L, Tronstad L. Mandibular premolars with more than one root canal in different race groups. J Endod 1986;12:343–5.
[11] Awawdeh L, Abdullah H, Al-Qudah A. Root form and canal morphology of Jordanian maxillary first premolars. J Endod 2008;34:956–61.
[12] Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod 2004;30:391–8.
[13] Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. Oral Surg Oral Med Oral Pathol 1969;28:419–25.
[14] Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. J Endod 2007;33:1121–32.
[15] Scarfe WC, Levin MD, Gane D, Farman AG. Use of cone beam computed tomography in endodontics. Int J Dent 2009; 634567:1–20.
[16] Sert S, Aslanalp V, Tanalp J. Investigation of the root canal configurations of mandibular permanent teeth in the Turkish population. Int Endod J 2004;37:494–9.
[17] Caliskan MK, Pehlivan Y, Sepetcioglu F, Turkun M, Tuncer SS. Root canal morphology of human permanent teeth in a Turkish population. J Endod 1995;21:200–4.
[18] Cohen S, Hargreaves KM. Pathways of the pulp. 10th edition. St Louis, MO: Mosby-Year book Inc; 2011;p 153–70.
[19] Kartal N, Ozcelik B, Cimilli H. Root canal morphology of maxillary premolars. J Endod 1998;24:417–19.
[20] Vertucci FJ, Gegauff A. Root canal morphology of the maxillary first premolar. J Am Dent Assoc 1979;99:194–8.
[21] Vertucci F, Seelig A, Gillis R. Root canal morphology of the human maxillary second premolar. Oral Surg Oral Med Oral Pathol 1974;38:456–64.
[22] Vertucci FJ. Root canal morphology of mandibular premolars. J Am Dent Assoc 1978;97:47–50.