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Evaluation of Root Morphology and Root Canal Configuration of Mandibular and Maxillary Premolar Teeth In Turkish Subpopulation By Using Cone Beam Computed Tomography

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ABSTRACT

The aim of this study was to evaluate the root morphology and root canal configuration of the lower and upper premolars using cone-beam computed tomography (CBCT), according to gender and right-left position of the tooth in the Turkish subpopulation. For the evaluation of root canal anatomy of mandibular and maxillary premolar teeth, 494 patients were used. In total, 3,880 premolar teeth were evaluated. CBCT images were examined in the coronal, sagittal, and axial planes. Number of roots, canals, and canal configurations of the teeth were determined according to Vertucci's classification. Qualitative data were analysed with Chi-square, Fisher Exact, and Bonferroni tests (α=0.05%). According to the results of this study, in maxillary first premolars, 64.5% two roots, 87.7% two canals, and 67.8% Type Ⅳ canal configuration; in maxillary second premolars 77.3% one root, 50.4% one canal, and 50.4 Type Ⅰ canal configuration; in mandibular first premolars 89.9% one root, 76.9% one canal, and 76.9% Type Ⅰ canal configuration; and in mandibular second premolars 98.4% one root, 95.9% one canal, and 95.9% Type Ⅰ canal configuration were observed. No statistically significant effect of the tooth position (right, left) on the number of roots, canals, and canal configuration in maxillary and mandibular premolars was observed (p>0.05). Maxillary second premolar and mandibular first premolars showed a statistically significant effect on number of roots, canals, and canal configuration by gender (p=0.00, p=0.032). In addition, gender had a significant effect on number of roots in maxillary first premolars (p=0.017).

Keywords: Cone-beam computed tomography, mandibular premolar, maxillary premolar, root canal anatomy

Introduction

To detect root canals and perform adequate enlargement and shaping, clinicians must have sufficient knowledge of root canal anatomy (1). To prevent unsuccessful root canal treatment, the anatomy of the root canal should be determined by developing diagnostic imaging methods before starting the treatment (2).

Studies in the literature revealed that the canal systems in maxillary and mandibular premolars are variable and complex (3–5). Particularly, mandibular premolars are considered to be one of the teeth with the most anatomical differences and the most difficult root canal treatment (6,7).

Cone beam computed tomography (CBCT) imaging is a good diagnostic method for treatment planning in dentistry (8). CBCT is used in endodontics in the diagnosis of root resorption, root fractures, and pathologies of nonendodontic origin, and the diagnosis and the follow-up of the prognosis of periapical lesions (9). In addition, it prevents superposition of anatomical structures, creates 3-dimensional images with high geometric accuracy, and provides a detailed evaluation of root canal morphology (10).

In the literature, there are many studies evaluating the variations in root canal morphology of mandibular and maxillary premolar teeth in different populations (3,4,6,7). According to the results of these studies, the existence of complex root canal anatomies has been reported. There are a limited number of studies examining the root canal anatomy of both maxillary and mandibular premolars with CBCT in the Turkish population by gender and tooth position (11,12). Therefore,

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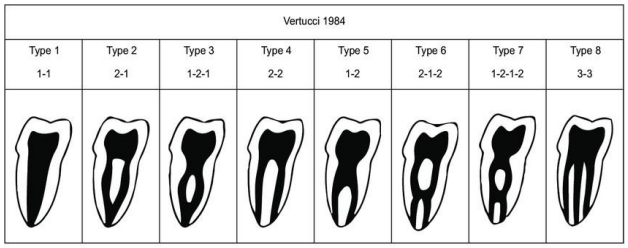

Fig. 1. Vertucci Root Canal Configuration Classification

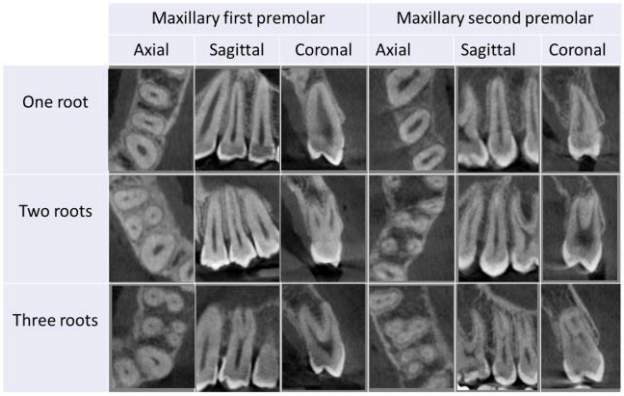

Fig. 2. Axial, Sagittal and Coronal Section View of Root Number of Maxillary Premolar Teeth

the aim of the present study is to evaluate the root morphology and root canal configuration of mandibular and maxillary premolar teeth by gender and tooth position with cone beam computed tomography. The null hypothesis of this study is that gender and tooth position have no effect on root canal morphology in maxillary and mandibular premolars.

Material and Methods

Approval for this study was obtained from the Non-Invasive Ethics Committee of Van Yüzüncü Yıl University (2021/11-10). In this study, CBCT images obtained for diagnosis and treatment in a private clinic between 2018 and 2020 were scanned retrospectively.

CBCT images of 3880 (1002 mandibular and 1002 maxillary) premolars belonging to 494 (225 males, 269 females) patients were evaluated. Caries-free patients with complete root development, without endodontic treatment, who have fully erupted teeth, and have high-resolution CBCT images were included in the study. Patients with teeth with coronal or post-coronal restoration, periapical lesion, and root resorption were excluded.

CBCT images were obtained using the Orthophos XG Plus (Sirona, Bensheim, Germany) device with 8×8 FOV, 75 µm voxel size, 85 kVp, and 6 mA,

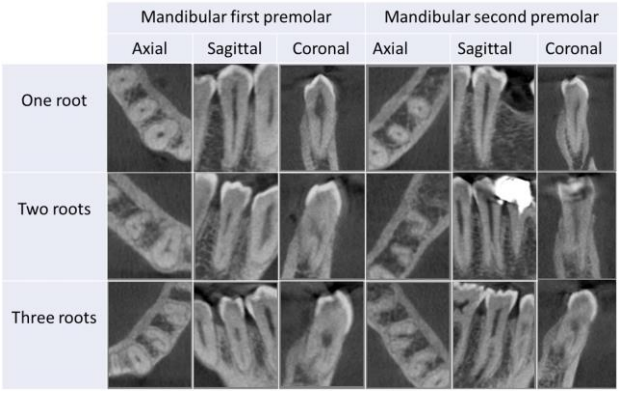

Fig. 3. Axial, Sagittal and Coronal Section View of Root Number of Mandibular Premolar Teeth

14.4 seconds irradiation parameters. CBCT sections were taken from the apical to the coronal regions with a thickness of 1 mm. All scannings were performed according to the manufacturer's recommended protocol. The images were investigated in the coronal, sagittal, and axial planes by an experienced endodontist using the device's software, GALILEOS Comfort VO1 HC (Sirona, Bensheim, Germany).

Number of roots, canals, and canal morphology according to Vertucci's classification of mandibular and maxillary premolar teeth were analysed (Figure 1). Furthermore, it was evaluated whether there was a statistical difference between these criteria by gender and right and left positions. All statistical data were analysed with Chi-square, Fisher Exact, and Benferoni tests using IBM SPSS V23 software. A p-value of <0.05 was considered statistically significant.

Results

A total of 494 CBCT images were analysed. A total of 3880 teeth were examined, including 988 mandibular first premolars, 974 mandibular second premolars, 966 maxillary first premolars, and 952 maxillary second premolars. Of the patients, 54.5% (269) were females and 45.5% (225) were males. Variations in root canal morphology and classifications of upper maxillary premolars were shown in Figure 2, and lower mandibular premolars were shown in Figure 3.

Maxillary Premolar: The ratio of number of roots, canals, and Vertucci canal configuration by gender in maxillary premolars were shown in Table 1.

In maxillary first premolars, 31.2% one root, 64.5% two roots and 4.3% three roots were detected. The number of root canals were determined as 8% one, 87.7% two, and 4.3%

Table 1. The Ratio of Number of Roots, Number of Root Canals, and Vertucci Canal Configuration By Sex In Maxillary Premolars

	Maxillary first premolar				Maxillary second premolar			
	Male	Female	Total	P	Male	Female	Total	p
No. of roots				n(%)				
1	123 (27.6%)[a]	178 (34.2%)[b]	301 (31.2%)	0.017*	312 (71.9%)[a]	424 (81.9%)[b]	736 (77.3%)	0.000*
2	297 (66.6%)	326 (62.7%)	623 (64.5%)		121 (27.9%)[a]	92 (17.8%)[b]	213 (22.4%)	
3	26 (5.8%)[a]	16 (3.1%)[b]	42 (4.3%)		1 (0.2%)	2 (0.4%)	3 (0.3%)	
Total	446	520	966		434	518	952	
No. of root canals				n(%)				
1	36 (8.1%)	41 (7.9%)	77 (8%)	0.109*	175 (40.3%)[a]	305 (58.9%)[b]	480 (50.4%)	0.000*
2	384 (86.1%)	463 (89%)	847 (87.7%)		258 (59.5%)[a]	211 (40.7%)[b]	469 (49.3%)	
3	26 (5.8%)	16 (3.1%)	42 (4.3%)		1 (0.2%)	2 (0.4%)	3 (0.3%)	
Total	446	520	966		434	518	952	
Vertucci classification				n(%)				
Tip Ⅰ	32 (7.2%)	41 (7.9%)	73 (7.6%)	0.202**	175 (40.3%)[a]	305 (58.9%)[b]	480 (50.4%)	0.000*
Tip Ⅱ	38 (8.5%)	54 (10.4%)	92 (9.5%)		44 (10.1%)[a]	34 (6.6%)[b]	78 (8.2%)	
Tip Ⅲ	29 (6.5%)	48 (9.2%)	77 (8%)		51 (11.8%)	53 (10.2%)	104 (10.9%)	
Tip Ⅳ	311 (69.7%)	344 (66.2%)	655 (67.8%)		125 (28.8%)[a]	89 (17.2%)[b]	214 (22.5%)	
Tip Ⅴ	7 (1.6%)	11 (2.1%)	18 (1.9%)		33 (7.6%)	30 (5.8%)	63 (6.6%)	
Tip Ⅵ	2 (0.4%)	2 (0.4%)	4 (0.4%)		0	1 (0.2%)	1 (0.1%)	
Tip Ⅶ	1 (0.2%)	4 (0.8%)	5 (0.5%)		5 (1.2%)	4 (0.8%)	9 (0.9%)	
Tip Ⅷ	26 (5.8%)	16 (3.1%)	42 (4.3%)		1 (0.2%)	2 (0.4%)	3 (0.3%)	
Total	446	520	966		434	518	952	

n, Number of teeth;* Fisher's exact test; ** Chi-square test; a,b, Teeth presenting differences in the number of roots, number of roots canals, and Vertucci canal configuration between sex

three. Also 7.6% Type Ⅰ, 9.5% Type Ⅱ, 8% Type Ⅲ, 67.8% Type Ⅳ, 1.9% Type Ⅴ, 0.4% Type Ⅵ, 0.5% Type Ⅶ, and 4.3% Type Ⅷ canal configuration were observed.

There was no statistically significant effect of the tooth position (right, left) on the number of roots, canals, and root canal configuration in the maxillary premolars (p>0.05). No statistically significant effect of gender on the number of root canals and Vertucci canal configuration in maxillary first premolars were detected (p>0.05). However, in maxillary first premolars, the ratio of one root in females and three roots in males were found to be statistically higher (p=0.017).

In maxillary second premolars, 77.3% one, 22.4% two and 0.3% three roots were detected. The number of root canals was determined as 50.4% one, 49.3% two and 0.3% three canals. Also, 50.4% Type Ⅰ, 8.2% Type Ⅱ, 10.9% Type Ⅲ, 22.5% Type Ⅳ, 6.6% Type Ⅴ, 0.1% Type Ⅵ, 0.9% Type Ⅶ, and 0.3% Type Ⅷ canal configurations were observed.

In maxillary second premolars, the ratio of one root and one canal in females and two roots and two canals ratios in males were statistically higher by gender (p=0.000). In addition, the rate of Type Ⅰ in females, and, on the other hand, Type Ⅱ and Ⅳ Vertucci canal configurations in males were found to be statistically higher (p=0.000).

Mandibular Premolar: The ratio of number of roots, canals, and Vertucci canal configuration by gender in mandibular premolars were shown in Table 2.

In mandibular first premolars, 89.9% one, 9.7% two and 0.4% three roots were detected. The number of root canals were determined as 76.9% one, 22.7% two, and 0.4% three canals. Also, 76.9% Type Ⅰ, 0.1% Type Ⅱ, 1.4% Type Ⅲ, 10.1% Type Ⅳ, 10.9% Type Ⅴ, 0.1% Type Ⅶ and 0.4% Type Ⅷ canal configurations were observed.

A statistically significant effect of the tooth position on the number of roots, canals, and canal configuration in mandibular premolars was observed (p>0.05). On the other hand, by gender, the ratio of one root in females and two, three roots (p=0.000) and three canals (p=0.032) in males were statistically higher in mandibular first premolars. In addition, the rate of Type Ⅳ and Ⅷ canal configurations in males and Type Ⅴ in females were statistically higher (p=0.000).

In mandibular second premolars, 98.4% one, 1.3% two, and 0.3% three roots were detected. The number of root canals were found as 95.9% one, 3.6% two, and 0.5% three canals. Also, 95.9% Type Ⅰ, 0.4% Type Ⅲ, 1.1% Type Ⅳ, 2.1% Type

Table 2. The Ratio of Number of Roots, Number of Root Canals, and Vertucci Canal Configuration By Sex In Mandibular Premolars

	Mandibular first premolar				Mandibular second premolar			
	Male	Female	Total	p	Male	Female	Total	p
No. of roots				n(%)				
1	380 (84.4%)[a]	508 (94.4%)[b]	888 (89.9%)	0.00*	431 (97.5%)	527 (99.1%)	958 (98.4%)	0.131*
2	66 (14.7%)[a]	30 (5.6%)[b]	96 (9.7%)		9 (2%)	4 (0.7%)	13 (1.3%)	
3	4 (0.9%)[a]	0b	4 (0.4%)		2 (0.5%)	1(0.2%)	3 (0.3%)	
Total	450	538	988		442	532	974	
No. of root canals				n(%)				
1	336 (74.7%)	424 (78.8%)	760 (76.9%)	0.032*	418 (74.7%)	516 (97%)	934 (95.9%)	0.091*
2	110 (24.4%)	114 (21.2%)	224 (22.7%)		22 (24.4%)	13 (2.4%)	35 (3.6%)	
3	4 (0.9%)a	0b	4 (0.4%)		2 (0.9%)a	3 (0.6%)	5 (0.5%)	
Total	450	538	988		442	532	988	
Vertucci classification				n(%)				
Tip Ⅰ	336 (74.7%)	424 (78.8%)	760 (76.9%)	0.00*	418 (94.6%)	516 (97%)	934 (95.9%)	0.164*
Tip Ⅱ	1 (0.2%)	0	1 (0.1%)		0	0	0	
Tip Ⅲ	7 (1.6%)	7 (1.3%)	14 (1.4%)		2 (0.5%)	2 (0.4%)	4 (0.4%)	
Tip Ⅳ	67 (14.9%)[a]	33 (6.1%)[b]	100(10.1%)		8 (1.8%)	3 (0.6%)	11(1.1%)	
Tip Ⅴ	34 (7.6%)[a]	74 (13.8%)[b]	108 (10.9%)		12 (2.7%)	8 (1.5%)	20 (2.1%)	
Tip Ⅵ	0	0	0		0	0	0	
Tip Ⅶ	1 (0.2%)	0	1 (0.1%)		0	0	0	
Tip Ⅷ	4 (0.9%)[a]	0b	4 (0.4%)		2 (0.5%)	1 (0.2%)	3 (0.3%)	
Tip ⅩⅦ	0	0	0		0	2 (0.4%)	2 (0.2%)	
Total	450	538	988		442	532	974	

n, Number of teeth;* Fisher's exact test; a,b, Teeth presenting differences in the number of roots, number of roots canals, and Vertucci canal configuration between sex

Ⅴ, 0.3% Type Ⅷ, and 0.2% Type ⅩⅦ canal configurations were observed.

No statistically significant effect of gender was found on number of roots, canals, and canal configuration in mandibular second premolars ($p>0.05$).

Discussion

It is of great importance to know about root canal systems to perform a successful root canal treatment (13). Understanding the impact of demographic factors on the anatomy of different dental groups helps clinicians predict more complex morphologies (4).

According to the results of this study, 64.5% two roots, 87.7% two canals, and 4.3% three roots were detected in the maxillary first premolars. Type Ⅳ canal structure was observed the most with a rate of 67.8%. In the literature, it has been reported that the ratio of two roots varied between 51.4% and 75%, and two canals varied between 70.8% and 90.7% in maxillary first premolars (11,12,14-18). The rate of three roots varied between 0.2% and 2.6% (11,12,14–16,19). Vertucci Type IV canal configuration has been reported to be the most common (12,14–16,19–21). In this study, the number of root canals and root canal configuration rates in maxillary first premolars were found to be similar to the studies in the literature. However, the ratio of three roots was observed to be higher than in the present studies.

In this study, 77.3% one root, 50.4% one canal, and 50.4% Type Ⅰ canal structure were observed in maxillary second premolars. When the literature is reviewed, one root rate varying between 69.6% and 82.9% and one canal rate varying between 48.7% and 69.7% have been reported in maxillary

second premolars (11,14,15,21). Vertucci Type I canal configuration was stated to be the most common configuration (11,12,14,15,20). As a result of this study, the ratios of number of roots, canals, and canal configuration in maxillary second premolars were found to be similar to the studies in the literature.

In mandibular first premolars, 89.9% one root, 9.7% two roots, 76.9% one canal, and 22.7% two canals were detected. Type I canal structure was observed the most with a rate of 76.9%. In the literature, one root has been found between 91.4% and 99.8% and two roots between 0.2% and 8.6% in mandibular first premolars (11,16,18,22,23). One canal ranging from 69.7% to 93.5%, two-canal ratios between 6.4% and 29.4%, and Type I canal structure ranging from 21.9% to 94.2% have been reported (5,11,12,16,18,22,23). According to the results of this study, the ratio of two roots was found to be higher than the studies in the literature.

In mandibular second premolars, 98.4% one root, 95.9% one canal, and 95.9% Type I canal structure were observed. In the literature, one root between 98.6% and 99.8%, one canal between 69.7% and 98.5%, and Type I canal structures ranging from 71% to 98.9% have been reported in mandibular second premolars (11,12,16,18,22,23). As a result of this study, the ratios of number of roots, canals, and canal configuration in mandibular second premolars were found to be similar to the studies in the literature.

According to the results of this study, the number of roots in all premolars except the mandibular second premolars showed a statistically significant difference by gender. The number of teeth with one root was higher in females and the number of teeth with two and three roots was higher in males. When the literature was examined, it was found that similar results have been reported by Evlice et al. in the maxillary first and second premolars, and by Bulut et al. in the maxillary first premolars (11,21). In addition, similar to the results of this study, Burklein et al. have reported in their study with the German population that males showed higher number of roots than females in all premolars except the mandibular second premolar (16). Martins et al., in their study with the Portuguese population, have stated that the ratio of one root in the maxillary first premolars was higher in females while the ratio of two roots was higher in males (23). Unlike the results of this study, it has been reported that the number of roots did not differ by gender in the maxillary second and mandibular first premolars by Bulut et al. and Martins et al., in the mandibular first premolars by Akyol et al., and in the maxillary first and second premolars by Abella et al. (11,15,22).

According to the results of this study, a significant effect of gender on the number of root canals was found in the maxillary second and mandibular first premolars. In the maxillary second premolars, the ratio of one canal was found to be higher in females, and the ratio of two canals in males; in mandibular first premolars, the ratio of three canals were found to be higher in males. There are different results in the literature regarding the effect of gender on the number of root canals in maxillary and mandibular premolars. In many studies conducted with different populations, it has been revealed that the ratio of one canal was higher in females, while the ratio of two and three canals was higher in males (12,16,21,23). In some studies, it has been reported that there is no difference in the number of root canals by gender (11,22). This difference in results may be due to ethnic differences and differences in sample size.

As a result of this study, it was found that gender had a significant effect on root canal configuration in maxillary second and mandibular first premolars. In maxillary second premolars, the ratio of Type I canal configuration was detected to be higher in females, Type II and Type IV ratios in males, Type IV and Type VIII canal configurations in mandibular first premolars were found to be higher in males, and Type V ratio was detected to be higher in females. Ok et al. and Martins et al., similar to the results of this study, have found that the root canal configuration was different by gender in the mandibular and maxillary premolars (12,23).

As a result of this study, no statistically significant effect of the tooth position (right, left) on the number of roots, canals, and canal configuration in maxillary and mandibular premolars was observed. No difference in the root number of root canals by the tooth position has been reported by Bulut et al., Burklein et al. in mandibular and maxillary premolars, by Abella et al., Li et al., Tian et al. in maxillary premolars, and by Akyol et al. in mandibular premolars (11,15–17,22,24). Ok et al., have reported that there were differences in the number of root canals in mandibular first premolars and root canal configuration in maxillary first premolars by position (12).

In the literature, there is no consensus as a result of studies evaluating the effect of gender and tooth position on root canal anatomy. Therefore, considering that geographical and ethnic origins will cause different configurations in root canal anatomy, we think that CBCT should be performed for successful endodontic treatment before the procedure in the presence of complex anatomies.

Limitations: The limitations of this study can be counted as the single-centre study and the sample size. Further studies with multicentre and larger sample sizes are needed.

Unusual root canal morphologies and extra canals should be awaited before starting root canal treatment in both maxillary and mandibular premolars. In maxillary first premolars, maxillary second premolars, and mandibular first premolars, teeth with extra root canals are more common in males. CBCT imaging provides comprehensive information about the root canal morphology of the maxillary and mandibular premolars. These data can help clinicians in diagnosis and root canal treatment.

Ethical Approval: Approval for this study was obtained from the Non-Invasive Ethics Committee of Van Yüzüncü Yıl University (2021/11-10).

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