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ORIGINAL ARTICLE

Evaluation of the root canal number and morphology of maxillary premolars using Cone Beam Computed Tomography in an Iranian subpopulation

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Abstract

Background: There is considerable diversity in the number and shape of canals in each root, the number of roots, and the occurrence of root fusion in permanent maxillary premolars. This study aimed to investigate the morphology of the root and root canal of the first and second maxillary premolars using Cone Beam Computed Tomography.

Materials and Methods: This descriptive-analytical study included 109 CBCT samples from patients referred to the radiology department at the Faculty of Dentistry, Islamic Azad University of Isfahan. The number of roots, the number of canals, and canal structure were identified and evaluated using Vertucci's classification. Data were analyzed using Chi-square and Fisher's exact tests (α=0.05).

Results: In the first maxillary premolar, 71.6% of the teeth had two roots, while in the second premolar, 89.2% of the teeth had one root. Most teeth had two canals in the first maxillary premolar (98.6%) and a single canal in the second maxillary premolar (67.7%). Type IV was the most common canal structure in the first maxillary premolars, while type I was the most prevalent type in the second maxillary premolars. The greatest root curvature in both the first and second premolars was straight in the mesiodistal and buccolingual directions. There was a significant difference in the mesiodistal direction in the first premolar (P=0.038) and the second premolar (P=0.001), as well as in the number of canals (P=0.001) and canal type (P=0.01) in the second premolar regarding gender, while no differences were observed in other cases between males and females.

Conclusion: The number of roots and canals, and the type of canal, differed between the first and second premolars; however, in the mesiodistal and buccolingual directions, the first and second premolars were similar. There was no significant difference in the number of roots or buccolingual direction between the first and second premolars, nor in the number of canals or canal type of the first premolar by gender. In contrast, significant differences were observed in the mesiodistal direction of the first and second premolars and in the number of canals and canal type of the second premolar.

Keywords: Root Canal Anatomy; Cone-Beam Computed Tomography; Endodontics

Introduction

In modern dentistry, endodontic treatment is an effective and important method for preserving and maintaining teeth. A thorough understanding of tooth anatomy and root canal morphology is a prerequisite for the success of root canal treatment (1). The dentist's awareness of tooth anatomy and canals during access cavity preparation minimizes the risk of missing additional canals during treatment. Therefore, before proceeding with root canal treatment, the dentist needs to acquire sufficient knowledge about the morphology of the tooth (2).

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Additionally, treating multi-rooted teeth with periodontal disease at root bifurcations presents specific challenges (3). The apical positioning of the bifurcation area, the narrow entrance to the bifurcation site, the concavities existing on the root surface, and the lack of awareness of root surface morphology complicate scaling and microbial plaque control. Furthermore, the convexities and concavities on root surfaces create conditions for plaque accumulation and root surface decay, which subsequently lead to the development of advanced periodontal diseases (4). Given the importance of removing pathogenic factors from the root surfaces of multi-rooted teeth and the bifurcation area, a thorough understanding of their root morphology is essential (5).

For permanent maxillary premolars, there is considerable diversity in the number and shape of canals in each root, the number of roots, and the occurrence of root fusion, which are influenced by age, gender, and ethnicity.

Racial differences in root canal anatomy lead to variations in root canal anatomy, and evaluating root canal anatomy across different races and ethnic groups enhances awareness and increases the success of treatments (6). Therefore, determining the status of root canal anatomy is essential. One of the main reasons for the failure of endodontic treatments is the inability to identify and treat all root canals, which arises from the clinician's lack of awareness of the tooth's internal and external anatomy and the complexity and high variability of the root canal system (7).

Various methods, such as radiography, staining, and others, have been used to examine the root canal system. With advancements in technology and the use of methods such as CT and micro-CT scans, human understanding of the complexities and three-dimensional relationships of the root canal has increased (8).

CBCT is one of the radiographic methods used to examine the anatomy and morphology of the root canal (9), which reduces the limitations of two-dimensional radiography and, due to lower radiation exposure compared to CT and the ability to limit the scanning volume, decreases the radiation dose received by the patient while enhancing the image quality (10, 11). CBCT, by providing valuable information on tooth position and root canal morphology, can assist dentists in non-surgical root canal treatments. High resolution, significant reduction in patient radiation dose, quick operation, and low cost are the main advantages of CBCT (12).

In a study by Watanabe et al. (13), maxillary premolars in a Japanese population exhibited significant anatomical variation. The study by Tafakhori and Rafie (14) demonstrated that the Iranian population has complex root canal morphology in the first maxillary premolar, with types II and IV being more common according to Vertucci's classification. Therefore, the clinician should be very cautious before performing root treatments on the first maxillary premolars. In the study by Asheghi et al. (15), the complexity of the root canal system and the number of roots were found to be less in women than in men.

The most important factor in endodontic treatments is the chemical and mechanical preparation of the canal system. While the primary goal of chemical-mechanical preparation is to remove bacteria, their byproducts, and degenerated tissues using endodontic instruments and irrigants, some canals in the root of the tooth may not be easily found and remain untreated. Lack of awareness of root canal anatomy and insufficient negotiation for additional canals are two significant causes of this issue. However, if the additional canals of a tooth are found, adequately prepared, and filled, the prognosis of the treatment will be very favorable. The best method to achieve this is to create a proper access cavity and to be aware of the

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root canal anatomy and morphology (1). This study aimed to investigate the morphology of the roots and root canals of the first and second maxillary premolars using CBCT.

Materials and Methods

In this descriptive-analytical cross-sectional study (Ethics Code: IR.IAU.KHUISF.REC.1399.22), CBCT samples were randomly selected from 109 patients (49 men and 60 women) aged 18 to 67 years, referred to the radiology department of the Isfahan Azad University Dental School.

The scans were examined using the Galileos device (Sirona, Germany) at high resolution, and the CBCT images were analyzed in the Sidexis 3D software. The CBCT images included axial, sagittal, and coronal sections (Figure 1).

Figure 1. a) Axial section assessing the number of roots and the number of canals in the first maxillary premolar. b) Coronal section evaluating the type of canal and the direction of the buccolingual roots of the first maxillary premolar.

The teeth in the CBCT samples used must show no evidence of attrition, resorption, previous root canal treatment, extensive restorations, or root canal treatment in adjacent teeth (due to reduced accuracy and interpretation in CBCT studies). Additionally, the CBCT images must have acceptable quality. A radiologist and an endodontist simultaneously examined the CBCT images, and the data were recorded in specific observation forms and questionnaires. In these images, the variables of the number of roots and their morphology, the number of canals in the roots, the type of root canals based on Vertucci's classification, the direction of the curvature of the first and second maxillary premolar roots in the buccolingual and mesiodistal dimensions, as well as related factors such as the age and gender of the patients, were assessed. The obtained data were analyzed using the Chi-square and Fisher's exact tests in SPSS software, version 22, with a significance level of 0.05.

Results

In the first maxillary premolar, 71.6% of the teeth had two roots, while in the second maxillary premolar, 89.2% had one root. Most teeth had two canals in the first maxillary premolar (98.6%) and a single canal in the second maxillary premolar (67.7%). Type IV was the most common canal structure in the first maxillary premolars, while type I was the most prevalent type in the second maxillary premolars (Table 1).

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Table 1. Frequency distribution of first and second premolar teeth based on the number of roots and root canals.

Variable	Category	First Premolar	Second Premolar
		n (%)	n (%)
Number of Roots	Single Root	40 (28.4)	116 (89.2)
	Double Roots	101 (71.6)	14 (10.8)
Number of Canals	One Canal	2 (1.4)	88 (67.7)
	Two Canals	139 (98.6)	98.6 (32.3)
Type of Canal	Type I	2 (1.4)	88 (67.7)
	Type II	15 (10.6)	12 (9.2)
	Type III	10 (7.1)	7 (5.4)
	Type IV	105 (74.5)	17 (13.1)
	Type V	2 (1.4)	3 (2.3)
	Type VI	7 (5.0)	3 (2.3)

In examining the frequency distribution of the first premolar teeth based on the morphological status of the teeth in the mesiodistal and buccolingual directions, the greatest curvature of the roots in both the first and second premolars was straight in the mesiodistal and buccolingual directions (Tables 2 and 3).

Table 2. Frequency distribution of first and second premolar teeth based on dental morphology status - mesiodistal direction.

Variable	Category	First Premolar	Second Premolar
		n (%)	n (%)
Mesiodistal Direction	Distal	39 (27.7)	48 (36.9)
	Mesial	14 (9.9)	13 (10.0)
	Straight	88 (62.4)	69 (53.1)

Table 3. Frequency distribution of first and second premolar teeth based on dental morphology status - buccolingual direction.

Root Count		Category	First Premolar	Second Premolar
			n (%)	n (%)
Single Root	Buccolingual Direction	Lingual	8 (20.0)	19 (16.4)
		Buccal	8 (20.0)	28 (24.1)
		Straight	24 (60.0)	69 (50.5)
Double Roots	Buccolingual Direction (Buccal Root)	Lingual	22 (21.8)	2 (14.3)
		Buccal	4 (4.0)	0 (0)
		Straight	75 (74.3)	12 (85.5)
	Buccolingual Direction (Lingual Root)	Lingual	2 (2.0)	0 (0)
		Buccal	18 (17.8)	3 (21.4)

Based on the results of Fisher's exact test, there was no significant difference in the number of roots of the first premolar teeth ($p = 0.264$) and the second premolar teeth ($p = 0.152$) between women and men. According to the results of Fisher's exact test, there was no significant difference in the number of canals in the first premolar teeth between women and men ($p = 1.00$), while in the second premolar teeth, the number of single canal teeth in women was significantly higher than in men ($p = 0.004$). According to the results of the chi-square test, the type of canal in the first premolar teeth of women did not significantly

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differ from that of men (p = 0.862). However, a significant difference was observed in the types of canals in the second premolar teeth between women and men, with Type I canals more prevalent in women and Types II, III, and IV canals more prevalent in men (p = 0.010) (Table 4).

Table 4. Comparison of first and second premolar teeth based on the number of roots and root canals by gender.

Variable	Category	First premolar		P value	Second premolar		P value
		Male	Female		Male	Female	
		n (%)	n (%)		n (%)	n (%)	
Number of Roots	Single Root	15 (23.4)	25(32.5)		42(84.0)	74(92.5)	
	Double Roots	49(76.6)	52(67.5)	0.264	8(16.0)	6(7.5)	0.152
Number of Canals	One Canal	1(16)	1(1.3)		26(52.0)	62(77.5)	
	One Canal	63(98.4)	76(98.7)	1.00	24(48.0)	18(22.5)	0.004
Canal Type	Type I	1(1.6)	1(1.3)		26(52.0)	62(77.5)	
	Type II	7(10.9)	8(10.4)		7(14.0)	5(6.3)	
	Type III	3(4.7)	7(9.1)		2(4.0)	5(6.3)	
	Type IV	50(78.1)	55(71.4)	0.862	10(20.0)	7(8.8)	0.010
	Type V	1(1.6)	1(1.3)		2(4.0)	1(1.3)	
	Type VI	2(3.1)	5(6.5)		3(6.0)	0(0)	

Based on the results of the Chi-square test, in the mesiodistal direction (Tables 2 & 3), the first premolar teeth (p = 0.038) and the second premolar teeth (p = 0.001) were significantly different between women and men. In the buccolingual direction, no significant difference was observed between women and men for the first premolars (p = 0.038) or the second premolars (p = 0.216).

Based on the results of the Chi-square test (Table 4), no significant difference was observed between women and men in the buccolingual direction for the first and second premolar teeth.

According to the results of the Chi-square test regarding the impact of age on the first and second premolar teeth, a significant difference was found between the age groups, except for the type of canal in the first premolar teeth (p = 0.007), where no significant difference was observed in the other variables (Table 5,6).

Table 5. Comparison of first premolars based on the number of roots and root canals according to age group

Variable	Category	Under 20 years	**20–40 years**	Over 40 years	P value
		n (%)	n (%)	n (%)	
Number of Roots	Single Root	7(25.9)	23(31.9)	10(23.8)	0.620
	Double Roots	20(74.1)	49(68.1)	32(76.2)	
Number of Canals	One Canal	1(3.7)	1(1.4)	0(0)	0.435
	One Canal	26(96.3)	71(98.6)	42(100.0)	
Canal Type	Type I	1(3.7)	1(1.4)	0(0)	0.007
	Type II	0(0)	10(13.9)	5(11.9)	
	Type III	6(22.2)	3(4.2)	1(2.4)	
	Type IV	20(74.1)	52(72.2)	33(78.6)	
	Type V	0(0)	0(0)	2(4.8)	
	Type VI	0(0)	6(8.3)	1(2.4)	

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Table 6. Comparison of second premolars based on the number of roots and root canals according to age group

Variable	Category	Under 20 years	20–40 years	Over 40 years	P value
		n (%)	n (%)	n (%)	
Number of Roots	Single Root	23(85.2)	61(88.4)	32(94.1)	0.518
	Double Roots	4(14.8)	8(11.6)	2(5.9)	
Number of Canals	One Canal	22(81.5)	44(63.8)	22(64.7)	0.255
	One Canal	5(18.5)	25(36.2)	12(35.3)	
Canal Type	Type I	22(81.5)	44(63.8)	22(64.7)	0.147
	Type II	0(0)	9(13.0)	3(8.8)	
	Type III	0(0)	5(7.2)	2(5.9)	
	Type IV	3(11.1)	10(14.5)	4(11.8)	
	Type V	2(7.4)	0(0)	1(2.9)	
	Type VI	0(0)	1(1.4)	2(5.9)	

Discussion

Based on the results of the present study, most teeth had two roots in the first maxillary premolar (71.6%) and one root in the second maxillary premolar (89.2%). Most teeth had two canals in the first maxillary premolar (98.6%) and a single canal in the second maxillary premolar (67.7%). Type IV was the most common canal structure in the first maxillary premolars, while type I was the most prevalent type in the second maxillary premolars. The greatest curvature of the roots in both the first and second premolars was straight in the mesiodistal and buccolingual directions.

In the study by Kfir et al. (16), the Type IV Vertucci configuration was more common among all teeth. In the present study, the most common canal type was Type IV, while the least common were Types I and V, which aligns with the current findings. In the study by Maghfuri et al. (17), an evaluation of root canal morphology in maxillary first premolars using CBCT showed that most teeth had two roots, followed by one root. 97% had two canals, 3% had three canals, and no teeth had a single canal. The Type IV canal configuration was the most common, followed by Type V. In the study by Nazeer et al. (18), of 114 first premolars, 68.6% were two-rooted, and 31.5% were single-rooted, findings consistent with those of the present study. In the study by Nazeer et al. (18), the most common canal morphology reported for first maxillary premolars was 68% Type I and 12.9% Type II. However, in the current research, the most common canal type was Type IV, with Types I and V being the least common. The most common canal morphology reported for the second premolar was 53.3% Type I and 12.9% Type II. In the present study, the most common canal type was Type I, while Types V and VI were the least common, which matched Nazeer's findings. No gender differences were found in the root canal morphology of maxillary premolars, consistent with the current study's results. However, in the second premolar, teeth with Type I canals were more prevalent in women than in men, while teeth with Type II, III, and IV canals were more common in men than in women.

Alfawaz et al. (19), in their investigation of the root canal morphology of maxillary premolars in the Saudi population using CBCT, found that most first maxillary premolars had a single root, whereas second maxillary premolars had two roots. However, in the present study, the highest number of roots in the first premolar was two, and in the second premolar, the highest number was one. Type IV was the most

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common canal structure in the first maxillary premolars, while type I was more prevalent in the second maxillary premolars, which aligns with the current study's results. In Alfawaz's research, no significant relationship was found between gender and the number of roots and canal configuration in the first and second maxillary premolars. However, in the present study, the findings for the first premolar were similar to those of Alfawaz. In contrast, for the second premolar, there were differences in both the number of roots and the canal type and number of canals.

Racial differences in the morphology of the roots and root canals of first maxillary premolars can be significant. In the study by Martin et al. (20), a significant difference in the prevalence of single-rooted premolar morphologies was observed, with 83.2% in the Chinese population and 48.7% in the Portuguese population. In the study by Tafakhori and Rafie (14), it was shown that the Iranian population has a complex root canal morphology in the first maxillary premolar, with Types II and IV being the most prevalent according to the Vertucci classification.

In the study by Saber et al. (21), an evaluation of the root and canal morphology of maxillary premolars in an Egyptian population using CBCT revealed that more than half of the first maxillary premolars had two roots. In contrast, the majority of the second maxillary premolars were single-rooted. According to the Vertucci classification, Type IV canal structure was the most common in both the first and second maxillary premolars.

Gender differences can also affect the composition of the root canal system. Women had a higher prevalence of single-root canals in the first maxillary premolars compared to men (13). In the study by Asheghi et al. (15), the complexity of the root canal system and the number of roots were lower in women than in men. In the study by Martin et al. (20), the prevalence of single-root canals was higher in women than in men, particularly in the first maxillary premolars. Additionally, in the study by Watanabe et al. (13), 64.7% of the first premolars showed single-root morphology, with a higher prevalence in women (71.0%).

In the study by Tofangchiha et al. (22), which examined the root and canal morphology of the first maxillary premolar using CBCT images, 57.8% had 1 root, 41.4% had 2 roots, and 0.9% had 3 roots. However, in the present study, the highest number was found to have two roots in the first premolar. Regarding canal types, 19.4% were type I, 11.9% were Type III, 1.5% were Type IV, 7.5% were Type V, and 3% were Type VI. In contrast, in the present study, the most common canal type was Type IV, while the least common types were Type I and V, which do not align with the findings of Tofangchiha et al. (22).

Conclusion

The number of roots and canals, as well as the canal type, differed between the first and second premolars, but the mesiodistal and buccolingual orientations of both premolars were similar. There was no significant difference in the number of roots or buccolingual orientation between the first and second premolars, nor in the number of canals or canal type of the first premolar between genders. However, there were differences in the mesiodistal orientation of the first and second premolars, as well as in the number of canals and canal type of the second premolar. Except for the canal type of the first premolar, there was no significant difference between age groups in the first and second premolars.

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