Original Article

Frequency of root canal configurations of maxillary premolars as assessed by cone-beam computerized tomography scans in the Pakistani subpopulation

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Abstract

Introduction: The understanding of canal morphology helps the clinician to conduct endodontic procedures effectively. The aim of the study was to assess the morphological variations in canals of maxillary premolars, and categorize them in accordance with Vertucci's classification.

Materials and Methods: Cone-beam computerized tomography (CBCT) images were taken from the archives of Islamabad Diagnostic Center. Investigations were carried out by employing CBCT images of 120 individuals. The images of maxillary first (n = 203) and second premolars (n = 205) were analyzed in the axial, sagittal, and coronal planes. The number of canals, roots, and categorization as per the Vertucci's classification was recorded. Data were statistically analyzed by using SPSS 23.

Results: The 88.7% maxillary first premolars were found to have two roots and 78% of second premolars were single rooted. The most common Vertucci configuration among first premolars was Type IV (55.3%) and second premolars were Type I (66.8%). The gender-wise difference in the frequency of one- and two-rooted second maxillary premolars was statistically significant (P = 0.01). The gender-wise difference in the frequency of different Vertucci subclassifications for the second maxillary premolars teeth was statistically significant (P = 0.01).

Conclusion: The maxillary premolars showed configuration variations in the Pakistani subpopulation.

Keywords: Cone-beam computerized tomography, maxillary first premolar, maxillary second premolar, root canal morphology, Vertucci classification

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INTRODUCTION

The endodontic treatment procedure is executed to conserve the teeth and preserve/restore the health of periradicular region.[1] A detailed history, in-depth examination, and prudent use of diagnostic aids are essential for the correct diagnosis of the chief complaint of

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the patient. In addition, extensive knowledge and accurate interpretation of the canal morphology along with the adequate procedural skills of the clinician at every step are pivotal for endodontic treatment's success and to minimize the postoperative complications.[2,3]

During the previous century, documentation of external and internal morphological variances of roots revealed a complicated pattern. Considering this, the variability of the root count and morphological complexity of canals can mask the microbial flora that is well protected within the confines of canals.[3] Variations of the root canal system (RCS) if undetected lead to missed canals, substandard shaping, cleaning, and filling of RCS resulting in treatment failure.[4]

Zaatar *et al*. noted that the maxillary premolar teeth commonly require root canal treatment among the maxillary dentition, second to only the maxillary first molar teeth.[5] Therefore, the understanding of the maxillary premolars' morphological variations is of significant importance to avoid unexpected complications in clinics.[3]

The root canal classification system put forward by Vertucci *et al*. is beneficial for categorizing different canal variations.[6] The maxillary premolars have the distinction of being the only teeth to demonstrate all eight variations of Vertucci's classification system.[7] Various imaging methods reveal huge unreported complex tooth anatomy of maxillary premolars.[8] As the diagnostic methods have become more advanced, further subgroup classification of root canal has been proposed based on Vertucci's classification to provide practical and precise solution which will further facilitate clinical practice, research, and training.[8] The root numbers for maxillary premolars range from one to three, which may appear separate or fused. On the other hand, the studies have reported numerous variations of root canal configuration.[4,6,9] A review by Ahmed and Alenezi concluded that the maxillary first premolar teeth commonly have 1 (41.7%) or 2 roots (56.6%). Likewise, the majority of first premolars (86.6%) have two canals with 64.8% teeth with Vertucci's Type IV configuration.[4] Alternatively, about 75% of second maxillary premolars showed one canal at the apex and 24% of teeth had two canals at the apex.[6] The characteristics of RCS of maxillary premolars also vary with relation to gender, race, and geographic origin which have been documented in previous studies.[9-11]

The canal morphology has been investigated by various *in vitro* and *in vivo* methods. The *in vitro* methods include tooth clearing and staining technique, sectioning methods, and micro-computed tomography (micro-CT).[12,13]

The *in vivo* techniques comprise of conventional periapical and panoramic radiography, digital radiography, contrast media enhanced radiography, and cone-beam computed tomography (CBCT).[14-16] Being a two-dimensional image, the drawbacks of conventional periapical radiography include image distortion and superimposition of roots, canals, and neighboring structures which limit the evaluation of canal morphology.[16,17]

CBCT – A noninvasive, reliable diagnostic tool, which provides superior quality images, has been widely used for the three-dimensional evaluation of tooth morphology. The CBCT studies (clinical and experimental) have been conducted to investigate the RCS in different teeth types.[18] Neelakantan *et al*. suggested that CBCT can accurately identify morphological variation of RCS like *in vitro* clearing–staining technique.[16] micro-CT, as a diagnostic tool, has provided valuable in-depth information on RCS including accessory canals and isthmus that can be very useful for the training of researchers and clinicians. However, in comparison to CBCT, micro-CT is time consuming and expensive. Considering this, micro-CT presently is not a suitable tool for clinical studies.[19] Conversely, the CBCT scanner provides images which are simultaneously displayed in sagittal, axial, and coronal planes. By avoiding the overlapping of structures, CBCT image provides magnified view of the target object. Consequently, it has been recommended as an auxiliary imaging tool for the accurate evaluation of complicated RCS.[16,18]

Extensive CBCT-based literature exists on the morphological variation of maxillary premolars worldwide.[9,11,16,18,20] However, in Pakistan, data are limited in this regard. To date, only one CBCT study has been conducted on maxillary premolars of the southern Pakistani subpopulation.[21] Therefore, the study aimed to assess the morphological variations in canals of maxillary premolars using CBCT in the Central Pakistani subpopulation.

MATERIALS AND METHODS

The current retrospective clinical study was carried out at the College of Dentistry, Riphah International University, Islamabad, Pakistan, on the CBCT images of patients that were taken from February 2015 to February 2017 and were acquired from the archives of large diagnostic facility, Islamabad Diagnostic Center. Ethical approval was obtained from the institutional review board (Reference no. IIDC/IRC/2017/004/002). Maxillary first and second premolar teeth with closed apices were included in the study, whereas the teeth with root resorption, sclerosed

canals, endodontic treatment, open apices, endopost/crown, and periapical periodontitis were excluded. The sample size calculation was done using Raosoft sample size calculator.[22] Estimating a confidence level of 95%, margin of error of 5%, and anticipated population proportion of 85%,[23] a sample size of 195 teeth was calculated. For the purpose of this study, a sample of 203 maxillary first premolars and 205 maxillary second premolars were used. CBCT images were analyzed with the in-built software named PLANMECA ROMEXIS Version 4.6.0.R viewer with the resolution setting of 1366 × 768 pixels in a dark room on a Dell inspiron laptop having 15.6" LCD screen. The brightness/contrast of CBCT images was adjusted by utilizing the image processing tool for optimal visualization. Before starting the analysis, the calibration process was carried out among the two assessors to increase the intra-evaluator reliability and minimize the inter-evaluator bias. Inter-evaluator reliability was ascertained by analyzing the 15 maxillary first and second premolars and categorizing them according to Vertucci's classification. Intra-evaluator reliability was assessed by the reevaluation of the same teeth sample after a week. The kappa test was used to find out the inter- and intra-evaluator reliability. In case of differences of interpretation among the two evaluators, the CBCT image was analyzed by the consultant radiologist. In addition, the teeth were also assessed for number of canals and roots.

The data were analyzed using SPSS version 23 (IBM Corp, Armonk, NY, USA). The percentages and frequencies were described for the number of roots, canals, and Vertucci's classification configuration types. A gender-wise analysis for both maxillary and second premolars was carried out. To compare the frequency distribution of the canals, roots, orifices, foramina, and Vertucci classification configuration types as per gender, and tooth type, Chi-square test was applied. An arbitrary value of <0.05 was considered to be significant.

RESULTS

The number of CBCT scans evaluated for male (n = 59) and female (n = 61) patients was almost equal. The first maxillary premolar had single root in 11.3% and two roots in 88.7% of teeth. Conversely, the second maxillary premolar had single root in 78% and two roots in 22% of teeth. The gender-wise difference in the frequency of one- and two-rooted second maxillary premolars was statistically significant (P = 0.01).

The Vertucci's classification for RCS is documented in Table 1. The most common canal configuration was Type IV (55.2%) for first maxillary premolar and Type I (66.8%) for second maxillary premolar [Figures 1 and 2]. On the other hand, the least common canal configuration was Type VII (0.5%) for first maxillary premolar and Type VI (0.5%) for second maxillary premolar. The gender-wise difference in the frequency of different Vertucci subclassifications for the second maxillary premolar teeth was statistically significant (P = 0.01) [Table 2].

Table 1: Distribution of the number of roots in maxillary premolars according to gender

Tooth type and number of roots	Number of roots			
	Male, *n* (%)	Female, *n* (%)	Total, *n* (%)	*P*
First premolar				
One	10 (10.1)	13 (12.5)	23 (11.3)	0.59
Two	89 (89.9)	91 (87.5)	180 (88.7)	
Total	99	104	203	
Second premolar				
One	71 (67)	89 (89.9)	160 (78)	0.01*
Two	35 (33)	10 (10.1)	45 (22)	
Total	106	99	205	

*Statistically significant $P<0.05$

The quadrant-wise difference in the frequency of different Vertucci subclassifications for the first and second maxillary premolar teeth was statistically insignificant ($P > 0.05$) [Table 3]. The kappa test showed inter-rater reliability to be in average 87.6%. The intra-examiner reliability was 89%.

DISCUSSION

The favorable outcome of the nonsurgical root canal therapy is dependent on the proper localization, disinfection, debridement, and shaping of the canal, and filling it with adequate obturating material.[24] Accordingly, it is important for dental clinicians to have an adequate understanding of the inter-racial and intra-racial morphological variations of root canals.[10]

The introduction of CBCT in dentistry has led to revolutionary changes regarding the diagnosis of oral conditions. In contrast to *in vitro* methods, the use of CBCT in *in vivo* studies of tooth anatomy offers a much more efficient, swifter, non-invasive, and accurate method.[25] The CBCT has been utilized to assess the RCS of different teeth of the human dentition in different studies. Wide variations in root morphological features, based on race and ethnicity, have been reported in literature. The present CBCT-based study adds to the literature by reporting the root canal morphological features of the first and second maxillary premolar of a cohort of the Pakistani subpopulation.

In the present research, two roots were frequently noted in first premolars (88.7%). Nazeer *et al.* reported a lower

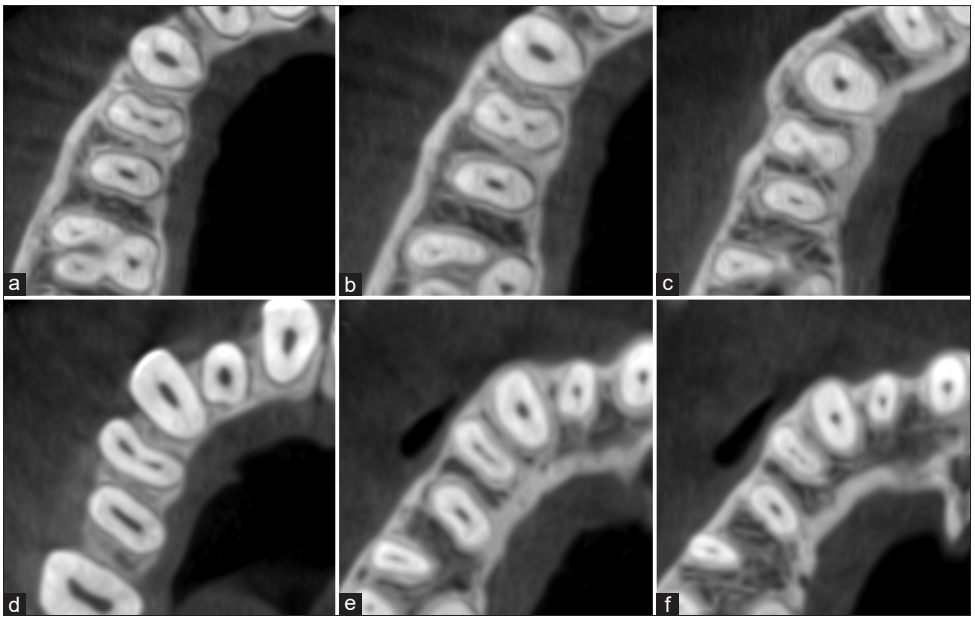

Figure 1: Cone-beam computerized tomography axial cross-sections showing different Vertucci configurations: Type IV in first premolar and Type I in second premolar (a) coronal third (b) middle third (c) apical third, Type VI in first premolar and Type I in second premolar (d) coronal third (e) middle third (f) apical third

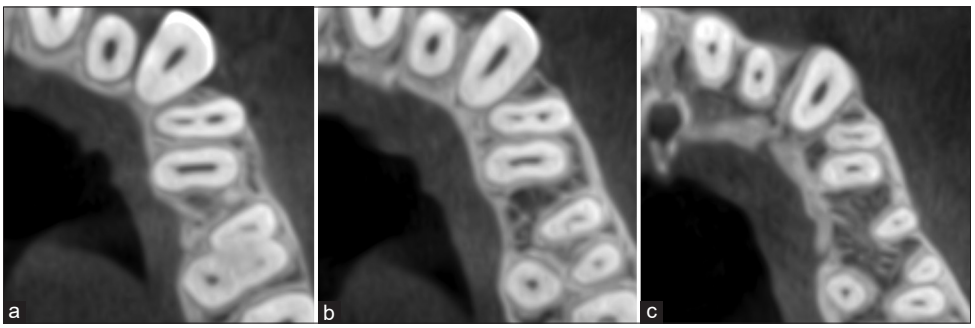

Figure 2: Cone-beam computerized tomography Axial Cross sections showing different Vertucci configurations: Type II in first premolar and Type I in second premolar (a) coronal third (b) middle third (c) apical third

Table 2: Gender-wise assessment of configuration of root canal morphology of maxillary premolars according to Vertucci's classification

Tooth type and gender	Type I (1-1), *n* (%)	Type II (2-1), *n* (%)	Type III (1-2-1), *n* (%)	Type IV (2-2), *n* (%)	Type V (1-2), *n* (%)	Type VI (2-1-2), *n* (%)	Type VII (1-2-1-2), *n* (%)	Type VIII (3-3), *n* (%)	Total	*P*
First premolar										
Male	8 (8.1)	16 (16.2)	2 (2)	55 (55.6)	18 (18.2)	0	0	0	99	0.67
Female	8 (7.7)	13 (12.5)	1 (1)	57 (54.8)	21 (20.2)	3 (2.9)	1 (1.0)	0	104	
Total	16 (7.9)	29 (14.3)	3 (1.5)	112 (55.2)	39 (19.2)	3 (1.5)	1 (0.5)	0	203	
Second premolar										
Male	57 (53.8)	2 (1.9)	15 (14.2)	10 (9.4)	19 (7.9)	1 (0.9)	2 (1.9)	0	106	0.01*
Female	80 (80.8)	4 (4.0)	13 (13.1)	1 (1)	1 (1)	0	0	0	99	
Total	137 (66.8)	6 (2.9)	28 (13.7)	11 (5.4)	20 (9.8)	1 (0.5)	2 (1.0)	0	205	

*Statistically significant $P<0.05$

percentage of first premolars with two roots (68.5%) in the study on subpopulation from South Pakistan. Likewise, previous studies have reported lower percentage of two-rooted maxillary premolars (range: 37.8%–75.1%) as compared to the current study.[20,21,23,26-29] The gender-wise difference in the frequency of one- and two-rooted first maxillary premolars was found to be statistically insignificant in the present study. The finding is similar to the study of Alqedairi *et al.* on the Saudi Population.[23] Conversely, Asheghi *et al.* found a statistically significant difference where single-rooted first premolar was dominant in females and two rooted was dominant in males.[27] The current study like the previous study on the Pakistani subpopulation has not reported three-rooted

Table 3: Quadrant-wise assessment of configuration of root canal morphology of maxillary premolars according to Vertucci's classification

Tooth type and quadrant	Type I (1-1), *n* (%)	Type II (2-1), *n* (%)	Type III (1-2-1), *n* (%)	Type IV (2-2), *n* (%)	Type V (1-2), *n* (%)	Type VI (2-1-2), *n* (%)	Type VII (1-2-1-2), *n* (%)	Type VIII (3-3), *n* (%)	Total	*P*
First premolar										
Right	8 (7.6)	12 (11.5)	2 (1.9)	59 (56.7)	22 (21.1)	1 (0.9)	0	0	104	0.76
Left	8 (8.1)	17 (17.2)	1 (1.0)	53 (53.5)	17 (17.2)	2 (2.0)	1 (1.0)	0	99	
Second premolar										
Right	70 (67.9)	4 (3.9)	13 (12.6)	5 (4.8)	8 (7.7)	1 (0.9)	2 (1.9)	0	103	0.57
Left	67 (65.7)	2 (1.9)	15 (14.7)	6 (5.9)	12 (11.8)	0	0	0	102	
Total number of teeth	153 (37.5)	35 (8.6)	31 (7.6)	133 (32.6)	59 (14.5)	4 (0.9)	3 (0.7)	0	408	

maxillary first premolar.[21] Alternatively, the studies on the other populations have reported three-rooted first premolars (range: 0.9%–2.6%).[20,23,26-29]

The current study that was conducted on the Central Pakistani subpopulation noted a high percentage of single root in second maxillary premolars (78%). The percentage was lower than the study by Nazeer *et al*. (84.3%) on the Pakistani subpopulation.[21] The relatively higher frequency of single-rooted second premolars reported by Nazeer *et al*. might be attributed to the subpopulation belonging different ethnic groups residing in Karachi, South Pakistan. Likewise, the number of previous studies on different populations has reported a higher percentage of second premolars with single root.[23,26-29] On the other hand, Bulut *et al*. (71.9%) and Elnour *et al*. (67%) have noted a lower percentage of single-rooted second premolars in Turkish and Saudi populations, respectively.[20,30] The present study noted a statistically significant gender-wise difference in the frequency of one- and two-rooted second maxillary premolars. The finding was in line with the outcome of the study by Asheghi *et al*.,[27] whereas Alqedairi *et al*. found statistically insignificant differences on the basis of gender.[23] The present study like the previous studies on Chinese and Pakistani subpopulations has not reported three-rooted maxillary second premolars.[29,21] Alternatively, several other studies have reported three-rooted second premolars (range: 0.4%–3%).[20,23,26-28,30]

All subtypes of Vertucci's classification except Type VIII were noted both in first and second maxillary premolars in the present study. Type IV (55.2%) was the most frequently found configuration in first premolars. This was followed by Type V (19.2%). The finding was in contrast with the previous study on the Pakistani subpopulation where Type IV was the least commonly found configuration in the first premolar teeth.[21] Conversely, the result of the current study was in accordance with the outcomes noted in several previous studies that documented Type IV as the most common subtype in first premolars of different populations (range: 51%–76.8%).[11,23,26,28,29,31,32] The relation between gender and tooth morphology was found to be insignificant in the current study. The results are in line with the findings of Nazeer *et al*.[21] Alternatively, Celikten *et al*. noted a statistically significant difference in the canal configuration of first premolar on the basis of gender.[28]

Type I configuration was most commonly noted in the maxillary second premolars (66.8%) in the current study. This was followed by Type III (13.7%). Accordingly, previous studies documented Type I as the most common canal configuration in second premolar teeth (range: 39.3%–63%).[21,23,26-28,33] On the other hand, Elnour *et al*.[30] and Shi *et al*.[29] documented Type IV/Type V (23% each) and Type II (40%) as the most common canal configuration in the second premolars of Saudi and Chinese subpopulations. The gender-wise difference in the frequency of different Vertucci subclassifications for the second maxillary premolar teeth was found to be statistically significant in the present study. The outcome is in contrast with previous studies where no relation between gender and tooth morphology.[21,28]

The relatively smaller sample size was the limitation of the present study. Moreover, all the CBCT images were obtained from a single center. By taking a larger sample and involving multiple diagnostic centers for a larger selection of CBCT images in future research can provide a better understanding of the morphological variations in the maxillary premolars of the Pakistani population.

CONCLUSION

The CBCT is an effective tool for assessing the canal configuration of maxillary premolars. The maxillary premolars showed configuration variations in the Pakistani subpopulation. The present study reported the majority of first premolars having two roots. The majority of second premolars were found to have single root.

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Conflicts of interest

There are no conflicts of interest.

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