Research Article

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Cone Beam Computed Tomography Analysis of the Root Canal Morphology of Maxillary First Premolar

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ABSTRACT

Introduction: Maxillary first premolar teeth have complex root canal system, which varies on ethnic background, gender, age and study design. For successful outcome complete understanding of root canal system is necessary.

Objective: To evaluate the external and internal anatomy of maxillary first premolar teeth in a sample of Nepali population using cone beam computed tomography (CBCT).

Materials and Method: This quantitative, analytical, cross-sectional observational study was conducted from 2020 November to 2023 March in department of Conservative Dentistry and Endodontics and Oral Medicine and Radiology in People's Dental College and Hospital after receiving institutional ethical approval. Cone beam computed tomography images of 261 maxillary first premolars with completely formed roots were used. The research was conducted taking a tooth as a unit. Convenience sampling technique was done. The number of roots, canals and canal configuration were recorded. The total tooth and root length was measured. Statistical analysis was done by using SPSS V22.

Result: Among the samples, 172 (65.9%), 88 (33.7%), and one (0.4%) had one, two and three roots respectively; and 17 (6.5%), 241 (92.3%) and three (1.1%) had one, two and three root canals respectively. The most frequent configuration was type IV, followed by type II, type I, and type VIII. The mean total length and root length were found to be 20.61±1.68 mm and 13±1.88 mm.

Conclusion: Single-rooted and type IV canal configuration is common finding. Moreover, single-rooted premolar has diverse canal configuration.

Keywords: Cone beam computed tomography; maxillary first premolar; root canal configuration; root canal morphology.

INTRODUCTION

Success of endodontic treatment lies on complete cleaning, shaping and three-dimensional (3D) filling of root canal system.[1] However, root canal system is complex and risk of missing anatomical structure is high, which may lead to treatment

Citation

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failure.[1,2] Maxillary first premolar teeth have been reported to have variable and complex root canal systems (Kartal et al. 1998).[3] Variations in root and root canal morphology may be attributed to a number of factors including ethnic background, gender, age and study design.[4]

Previously various methods have been used to determine root canal morphology including clinical evaluation during root canal treatment, clearing technique, sectioning of teeth, conventional radiographic technique, microcomputed tomography (μ-CT), etc. Cone beam computed tomography (CBCT) provides three-dimensional image, which allows accurate three-dimensional evaluation of root canal system.[2]

Reviewing of literature in PubMed/MEDLINE showed, no study had been conducted to evaluate root canal morphology of maxillary first premolar using CBCT in context of Nepal. So far only one study has been done in Nepal by Kafle et al. evaluating maxillary first premolar morphology.[5] Therefore, this study needs to be conducted for better understanding the root canal morphology of maxillary first premolar teeth in Nepali population.

MATERIALS AND METHOD

A quantitative, analytical, cross-sectional observational study was conducted in the department of Conservative Dentistry and Endodontics and Oral Medicine and Radiology, People's Dental College and Hospital (PDCH), Sorhakhutte over a period of 28 months from 2020 November to 2023 March after receiving ethical clearance from Institutional Review Committee, PDCH on 2020 November (Ref. 01. CH no. 07, 2077/2078).

Patients between the ages of 20-70 years requiring CBCT scans as a subsidiary examination prior to or during treatment procedures were taken. The CBCT image including at least one maxillary first premolar in scan with clear and complete view and completely formed roots in scan was selected. The CBCT images of maxillary first premolars with root resorption or calcification, root canal fillings, posts, or coronal restorations were excluded from the study. Convenience sampling technique was used to collect the sample. Informed consent was obtained from all the patients whose CBCT images were taken in this study. Research was conducted taking a tooth as a unit.

The sample size was calculated as 237 using the formula $n = [z^2p(100-p)]/d^2$, where z is 1.96 at 95% confidence interval, prevalence of canal configuration (p) based on the study of Gupta et al.[6] is 33.2% and tolerated margin of error (d) is 6%. However, considering 10% technical and measurement errors in study, the sample size was taken as 261.

The CBCT images were acquired using a CBCT scanner (Galileos, Sirona, Germany) with 11 cm X 10 cm field of view, operated at 85 kV and 6 mA, with an exposure time of 14.4 s. The voxel size of the images was 80 µm. All CBCT exposures were performed by an experienced oral radiologist according to the manufacturer's recommended protocol for adequate image quality. The as low as reasonable achievable principle was followed. The data captured were converted into the Digital Imaging and Communications in Medicine (DICOM) format for analysis. All of the constructions and measurements were performed on a 14-inch flat-panel display (DELL) with a resolution of 1920 × 1080 at 60 Hz, operated at 6-bits.

The images were viewed in a dark setting, free of outside distractions, using laptop. The CBCT images were adjusted and analysed using the Galileos Viewer software. The images were analysed in three different views; axial (horizontal/occlusal), sagittal (lateral) and coronal (frontal) view. When needed, the contrast and the magnifying tool was used to enhance the image quality. The images were examined concurrently by two endodontists. Both the observers examined the CBCT images of maxillary first premolar for the number of roots and root canals, the morphology of the root canal configuration according to the Vertucci classification and number of apical foramina. The

total tooth and root length was measured. The root forms were identified as single root, two root, and three root. The root and tooth length were measured from mid-bucco cementoenamel junction and tip of buccal cusp to the root apex respectively with the help of measuring tool in the software. In case of multiple rooted teeth, the measurement was taken up to the apex of the longest root. However, if there were disagreement between endodontists then two oral radiologists assisted in making the decision. The findings were recorded in proforma. Data collected were entered in Microsoft Office Excel. Analysis of the data was done using IBM SPSS for Windows, version 22.0 (IBM Corp., Armonk, N.Y., USA).

Descriptive analysis was done for the root form, root canals, canal configuration, tooth and root length. Number of roots, root canals and canal configuration were compared between gender. The P value was kept 0.05 for the level of significance.

RESULTS

Among 261 images of maxillary first premolar, 118 (45.2%) were of male and 143 (54.8%) were of female; 130 (49.8%) were of right side and 131 (50.2%) were of left side. Among the samples, 172 (65.9%), 88 (33.7%), and one (0.4%) had one, two, and three roots respectively; whereas 17 (6.5%), 241 (92.3%), and three (1.1%) had one, two, and three root canals respectively. The frequency distribution of number of roots and gender was significant (P <0.05, Table 1). The frequency distribution of number of root canals and gender did not differ (P >0.05, Table 1, 2).

Type I, type II, type IV, and type VIII root canal configuration were found in 17 (6.5%), 105 (40.2%), 136 (52.1%), and three (1.1%) samples respectively (Table 3). The frequency distribution of root canal configuration and gender did not

Table 1: Root form distribution according to gender and position, n (%).

		Number of roots			Total	P value
		One root	Two roots	Three roots		
Sex	Male	67 (56.7)	50 (42.3)	1 (0.8)	118 (45.2)	0.025 Chi-square test
	Female	105 (73.4)	38 (26.5)	-	143 (54.8)	
Position	Right (14)	82 (63)	47 (36.1)	1 (0.8)	130 (49.8)	
	Left (24)	90 (68.7)	41 (31.3)	-	131 (50.2)	
Total		172 (65.9)	88 (33.7)	1 (0.4)	261	

Table 2: Gender-wise distribution of root canals, n (%).

Gender	Number of root canals			P value
	One	Two	Three	
Male	9 (3.4)	106 (40.6)	3 (1.1)	0.134 (Fisher's Exact Test)
Female	8 (3)	135 (51.7)	-	
Total	17 (6.5)	241 (92.3)	3 (1.1)	

Table 3: Gender-wise distribution of canal configuration, n (%).

Gender	Root canal configuration				P value
	Type I	Type II	Type IV	Type VIII	
Male	9 (3.4)	39 (14.9)	67 (25.7)	3 (1.1)	0.052 (Chi-square test)
Female	8 (3)	66 (25.3)	69 (26.4)	-	
Total	17 (6.5)	105 (40.2)	136 (52.1)	3 (1.1)	

Table 4: Frequency distribution of premolar according to number of roots and root canal configuration, n (%).

Type	Single-rooted		Total	Two-rooted		Total	Three-rooted		Total
	Right	Left		Right	Left		Right	Left	
Type I	8 (3)	9 (3.4)	17 (9.9)	-	-	-	-	-	-
Type II	49 (18.8)	56 (21.4)	105 (61)	-	-	-	-	-	-
Type IV	25 (9.6)	25 (9.6)	50 (29)	46 (17.6)	40 (15.3)	86 (97.7)	-	-	-
Type VIII	-	-	-	1 (0.4)	1 (0.4)	2 (2.3)	1 (0.4)	-	1 (100)

Table 5: Side-wise distribution of root canals and canal configuration, n (%).

Position	Number of root canals			P value	Root canal configuration				P value
	One	Two	Three		Type I	Type II	Type IV	Type VIII	
Right (14)	7 (46.7)	108 (50.0)	2 (66.7)	1.00 (Fisher's exact test)	7 (46.7)	44 (46.8)	64 (52.5)	2 (66.7)	0.782 (Chi-square test)
Left (24)	8 (53.3)	108 (50.0)	1 (33.3)		8 (53.3)	50 (53.2)	58 (47.5)	1 (33.3)	
Total	15	216	3		15	94	122	3	

Table 6: Total and root length.

	Mean ± Std. Deviation	Minimum	Maximum
Root length	13.00 ± 1.88	7	18
Total length	20.61 ± 1.68	16.2	25.8

differ (P >0.05). Single-rooted first premolars had more variable canal configuration than two-rooted premolars. Single-rooted premolars had 105 (61%) Type II canal configuration followed by Types IV 50 (29%), and type I 17 (9.9%). The two-rooted teeth had 86 (97.7%) type IV and two (2.3%) type VIII canal configuration (Table 4).

Out of 261 samples, 234 samples from 117 scans had bilateral maxillary first premolar in the same scan. The frequency distribution of the number of root canals and root canal configuration did not differ by side (P >0.05, Table 5).

The mean root length and total length were found to be 13 ± 1.88 mm and 20.61 ± 1.68 mm respectively (Table 6).

DISCUSSION

Maxillary first premolars have variations in number of roots, root form, root length and root canal configuration, which varies on ethnic background, gender, age.[3,4] These variations can be the possible risk factors for endodontic treatment failure. Failure to locate all canals, incomplete cleaning, shaping and obturation of root canal leads to failure of root canal treatment.[1] Therefore, thorough understanding of root form, number and root canal morphology is essential for successful endodontic treatment.

Among various methods to determine root canal morphology, CBCT is non-invasive method to achieve accurate, 3-D image of tooth and root canals.[2] The CBCT allows the morphological visualisation of the root canal and the measurements made are geometrically accurate, because of an isotropic voxel.[2] Thus, in this study CBCT was used to evaluate the root canal morphology of maxillary first premolar. In this study, two endodontists and an oral radiologist evaluated the root canal morphology of the maxillary first premolar. This method of image evaluation is in accordance with the study done by Tian et al.[4] and Joshi et al.[7] In this study, Vertucci classification was used to classify

root canal configuration. This classification is anatomic and one of the oldest which was used in other similar studies done by Gupta et al.,[6] Celikten et al.,[8] and Tian et al.[4]

In the present study, 172 (65.9%) teeth had single root followed by two-rooted teeth 88 (33.7%), while only one (0.4%) had three roots. The findings are in accordance with the study done by Kafle et al.[5] in Nepali population, Dinakar et al.[9] in South Indian population, Gupta et al.[6] in North Indian population, Tian et al.[4] in Chinese population, Celikten et al.[8] in Turkish population. In contrast, two-rooted premolars were common in the study done by Abella et al.[10] in Spanish population, Alqedairi et al.[11] in Saudi population and Neelakantan et al.[12] in Indian population. The prevalence of three-rooted premolar is in the range of 0.4%-9.2%.[1]

In the present study, two root canals was most common, followed by single root canal. These findings are in accordance to the study done by Ok et al.,[13] Bellizzi et al.,[14] Caliskan et al.[15] Three root canals were found in three (1.1%) first premolar, all in males. This finding is consistent with the study done by Celikten et al.[8] and Ok et al.,[13] who found 0.4% and 1.01% three root canals respectively, all in males.

The study result showed type IV canal configuration as commonly found root canal configuration followed by type II and type I, which is consistent with the result of other studies done by Gupta et al.,[6] Sert et al.,[16] and Celikten et al.[8] In the present study, a single canal at the apex (Type I and type II) was found in 122 (46.7%), two canals at the apex in 136 (52.1%) and three canals in three (1.1%) samples. This finding is in accordance with the study done by Pineda et al.,[17] who found 50.1%, 49.4%, and 0.5% one, two, and three canals at the apex respectively. However, in other studies two canal at apex was more common than one canal at apex; Caliskan et al. (90.2% and 9.8%),[15] Vertucci et al. (69% and 26%),[18] Celikten et al. (77.4% and 21.1%)[8]

The frequency distribution of the number of root canals; and root canal configuration was significant when compared with position of teeth. This means the prevalence of bilateral symmetry is higher in first premolar. This result is in accordance with the study done by Celikten et al.[8] and Tian et al.[4]

The mean total length and root length were found to be 20.61 ± 1.68 mm and 13 ± 1.88 mm. Other studies measuring the total length and root length found similar results; Kim et al. (21.37 ± 1.56, 13.10 ± 1.33),[19] Kafle et al. (21 ± 1.77, 12.76 ± 1.66)[5] However, this length is shorter than the length mentioned by Ash (22.5mm and 14mm).[20]

The variations in findings in different studies can be attributed to the methodology, sample size and population taken in the study.

The study was conducted in a wide range of age group. Age changes dentin deposition can affect the canal configuration. Further studies in different age group and ethnic background can be conducted to have a better understanding of root canal configuration. Also, the sample size was small and is a single centre study.

CONCLUSION

The findings of the study conclude that maxillary first premolars have variation in number of roots, root canals and canal configuration in Nepali population. Single-rooted and type IV canal configuration is common finding. Moreover, single-rooted premolar has diverse canal configuration. Therefore, one must be aware about the possible root canal configuration, prior to initiating endodontic treatment. In cases of dilemma, CBCT can be used as an adjunctive tool to assess the root canal configuration. The information from this study can be used by endodontists and general dental practitioner and for further research.

Conflict of interest: None.

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