Assessment of root and root canal morphology of mandibular premolars using cone beam computed tomography in a tertiary center of Nepal

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ABSTRACT

Introduction: Mandibular premolars are considered an enigma in dentistry because of their variability in anatomical and morphological features making it difficult to treat endodontically. This study was conducted to determine the root and canal morphology of mandibular premolars in the Nepalese population by using cone beam computed tomography imaging. **Methods**: One hundred and thirty-four cone beam computed tomography images of the Nepalese population were collected by convenience sampling method from April 1 to August 31, 2022 in Bir Hospital, Kathmandu, Nepal. A total of 536 premolars (268 mandibular first premolars and 268 mandibular second premolars) were evaluated by two examiners (one endodontist and one oral radiologist). Canal configuration was classified according to Vertucci's classification. **Results:** In mandibular premolar teeth, the majority had one root followed by two roots and fused roots. The most common configuration in mandibular premolars was Vertucci's type I (83.88% and 96.65% in the first and second premolar respectively) followed by type V (9.89%) in the first premolar and type III (1.86%) in the second premolar. Vertucci's type VII (0.37%), C-shaped configuration (1.46%), and an unusual configuration (0.37%) were observed in the first premolar. In mandibular first premolars, males showed more variation than females; while in second premolars, females showed more variation than males. **Conclusions:** Mandibular premolar teeth showed variation in root and canal morphology with one root and Vertucci's type I in the majority of the cases.

Keywords: Cone beam computed tomography, mandibular premolars, Nepalese population, root canal morphology, Vertucci's root canal configuration.

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INTRODUCTION

For the success of endodontic treatment, the knowledge of common root canal morphology and its anatomic variations is a basic requirement.[1] Thorough debridement, proper cleaning, shaping, and obturation of the root canals achieving a three-dimensional seal is the ultimate goal of endodontic treatment. Missed root canals may leave areas of infection untouched leading to failure of endodontic treatment. Therefore it is of utmost importance to know the common root canal morphology as well as the anticipation of its possible variations.[2]

Mandibular premolars are considered an enigma of endodontics due to their variation in the number of canals and roots.[3] Thus, these teeth have a high rate of failure after root canal treatment.[4] To study the canal morphology, different study designs (in vivo and ex vivo) and different techniques (staining and clearing,[5] transverse cross-sectioning,[6] conventional periapical radiography,[7] and micro–computed tomographic imaging,[8] a contrast medium–

enhanced digital radiography,[9] and cone-beam computed tomographic (CBCT) imaging[10] have been used. In a clinical setting, the most commonly used method for evaluating root canal morphology is periapical radiography taken at different angulations. However, it provides only two-dimensional images and may lead to the superimposition of structures and image distortion. CBCT scanning producing 3D scan is more accurate than conventional radiographs in determining root canal system.[10]

We can find several studies conducted in different populations including Egyptian,[6] Iranian,[11] South Indian,[12] Saudi,[13] Bangladeshi,[14] Taiwanese,[15] Kuwaiti,[16] and Chinese.[17] However, we found very few studies on the root and canal morphology of mandibular premolars in the Nepalese population.[5] Hence, the purpose of this study is to use CBCT scanning to investigate the root and canal morphology of mandibular premolars in selected Nepalese population.

METHODS

A descriptive, cross-sectional study was conducted in the Department of Dental Surgery, NAMS, Bir Hospital, Kathmandu, Nepal. The CBCT image of first and second premolars from a patient requiring CBCT, attending the Oral Radiology unit at the Department of Dental Surgery, Bir Hospital was collected with convenience sampling method in April 1 to August 31, 2022 after receiving the ethical clearance from the Institutional Review Board of National Academy of Medical Sciences, Bir Hospital (Ref no. 1328/2078/79). Written informed consent was received from the study participants before data collection. The sample size was calculated using a formula $n = Z^2pq/e^2$ where, n = sample size, z=standard deviation set at 1.96 (95% confidence level), p=prevalence of condition (according to Hajihassiani et al.[11] prevalence of type I canal of second premolar=78%), q=100-p, e=permissible error=5%. Placing these values, we get a sample size of 264. For the assessment of 264 second premolars, 132 CBCT were taken.

This study included permanent mandibular first and second premolars with well-defined root and crown morphology and excluded root caries, fracture, resorption, large restoration, calcification, root canal treated, and distorted CBCT images. The CBCT machine used in this study was Sirona Orthophos SL-3D with exposure parameters; FOV 11 x 11 $cm,^2$ 85 kV, 7mA, 14.4 seconds exposure time, and 160 x 160 x 160 $\mu m,^3$ isotropic voxel size.

The CBCT volumes were processed and reconstructed using Galaxy Gallileo Implant software. Axial, coronal, and sagittal sections, as well as multiplanar reconstructed (MPR) sections of the mandibular premolars, were displayed on a 21-inch Dell LCD monitor at a resolution of 1280 × 1024 pixels. The reading of the CBCT images was performed in a dark room. The image magnification, display contrast, and window size was adjusted to ensure optimal visualization. Canals in each root were visualized from the orifice to the apex in all planes by gradually progressing from the pulpal floor to the root tip and simultaneously changing the position and axis of the coronal and sagittal plane to orient it along the curvature of the root and canals. A series of screenshots were taken to visualize the root canal in each root. The following features were analyzed by two examiners (one endodontist and one oral radiologist) as per the above set guideline:

1) Number of roots and number of root canals per root

2) Root canal configuration based on Vertucci's classification[18]

3) Any other variants of root canal morphology

The recording criteria for canal identification were as follows:

(1) The pulp floor was determined at the level when separate orifices were visible and connected by a faint radiolucent line.

(2) The main canal was recorded as a long radiolucent connecting line that started from the orifice and ended in the apical foramen.

(3) The root tip was represented by the final radiopaque appearance of the root structure.

(4) A secondary canal was confirmed as a second radiolucent spot located off-center from the main canal.

Data were entered in microsoft excel sheet and analyzed in statistical package for the social sciences (SPSS) version 20.0. For descriptive statistics, mean, frequency, and percentage were calculated. Cohen's Kappa test was calculated for inter-evaluator reliability. An endodontist and radiologist evaluated 14 CBCT images (which represent 10% of the total sample) separately. The Kappa coefficient of agreement between both evaluators was 0.67 with substantial agreement.

RESULTS

CBCT radiographs of 134 subjects including 56 males and 78 females with the age ranging from 15 to 70 years (mean age 33.69) were collected. Number of roots and canal configuration of 536 mandibular premolars (268

mandibular first premolars and 268 mandibular second premolars) were evaluated.

Mandibular premolars showed variation in the morphology of root with the majority having one root (94.03% in mandibular first premolars and 99.26% in mandibular second premolars) (Table 1).

Table 1: Frequency of number of roots and canal configuration in mandibular first and second premolars

		Mandibular first premolar n= 268 (100.0%)			Mandibular second premolar n= 268 (100.0%)		
		Total	Male	Female	Total	Male	Female
Number of roots	One root	252 (94.03)	106 (94.64)	146 (93.59)	266 (99.26)	111 (99.11)	155 (99.36)
	Two roots	5 (1.87)	2 (1.78)	3 (1.92)	1 (0.37)	1 (0.89)	0 (0)
	Fused	11 (4.10)	4 (3.58)	7 (4.49)	1 (0.37)	0 (0)	1 (0.64)
Vertucci type	Type I	229 (83.88)	90 (78.95)	139 (87.42)	260 (96.65)	112 (99.12)	148 (94.87)
	Type III	11 (4.03)	6 (5.26)	5 (3.14)	5 (1.86)	0 (0)	5 (3.21)
	Type V	27 (9.89)	13 (11.40)	14 (8.81)	4 (1.49)	1 (0.88)	3 (1.92)
	Type VII	1 (0.37)	1 (0.88)	0	0 (0.0)	0	0
C-shaped configuration		4 (1.46)	4 (3.51)	0	0 (0.0)	0	0
Unknown configuration		1 (0.37)	0 (0)	1 (0.63)	0 (0.0)	0	0

Note: Each root present in a tooth has been considered for canal configuration

Regarding the canal configuration, 229 mandibular first premolar teeth and 260 mandibular second premolar teeth had Vertucci's type I configuration which also includes the two rooted teeth having type I configuration. Fused teeth having furcation at and below the middle third of the root were also considered as one root in this study. In mandibular premolars, type I configuration were the most prevalent (83.88% in the first premolar and 96.65% in the second premolars) (Table 1). In mandibular first premolar one tooth had type VII configuration. One tooth was found to have an unusual configuration not explained in Vertucci's classification where single canal leaves the pulp chamber and divides into two, out of which one further divides into two and ends with three foramina (Figure 1). Type II. IV, VI and VIII were not found in mandibular first premolar and Type II, IV, VI, VII, VIII and c-shaped configuration were not found in mandibular second premolar in our study (Table 1).

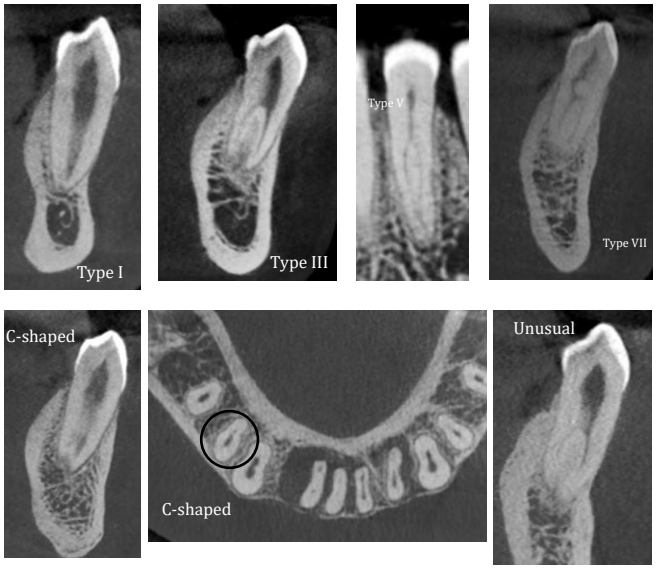

Figure 1. Root of mandibular premolars showing Vertucci's canal configuration type I, III, V, VII, c-shaped configuration (both in cross-section and axial view) and unusual configuration

Among the 112 mandibular premolars in males and 156 mandibular premolars in females, majority had one root (94.64% in males and 93.59% in females in first premolars and 99.11% in males and 99.36% in females in second premolars) (Table 1). Regarding canal configuration, among the mandibular first premolars in males and females, majority had type I followed by type V configuration. Similarly, among mandibular second premolars in males majority had type I followed by type V configuration, while in females majority had type I followed by type III configuration (Table 1).

Table 2: Bilateral symmetry of number of roots in mandibular first and second premolars

		Number (%) of root in left mandibular first premolars		
		Fused	One root	Two roots
Number (%) of root in right mandibular first premolars	Fused	4 (2.98)	1 (0.75)	0
	One root	2 (1.49)	124 (92.54)	0
	Two roots	0	1 (0.75)	2 (1.49)
		Number(%) of root in left mandibular second premolars		
		Fused	One root	Two roots
Number (%) of root in right mandibular second premolars	Fused	0	0	0
	One root	1 (0.75)	132 (98.50)	0
	Two roots	0	1 (0.75)	0

Regarding the bilateral symmetry, in mandibular first premolars, majority (92.54%) had one root on both sides, 2.98% had fused roots on both sides and only 1.49% had two roots on both sides. Similarly in mandibular second premolars, 98.50% had one root on both side (Table 2).

Table 3: Bilateral symmetry of canal configuration in mandibular first and second premolars

		Vertucci canal configuration in left mandibular first premolars n(%)		
		I	III	V
Vertucci canal configuration in right mandibular first premolars n(%)	I	92 (71.32)	7 (5.43)	14 (10.85)
	III	4 (3.10)	0	0
	V	9 (6.97)	0	3 (2.33)
		Vertucci canal configuration in left mandibular second premolars n(%)		
		I	III	V
Vertucci canal configuration in right mandibular second premolars n(%)	I	117 (93.60)	3 (2.40)	3 (2.40)
	III	1 (0.80)	0	0
	V	1 (0.80)	0	0

Regarding the bilateral symmetry of canal configuration of mandibular first premolars, 71.32% teeth had Vertucci's type I on both sides and 2.33% teeth had type V configuration on both side while, in mandibular second premolars, 93.60% teeth had type I on both side (Table 3).

DISCUSSION

Mandibular premolars are typically single rooted teeth, but different variations like two rooted, three rooted and four rooted mandibular premolars have also been reported.[15] In the current study, one root was the most prevalent in both mandibular first premolar 252(94.03%) and second premolar 266(99.26%). This is similar findings in other literature too, only the prevalence percentage differs.[6,16,19] In mandibular first premolar the prevalence of two rooted was 5(1.87%) and in second premolar only one tooth out of 268 had two root which was much low as compared to Alenezi et al.[16] The prevalence of fused teeth in this study in mandibular first premolar was 11(4.10%) and in second premolar was 1(0.37%).

Vertucci's classification system has been used in this study to classify the canal configuration as it is the most commonly used system by authors in text books and literatures.[5] Vertucci type I is the most common finding of all types with variable percentage in variable population. In the current study 83.88% and 96.65% of mandibular first and second premolars respectively exhibit type I canal morphology, which was similar to the CBCT study done in South Indian population[12] (83.91% and 93.48% in mandibular first and second premolars respectively) and slightly higher than the study done in Iranian population[11] (62.2% and 78% in mandibular first and second premolar respectively). In this study mandibular first premolar exhibit type V configuration as the second most common configuration with the prevalence of 9.89% followed by type III configuration (4.03%) whereas in mandibular second premolar both type III and type V are almost equally prevalent (1.86% and 1.49% respectively). One study done in Nepalese population in mandibular first premolar using clearing technique has also shown type V as a second most common configuration (18.6%). Iranian population[11] has also shown type V as the second most prevalent configuration with higher percentage as compared to our study (28.8% and 22% in mandibular first and second premolars respectively). In contrast to our result, some in vitro study conducted in USA,[20] India[21] has shown type IV as the second most common canal configuration. These variations can be attributed by the difference in racial factor, methods of study and sample size.

Type VII being a rare canal configuration, our study found one mandibular first premolar tooth with this configuration. The clinical significance of the knowledge of canal configuration is mainly to predict the course of root canal treatment. In Vertucci's configuration, type I and type IV are relatively simple with separate and distinct orifice and apex, whereas type II, III, V, VI, VII and VIII configuration are difficult to appreciate and treat due to the complexity leading to the high prevalence of failure. Thus clinician should be aware of the prevalence of these complex anatomy and should be skilled to obtain desirable outcome. Besides the canal configuration classified in Vertucci's, unusual configuration has been reported in many literatures.[5,15] Current study has observed one mandibular first premolar having unusual configuration. Thus, the clinician performing the routine root canal treatment in mandibular premolars should be cautious about the possibilities of the unusual configurations.

Current study has observed bifurcations in mandibular premolar roots tend to occur in middle and apical third, which is consistent with other literatures too.[19,20] This indicates the high probability of canal variation in middle and apical third. While classifying the canal configuration: when there were two roots, each roots were classified accordingly but when there was bifurcation of root in middle and apical third, in current study author has considered a single root and classified accordingly. While doing the root canal treatment number of canal or the canal configuration is more relevant than the number of root, thus bifurcation of root in middle and apical third were considered as a single root. C-shaped canal is mainly common in mandibular second molar; however, it is also prevalent in mandibular premolars. In Chinese population[19], C-shaped configuration was found 18% (first premolar) and 1.1% (second premolar) much higher than this study: 1.46% (first premolar) and 0% (second premolar). C-shaped configuration is more prevalent in Mongolian tribe thus more study is recommended in this tribe of Nepalese population.

In current study, regarding the number of roots in mandibular first and second premolars, both males and females have similar distribution. Regarding the canal configuration, in mandibular first premolars, male showed more variation than female; while in mandibular second premolars, female showed more variation than male which is consistent with the study done in German selective population.[22] The first mandibular premolars showed higher canal configuration variability in current study than the second mandibular premolars, while Alenezi et al.[16] observed more variability in mandibular second premolars in Kuwaiti subpopulation.

The study has some limitations. Sample was collected from the single tertiary center. It can be considered as the limitation to generalize the outcome in Nepalese population. Thus, we would like to recommend similar studies in multiple centers.

CONCLUSIONS

Mandibular premolar teeth showed variation in root and canal morphology with one root and Vertucci's type I canal configuration in majority of the cases followed by type V in mandibular first premolar teeth and type III in mandibular second premolar teeth. Thus clinician should be aware of these possible anatomical variations, while doing the root canal treatment.

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