Original Research Article

Evaluation of root and canal morphology of mandibular premolars in urban Indian population: an in-vivo cone beam computed tomographic study

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ABSTRACT

Background: *Inability to recognize anatomical variations in roots and canal configurations remains one of the principal factors in failure of endodontic therapy. Mandibular premolars, due to their varied internal morphology, present an endodontic challenge more often than other teeth.*

Objective: *To assess the root morphology and canal configuration of mandibular first and second premolars using three-dimensional cone-beam computed tomography imaging (3D CBCT).*

Methodology: *Bilaterally, mandibular premolars were evaluated on 100 CBCT images independently by two experienced endodontists. Vertucci's classification was used to identify and divide the canal configurations.*

Results: *97% of first premolars and 99.5% of the second premolars were found to have one root. The most common canal configuration was found to be Type- I. Other types of canal configurations were 5.5% and 5% in first and second premolars respectively.*

Conclusions: *Modern-day endodntist needs to be vigilant at all times to avoid missing canals and consequent failures.*

Key words*: Root morphology, mandibular premolars, vertucci's classification, canal configuration, cone-beam computed tomography*

Introduction

The first step to a successful root canal therapy is thoroughly understanding the normalcy and abberations that the root canal presents itself with. Inadequate cleaning, shaping and obturation of the root canals will ensure chances of failure. Apart from the endodontic treatment, the study of morphological characteristics of root and canal space is also important from anthropological point of view. [1,2,3] Owing to the high incidence of variations in the mandibular premolars roots and canal morphology, these teeth have been among the most difficult teeth and provide endodontic challenges.[4] Apart from the teeth specific variations, morphology of roots and canal configuration also varies depending on the ethnicity of the population.

Myriad of morphological variations for these teeth are reported in the

endodontic literature. Usually the buccal root canal is easily accessible whereas the locating lingual root canal orifice is highly challenging mainly because of lingual inclination of the crown, especially so in mandibular premolars.[5] Plenty of variations exist and canal configurations keep an endodontist always guessing. In case of two canals in a mandibular premolar, the canal morphology usually exhibits two separate canals circular in shape running to their respective apical foramina. In some instances, a single, broad root canal may divide into two separate root canals and orifices at the apex of the root.[6] At times, one root and four canals[7] or three roots and three canals[8,9,10] or have been observed in mandibular first premolar. C shaped canal anatomy has been reposrted in very few studies in the mandibular first premolar.[11,12]

Different techniques have been used by the researchers for the purpose of studying the root canal morphology such as traditional radiography, histomorphological studies using hard tissue section and root canal staining or tomography. Conventional images represent the three-dimensional (3D) anatomy into a two-dimensional image, resulting visualization of the anatomy only in the mesiodistal plane, undermining the importance of anatomy in other planes.

In recent years, with the introduction of 3-D imaging technology, esp. cone-beam computed tomography (CBCT), maxillofacial imaging with 3-D reconstruction has been possible with the lesser radiation. CBCT has been a useful tool in implant dentistry, for accurately identifying the anatomic structures and for the evaluation and detection of periapical lesions and assessing root canal morphology. [13,14,15,16] With the advantages of higher resolution and lower radiation than traditional CT scans [17,18,19] and, CBCT has shown to produce accurate three dimensional morphological details for accurate diagnosis and prognosis.[20,21] The reason behind interest of researchers in studying root and canal morphology in mandibular premolars is primarily because of the complex morphology of these teeth that often results in complicated treatment requiring re-treatment.[22,23] However, the majority of these studies have been performed in vitro and involved the destructive methods (hard tissue sections) to examine the root canal configuration which may not detect the configuration accurately in three dimensions[24,25,26] or obtain inadequate two dimensional anatomic information with traditional radiography.

Thus, the present study was carried out to assess the root morphology and canal configuration of mandibular first and second premolars using 3D CBCT imaging.

Material and methods

This cross-sectional study consisted of evaluation of 100 CBCT images of bilateral mandibular first and second premolars of patients, who were referred to SRL Diagnostics Pvt. Ltd., between May 2008 and September 2013. The patients included those suffering from maxillofacial trauma or odontogenic tumours, those who required a preoperative assessment for implants or who needed orthodontic treatment for an ectopic or impacted tooth. No patient was exposed to CBCT radiation for the sole purpose of evaluating the root canal system and the images were taken as part of the routine examination, diagnosis and treatment planning of these patients.

Understanding and written consent of each patient was obtained. To identify root canal system on clear images of the mandibular premolar teeth, those teeth with physiological and/or pathological defects were excluded. Teeth were selected according to the following criteria: (i) mandibular premolars with no periapical lesions; (ii) no root canal treatment; (iii) no root canals with open apices, resorption or calcification and (iv) the CBCT images of good quality.

Radiographic techniques

The CBCT images were taken using a 3D C9300 CBCT machine (Carestream, USA) operating at 60-90 kV and 2-15 mA, with an exposure time of 17s. The voxel size was 90-500µm and the slice thickness was 300µm. The scans were produced according to the manufacturer's recommended protocol. According to the examination requirements, a field of view of 40 ×40 mm or 60×60 mm was used. All CBCT exposures were performed by an appropriately licensed radiologist, with the minimum exposure necessary for adequate image quality.

Evaluation of the images

The CBCT images were analysed with the inbuilt software (CS 3D imaging software) in a Dell Precision T5400 workstation (Dell, Round Rock, TX, USA), with a 32-inch Dell LCD screen with a resolution of 1280×1080 pixels in a darkroom. The contrast and brightness of the images were adjusted using the image processing tool in the software to ensure optimal visualisation. Two independent endodontists assessed the number of roots and canals, the position where canal bifurcation occurred and the canal configuration. In cases where consensus was not reached, a third professional oral radiologist was asked to perform a decisive evaluation.

Results

Number of roots and canals

Of the total 200 mandibular first premolars evaluated, 194 had one root (97%) and 6 had two roots (3%); 88.5% had one canal, 10% had two canals, 1.5% had three canals, and 0.5% had C shaped canals. Of the 200 mandibular second premolars evaluated, 199 (99.5%) had a single root, whereas only one premolar (0.5%) had two roots (Figure-1); 95% had single canals, 4% had two canals, 0% had three canals, 1% had C shaped canals. (Table-1and 2)

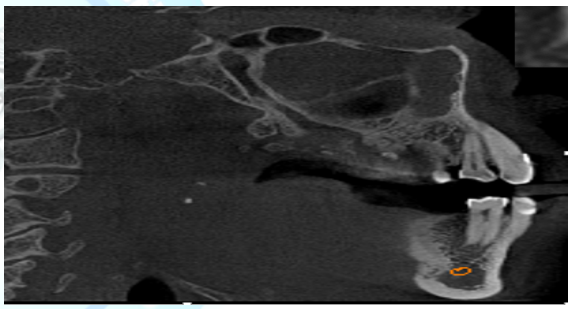
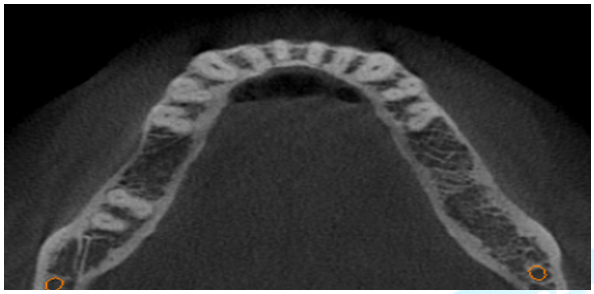


Fig. 1 Axial sectional view of mandibular second premolar with two roots

Variations in root canal system morphology

The canal morphology of mandibular first premolars according to Vertucci's classification[22] was as follows: Type I = 189 (94.5%), Type III = 4 (2%), Type V = 3 (1.5%), Type VIII = 1 (0.6%) (Figure 1), while one had a C-shaped configuration (0.5%) (Figure -2). Of the 200 mandibular second premolars, canal configurations of these teeth were Type I in majority of teeth (190 teeth, 95%), while Type II (one tooth, 0.55%), Type III (4 teeth, 2%) and Type V (2 teeth, 1%) canal configurations were also observed; two teeth had a C-shaped

configuration (1%) (Figure 2, Table 2, 3). In both first and second mandibular premolar teeth exhibiting Type V or Type VIII morphology, the canal bifurcation occurred at the middle-apical part of the root, which is where most of the canal system variations occurred in this study.



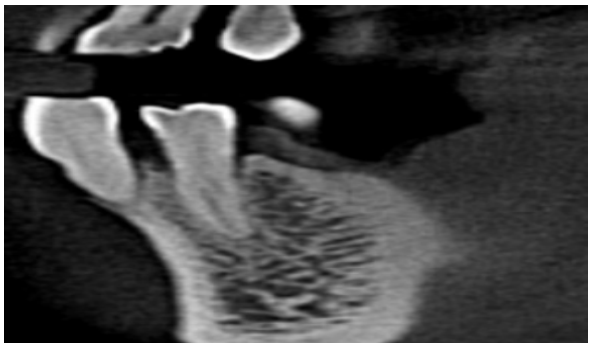


Fig. 2 C-shaped canal configuration in a mandibular first and second premolar at the middle–apical part of the canal in cross-sectional view

Table: 1 Number of roots in 400 mandibular premolars

	No. of roots			
	One-rooted		Two-rooted	
	Left	Right	Left	Right
First premolar	98	96	2	4
Total	194 (97%)		6 (3%)	
Second premolar	100	99	0	1
Total	199 (99.5%)		1 (0.5%)	

Table: 2 Number and percentage of canal system types in 200 mandibular first premolars

Root Canal Configurations									
	Type I 1	Type II 2-1	Type III 1-2-1	Type IV 2	Type V 1-2	Type VI 2-1-2	Type VII 1-2-1-2	Type VIII 1-3	C-shaped
Number	189	2	4	0	3	0	0	2	1
Percentage	94.5	1.0	2.0	0	1.5	0	0	1.0	0.5

Table: 3 Number and percentage of canal system types in 200 mandibular second premolars

Root Canal Configurations									
	Type I 1	Type II 2-1	Type III 1-2-1	Type IV 2	Type V 1-2	Type VI 2-1-2	Type VII 1-2-1-2	Type VIII 1-3	C-shaped
Number	190	1	4	1	2	0	0	0	2
Percentage	95	0.5	2.0	0.5	1.0	0	0	0	1.0

Discussion

It is of utmost importance to have a thorough knowledge of the root canal for the success of root canal treatment. Compared with the widely used ex-vivo methods such as cross section- grinding and the staining-clearing technique, CBCT is noninvasive method and can be used directly to evaluate canal configurations in-vivo. Compared with the helical CT scanner, its major advantages are a substantial reduction in radiation exposure[27] and higher quality image rendering for assessment of dental hard tissues. Our findings on the number of roots and canals in mandibular premolars, showed that most had only one root and one canal, are in accordance with the results of previous studies.[12,22,25,28,29] In our study, most mandibular first premolars (97%) had one root which is higher than that found by Trope et al[30] (94.5%) but less than that found by Vertucci[2] who reported it to be at 100%. The present study showed that 3% of mandibular premolars had two roots which is closer to that reported by Jain and Bahuguna[25] (2.89%) and Iyer et al[31] (3.9%) but was higher than that found by Park et al[32] and Tian et al[33], who reported the values of 0.1% and 0.5% respectively. The similarity or the difference of our values from the reported values seems to be due to similarity or the difference in the ethnicity of the population being studied.

Our study reported that 88.5% of mandibular first premolars had one canal, which was similar to that found by Xu et al[12] at 87% but higher than that found by Vertucci[2] who reported Type I canal system to be 70%, while Zillich & Dawnson[29] reported an incidence ranging from 67.2% to 86.3%. Despite of the same ethnic population studied, we found different results compared to Jain and Bahuguna[25] who reported the incidence of 67.3% for one canal in mandibular first premolars. The difference between our results could have been attributed to the fact that in contrast to their study who investigated CBCT images of extracted teeth, we examined the images of patients which would represent the population better. Furthermore, the in-vitro study on extracted teeth has certain inherent shortcomings. It involves evaluation of extracted teeth that are frequently difficult to collect in sufficient numbers along with known specifics like age, gender, and so forth. Furthermore, most extracted teeth collected are severely damaged leading to difficulties in determining accurately the tooth notation. [34] An additional negative impact if only sound teeth are selected is selection bias. [33.35]

Our results showed that mandibular second premolars had one root in all but one sample (99.5%), with only one premolar having two roots (0.5%). Our results are in accordance with a systemic review[34] which reported the values to be 99.28% for one root and 86.9% for one canal. Second premolars presented with a second canal in Indian population[36,37] (13.5–20%). In an Indian population, V. K. Sikri and P. Sikri[37] reported 10% first premolars exhibiting C-shaped canals while Sandhya et al[38] reported the variation in 2% teeth in a southern Indian population. A systemic review[34] found that in second premolars, the Type V pattern was more prevalent than Type IV in all population groups, with significantly higher prevalence of upto 15–17% in Indians. Similar to other populations, our study population also showed more prevalent Type V than Type IV. However, it was quite low as compared

the range upto 15-17%. The results of the current study showed that both mandibular first and second premolars showed variations in number of roots as well as in canal configurations. The clinician should be astute enough to identify any variation from the normal scenario in the root canal systems.

To develop a true sense of canal configuration, the clinician must be vigilant to identify any variations in the morphology of roots and canal systems when assessing the mandibular premolars. Although majority of premolars (almost 95%) had single root-single canal morphology in this study, challenge for the endodontists lies in identifying and negotiating aberrancy in the root canal system to avoid flare-ups and failures in these teeth.

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