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Variations in Root Canal Morphology of Mandibular First Premolar- A Cone-Beam Computed Tomography Study

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Abstract; *Introduction; Mandibular premolars, frequently considered an enigma to the endodontist, may present the greatest difficulty of all teeth to perform successful endodontic treatment. Owing to its tortuous nature and the variations in root canal anatomy, the mandibular first premolar is quite notorious for its high flare up and failure rates. Advanced modes of radiographic imaging and analysis have allowed for extensive knowledge of pulp space anatomy in three dimensions and identification of rare aberrations. CBCT scanning can help clinicians view morphologic features from a 3-dimensional perspective. The present study was done to evaluate the common root canal variation of mandibular first premolar using Cone-Beam Computed Tomography .Methods; 170 mandibular first premolars with fully developed roots were investigated. The CBCT images were collected from department of oral and maxillofacial radiology and were examined in axial sections. CBCT images were evaluated continuously by moving the toolbar from the orifice of the pulp chamber to the apex to determine the number of canals and their morphology. The number of canals, Vertucci's classification of canals and position of canal bifurcation were evaluated by Endodontist and a Radiologist and the information of each tooth was recorded. Data were subjected to statistical analysis. Results and conclusion; Type I (Single canal) found to be the common root canal variation in mandibular first premolar in the present study. Other canal variations found are type V, III and type II, IV.*

Keywords; *Mandibular first premolar; CBCT; Root canal variation*

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I. Introduction

Successful root canal treatment relies on thorough knowledge of the root canal morphology and its variations. Variation in the root canal anatomy is a commonly occurring phenomenon. The inability to detect, prepare or obturate one or more of the root canals is a common cause of failure of endodontic treatment.[1]

An enigma to the endodontist, the mandibular first premolar can generate complicated biomechanical problems due to its tortuous nature of the canals dividing at various levels of the root. Mandibular premolars may present the greatest difficulty of all teeth to perform successful endodontic treatment.[2]

Failure of endodontic treatment in mandibular premolars is attributed to a wide range of anatomical variations in root canal systems and difficult access to the second root canal, resulting in inability to carry out an effective root canal treatment in the entire root canal length.[3]

In addition, the access cavity in these teeth is relatively small, resulting in reduced visualization. Canal configurations in mandibular premolars may vary significantly with respect to ethnicity[4–6], race[7] and sex[5,8].Previous studies have shown that a high percentage of mandibular first premolars have more than one root canal ranging from 11.53% to 46%. These variations may result in missing root canals in mandibular first premolars that need root canal treatment.[9]

Advanced modes of radiographic imaging and analysis such as spiral computed tomography (SCT), micro-computed tomography (micro-CT) and cone-beam computed tomography (CBCT) have allowed for extensive knowledge of pulp space anatomy in three dimensions and identification of rare aberrations.[10]

CBCT is reportedly an excellent tool for more accurately detecting root canal anatomy than intraoral periapical radiography due to its ability to evaluate and assess root canal morphology in three dimensions. The CBCT technique has the ability to detect root canal morphology as precisely as the root canal staining and clearing techniques which, in the past, were considered superior to conventional techniques used for studying the root canal system because of their ability to provide three dimensional views and complete morphologic details.[11]

Present study has emphasized on analysing root canal morphology using CBCT which is a recent advance in dental radiology which gives all three dimensional views which overcomes the errors as well as

gives clear picture of canal with very minimal exposure of the patient to harmful x rays when compared to computed tomography(CT).

Hence, the purpose of this study was to determine the most common root canal variation of mandibular first premolar using CBCT according to Vertucci's classification (Fig 1). The level of root canal bifurcation, if present, was also noted.

II. Materials And Methods

The study was conducted in the Department of Oral Medicine & Radiology and Conservative Dentistry & Endodontics in Government Dental College, Kottayam.

Total 100 Cone-beam computed tomography images, which include mandibular first-premolars, were collected from the department of oral medicine and radiology. The inclusion criteria and the exclusion criteria are given below.

Inclusion criteria: CBCT images of teeth with fully formed roots.

Exclusion criteria: CBCT images of

- Teeth with open apex
- Grossly decayed teeth
- Teeth with calcification, root resorption & fractures
- Endodontically treated teeth

The CBCT images of mandibular first premolars with fully developed roots were examined in axial, sagittal and coronal sections and the information of each tooth was recorded & analyzed. The number of canals, Vertucci's classification of canals and position of canal bifurcation were evaluated by an endodontist and a radiologist.

Vertucci's classification was used to determine the pattern of the root canal.

- Type I: A single canal extends from the pulp chamber to the apex (1).
- Type II: Two separate canals leave the pulp chamber and join, short of the apex, to form one canal (2-1).
- Type III: One canal leaves the pulp chamber and divides into the root; the two then merge to exit as one canal (1-2-1).
- Type IV: Two separate, distinct canals extend from the pulp chamber to the apex (2).
- Type V: One canal leaves the pulp chamber and divides short of the apex into two separate, distinct canals, with separate apical foramina (1-2).
- Type VI: Two separate canals leave the pulp chamber, merge in the body of the root, and redivide short of the apex to exit as two distinct canals (2-1-2).
- Type VII: One canal leaves the pulp chamber, divides and then rejoins in the body of the root, and finally redivides into two distinct canals short of the apex (1-2-1-2).
- Type VIII: Three separate, distinct canals extend from the pulp chamber to the apex (3).

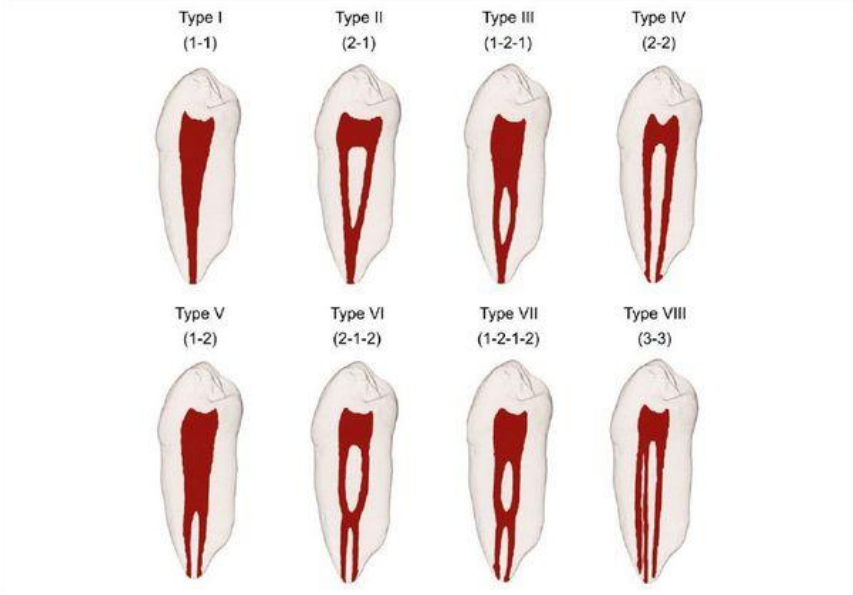

Fig 1 - Vertucci's classification

Bifurcation of the root canal

The level at which the canal bifurcation occurred was measured from the crown tip. The average length from crown tip to point of canal bifurcation was recorded.

III. Statistical Analysis

Raw data were entered into Microsoft Excel. All analyses were done in an SPSS environment (Version16; SPSS, Inc., Chicago, IL). A descriptive analysis of the data was performed.

IV. Results

Total 100 CBCT images which included 170 mandibular first premolars were examined. The teeth showed Vertucci's Type I, II, III, IV, and V in this study. 140 teeth (82%) showed type I, 15 teeth (9%) showed type V, 10 teeth (6%) displayed type III Vertucci's variations. Other canal variations found are type II (1%) & IV (2%).

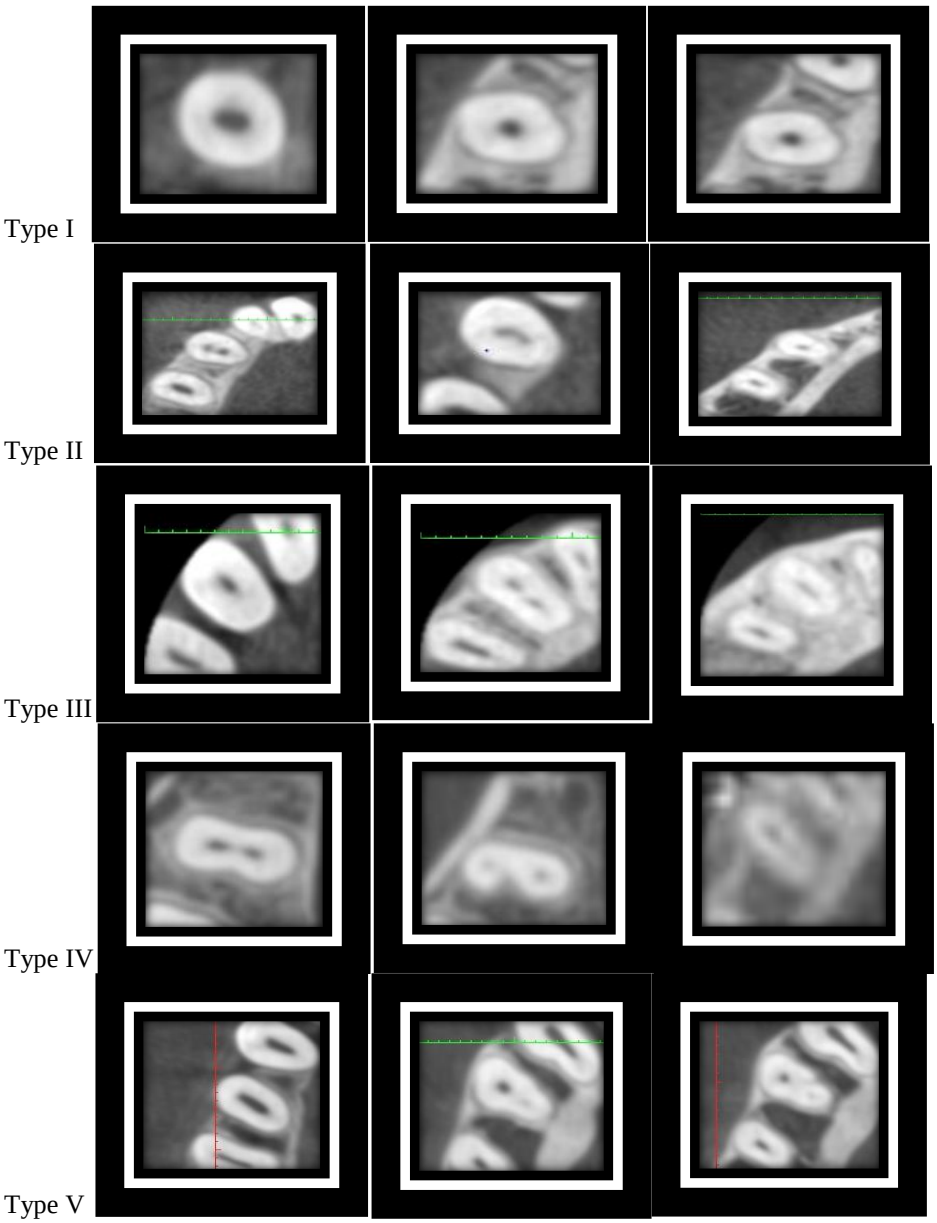

Fig. 2; CBCT images in axial plain in the coronal, middle, and apical thirds of the root displayed the variation in canal morphology.

TYPE	NUMBER	PERCENTAGE
TYPE I	140	82%
TYPE II	2	1%
TYPE III	10	6%
TYPE IV	3	2%
TYPE V	15	9%
TOTAL	170	100%

Table.1 Percentage variations in different types of canals.

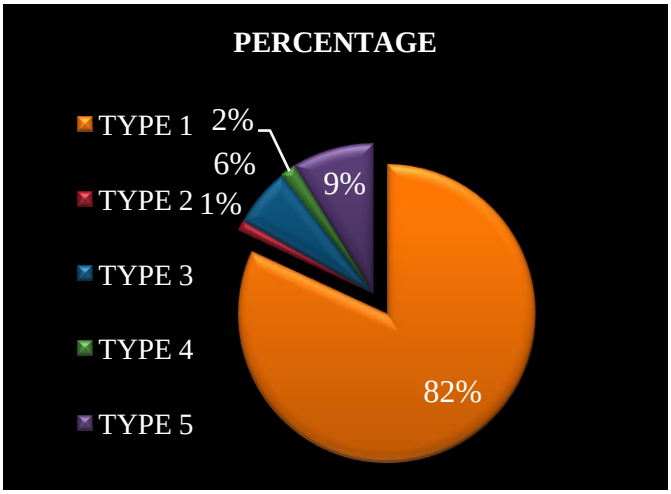

Fig. 3 - Percentage distribution of each canal variation

The results indicated that Vertucci's Type I canal configuration represented the highest percentage (82%). There was high incidence of Type V as compared to Types III, IV, and II in the descending order.

Bifurcation of the root canal

The number of teeth with canal bifurcation (samples that had a single canal that divided into two) was found to be fifteen. The level at which the canal bifurcation occurred was measured from the crown tip. The average length from crown tip to point of canal bifurcation was found to be 14.5 mm.

V. Discussion

Thorough knowledge of root canal morphology and canal configuration is essential for successful endodontic treatment. One of the most commonly missed canals is the second canals in the mandibular premolars. Therefore, to treat or retreat mandibular premolars, dentists need to be aware of the possible existence of two or more root canals before they initiate endodontic treatment.[12]

Many studies have examined root canal morphologies using various methods. The methods used in analyzing root canal morphology are sectioning, canal staining and tooth clearing techniques, conventional radiography techniques, contrast medium-enhanced radiography, modified canal staining and clearing, and computed tomography (CT) scanning.[13]

The CBCT technique has the ability to detect root canal morphology as precisely as the root canal staining and clearing techniques which, in the past, were considered superior to conventional techniques used for studying the root canal system because of their ability to provide three dimensional views and complete morphologic details.[11] In addition, CBCT is a non invasive technique, where as root canal staining and clearing techniques require sectioning of the tooth.

Reuben et al. reported that CBCT was as accurate as the modified canal staining and clearing technique in identifying root canal morphology.[14]

The most common variation found in our study was type I, one root and one canal, followed by type V, type III. This is in accordance with the study done by Salarpour et al. in 2013. In their study, the most common canal type in the mandibular first and second premolars found to be type I (71% and 76%, respectively), followed by type V (29% and 22%, respectively).[15]

Celikten et al.,(2016)[16] conducted a study on the Turkish Cypriot population and they found that the most common root canal configurations were type I (93%) in both mandibular first and second premolars. Sandhya *et al.*[17] reported that, among the Indian population, the Type I root canal morphology occurred more frequently (80%) in the mandibular first premolar teeth. Eighty percent of the teeth had a single canal, 11% of the teeth had two canals, and C-shaped canals were found in 2% of the teeth, in this study. Fourteen percent of the teeth had mesial invagination of the root. The level at which the canal bifurcation occurred was 14.15 mm.

However, in a study done on first premolars of an Iranian population, Khedmat *et al.*[18] showed that only 59% of the teeth on radiography had more than one root canal, in which Types I, V, and III were more prevalent. Jain and Bahuguna[19] reported that Type I canal system was found in only 67.39% (*n*=93) of the teeth studied.

The differences among various studies may be due to different ethnic population and also the sample size variation. These reasons may result in different frequencies of mandibular first premolars with various canal configurations.

Also, obturation of these complex root canals may require technique modifications. Most of the cases can be managed using warm vertical compaction with small sized heat carriers, pluggers, and narrow back filling needles. However, if the root canals are very thin, lateral compaction with thin spreaders or single cone obturation with 6% taper cones is recommended.[20] Enhanced magnification and illumination along with adequate coronal canal flaring to access the bifurcated canal orifices are recommended.

VI. Conclusion

In the present study, Type I canal configuration found to be the common variation in the mandibular first premolar (82%). Other canal variations found were type V, III, IV and type II. (15%, 10%, 3% & 2% respectively) The average length from crown tip to point of canal bifurcation was found to be 14.5 mm.

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