Original Article

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Dentistry Section

A Three-Dimensional Study of Variations in Root Canal Morphology Using Cone-Beam Computed Tomography of Mandibular Premolars in a South Indian Population

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ABSTRACT

Background: Conventional radiographic techniques being two dimensional, has its restrictions and is confined to limited diagnostic value. However, the incorporation of Cone Beam Computed Tomography (CBCT) gives a three dimensional insight to the tooth morphology and leads to better evaluation and treatment management.

Aim: The aim of this study was to evaluate and assess the root canal morphology of mandibular pre-molars in South Indian Population using CBCT radiographic technique.

Materials and Methods: One thousand and eighty six and 814 fully erupted mandibular first and second premolars respectively were scanned using CBCT to evaluate the canal morphology according to Vertucci and Gulabiwala's classification.

Results: The most common configuration in mandibular first and second premolars was Vertucci's Type I(83.81% and 93.48% respectively) followed by Type V (11.97% and 3.5% respectively).

Conclusion: South Indian population presented Type IV ertucci's canal morphology as the most common in mandibular first and second pre-molars followed by Type V. CBCT scanning poses a greater advantage in assessing the complexity of root canal morphology and planning an appropriate endodontic treatment for the same.

Keywords: Cone-beam computed tomography, Gulabiwala root canal configuration, Mandibular premolars, Root canal morphology, Vertucci root canal configuration

INTRODUCTION

Endodontic necessitates complete debridement and obturation of the root canals giving a three dimensional seal which cannot be possible without adequate knowledge of root and root canal anatomy, from correct diagnosis to negotiating all the canals especially of the diverse root canal anatomy present in human teeth. Variations in canal anatomy, incomplete canal instrumentation and obturation are the most substantial causes of endodontics failure. Ingle states that mandibular premolars are the most complex and a challenge to endodontically treat them [1]. Thus endodontic flare-ups, re-treatment and failures are most likely seen due to variants in root canal morphology [2].

A typical description of mandibular premolars is a 'single-rooted' tooth depicting a 'single' root canal, wider bucco-lingually than mesio-distally having two pulp horns; large pointed buccal and small rounded lingual [2]. Cervically the canal is oval shaped and as it approaches the middle, it becomes round. Another variation is seen as lingual canal emerging at a sharp angle from the main canal, making it difficult to negotiate [2]. Vertucci and Gulabiwala have classified canal morphology into various types. Vertucci has reported that 97.5% mandibular second premolars and 74% mandibular first premolars have one canal at the apex. It may also have three roots with three canals [3] or one root with four canals [4]. C-shaped canal anatomy cannot be overlooked in mandibular first premolars [5].

Researchers have documented studies on number of canals, incidence of multiple roots, complex canal morphology by using different study types like root canal clearing technique, radiographs of root canal treated teeth, in-vitro radiography and sectioning and analysis of extracted teeth [6]. Several factors contribute to the dissimilarities observed in anatomic studies in previously documented literature are perhaps due to differences in ethnicity, gender, age, unintentional bias in case selection, as well as due to in vitro or in vivo study designs [7,8].

Conventional images apparently deliver a two-dimensional mesio-distal view and making it impossible to view bucco-lingual concavities and other morphological variances. Thus the introduction of cone-beam computed tomography (CBCT) in Endodontics in 1990 was a break through invention promoting three-dimensional imaging technique. This noninvasive scanning has many applications in dental practice not excluding intense morphologic analysis which lead to several studies been conducted on permanent mandibular and maxillary premolars and molars which revealed that CBCT pre-evaluation is beneficial in identifying canal configurations [9,10].

MATERIALS AND METHODS

This cross-sectional double blind in-vitro study was conducted in A.B.Shetty Memorial Institute of Dental Sciences, Mangalore, India from July 2011 to June 2013. It was commenced after being approved by the Institutional Ethical Committee. The teeth samples used in this study were those indicated for orthodontic extraction. Gross debris, tissue tags, calculus was removed using a scaler from 1186 and 814 extracted fully erupted permanent mandibular first and second premolars respectively and sterilized in 5.25% sodium hypochlorite for 15min.The inclusion criteria was single rooted fully erupted teeth with closed apices and teeth with root canal fillings, post and core restorations were excluded from the study.

The aim was to analyze the number and percentage of root canal morphology according to Vertucci and Gulabiwala's Type 1 addition

Vertucci's Type	1	2	3	4	5	6	7	8	C shaped	Gulab-iwala Type 1
Number	994	4	25	3	142	2	0	4	11	1
Percen-tage(%)	83.81	0.3	2.1	0.27	11.97	0.1	0	0.3	0.92	0.08

[Table/Fig-1]: Number and percentage of canal types in 1186 mandibular first pre-molars

Vertucci's Type	1	2	3	4	5	6	7	8	C shaped	Gulab-iwala Type 1
Number	761	12	2	0	32	0	0	1	6	0
Percen-tage(%)	93.48	1.4	0.2	0	3.9	0	0	0.1	0.7	0

[Table/Fig-2]: Number and percentage of canal types in 814 mandibular second pre-molars

to Vertucci's classification [2] in South Indian population, which geographically involves regions of Karnataka, Goa and North Kerala.

All images were taken using a Kodak 9000 3D CBCT machine with exposure parameter of 60kV and 2.0 mA along with an exposure time of 10.8 sec. The voxel size was 0.076mm and slices thickness 76 µm with a field of view (FOV) of 5x3.7 cm. We selected 837 CBCT images from the imaging center. They were analysed with the inbuilt software using a Dell workstation. The radiographic analysis was done by two independent Endodontists and in cases of doubt; an oral radiologist was consulted to reach a confirmative decision.

RESULTS

The canal morphology of 1186 and 814 single-rooted permanent mandibular first and second premolars was assessed according to Vertucci's and Gulabiwala's Type 1 addition to Vertucci's classification [2] and were as follows:

Type 1- 994 (83.81%), Type 2-4 (0.3%), Type 3- 25(2.1), Type 4-3 (0.2%), Type 5- 142 (11.97%), Type 6- 2(0.1%), Type 7-0 (0.0%), Type 8-4 (0.3%), C-shaped-11 (0.92%), Gulabiwala Type 1-1 (0.08%) [Table/Fig-1].

Type 1- 761 (93.48%), Type 2- 12 (1.4%), Type 3- 2 (0.2%), Type 4-0, Type 5-32 (3.9%), Type 6, 7-0, Type 8-1 (0.1%), C-shaped-6 (0.7%),Gulabiwala Type 1-(0.0%) [Table/Fig-2].

DISCUSSION

A tenet that definitely applies to premolars, just like other teeth, is that the success rate of Endodontics is likely to be reduced if a root canal system is not adequately cleaned and obturated and that a complex anatomy of root canal system poses a challenge at every operatory step. Thus it is essential to assess the canal morphology in terms of number of canals present and the course of the canals before commencing the root canal treatment.

Several textbooks and studies portray Vertuccis Type I variation (single root canal with single apex) as the most common finding amongst all the types [1-3]. Although in different populations the occurrence of the Type I is common, percentage varies. This study on South Indian population involving regions of Karnataka, Goa and North Kerala showed 83.81% and 93.48% of mandibular first and second pre-molars respectively exhibiting Type I canal morphology respectively.

Yet, a study done on Chinese population by Lu et al., and Yang et al., showed only 54% and 86.8% of mandibular first premolars with a single canal respectively whereas only 22% and 97.2% in mandibular second premolars (vs 93.48% inour study on South Indian population) [11]. A similar CBCT study done by Salar Pour et al., and Kim et al., on Iranian and Korean population respectively also portrayed highest occurrence of Type I morphology in mandibular first and second pre-molars [12,13].

Vertucci had described the incidence of second canal (Type V) in mandibular first premolar as 26% [14] and this type was the next common variance seen in our studywith 11.97% and 3.9% in mandibular first and second premolars respectively. Similarly it was the second most frequent pattern of occurrence seen in Iranian population as well however the percentage varied (28.8% and 22% in mandibular first and second pre molars) [12].

Type III morphological variance was seen more in mandibular first premolar (2.1%) than second premolar (0.2%). The canal bifurcation in such variance can be better appreciated on a CBCT image, rather than paying focused attention to 'fast break' canal appearance on conventional radiograph. The rapid narrowing or the sudden disappearance of the canal on conventional radiographs needs meticulous notice.

C-shaped canals are always a tedious task to clean and obturate. Its occurrence is however common in mandibular second molars [1,2], certain percentage is also found in mandibular premolars. A higher existence was seen in Chinese population with 18% (first premolar) and 1.1% (second premolar) unlike 0.92% (first premolar) and 0.7% (second premolar) seen in ours [11]. However, the C-shaped canal was 14% in mandibular first premolars in a study Baisden et al., 10% and 18% by Sikri et al., and Lu et al., respectively [11,15,16]. The differences are due to ethnic and study design variants. The incidence of other types of Vertucci and Gulabiwala's Type I morphological variation was very low (0-1.4%) in our study.

The intricate internal anatomy of mandibular first premolars and an elevated frequency of congenital absence [17] can possibly be attributed to genetic pre-disposibility and/or evolutionary patterns. Missed root canals are often found during re-treatment and according to Pink and Hoen, missed canal contributes to 42% of the teeth that have been re-accessed for treatment [18]. Coronal calcification and dentine deposition were two common findings seen in the images of this study. Thus, magnification aids like loupes or microscope for endodontics, along with CBCT imaging can help seek a better endodontic treatment.

The various applications of CBCT in dental practice within specialties has been acknowledged by Alamri et al., in 2012 [19] and Endodontics secured the second position (25.6%) after Oral and Maxillofacial Surgery (26.3%) off all the different dental specialties [20,21]. Moreover, Neelakantan et al., [9] found similar results when they compared CBCT radiographic evaluation to four other methods in their morphological study.

CONCLUSION

Mandibular first and second premolars in South Indian population exhibited great variability in root canal morphology with Type 1 Vertucci's classification being most common followed by Type 5. CBCT imaging is of an advantage and an essential diagnostic tool in detecting complex variants than conventional routine radiography. A well- scanned image will portray all details and anomalies present, if any, and lead to successful endodontic treatment. However, it is every clinician's responsibility to outweigh benefits to risks posed for each patient before recommending CBCT imaging.

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