ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 2, Issue – 4, July – August - 2019, Page No. : 40 - 46

Variations in the root canal morphology of maxillary and mandibular second permanent molars among South Indian population using CBCT- an ex vivo study

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Type of Publication: Original Research Paper

Conflicts of Interest: Nil

Abstract

Context: The outcome of endodontic therapy is thoroughly based on the identification of all the root canals present. For this, a clinician must have a complete comprehensive understanding of the morphology of the root canal system in order to avoid clinical failures. This is however difficult as morphological variations in the internal root anatomy are highly variable and are influenced largely by ethnicity and genetic differences. It thus becomes essential to record the root canal anatomy patterns in different populations to provide a standardized data to the dentists for successful endodontic therapy.

Aim: The aim of the study was to study the variations in the root canal morphology of maxillary and mandibular second permanent molars among South Indian population using Cone Beam Computed Tomography (CBCT).

Materials and Methods : The study was designed as an *ex vivo* study and conducted with a total of 80 freshly extracted sound second permanent molar teeth (40- Maxillary second permanent molars, 40- Mandibular second permanent molars). The teeth included in the study were arranged as rows and columns in separate sheets of modelling wax and CBCT images were taken. The number of roots and the number of canals in each root were recorded and Vertucci's classification was used to evaluate the morphology of the root canal system in each tooth. The data thus obtained was tabulated and descriptive statistics was used to determine the frequency of occurrence of each class.

Results: Among all the maxillary second permanent molars assessed, all teeth had 3 roots and 60% had 3 canals, 37.5% had 4 canals and 2.5% had 5 canals. The most common type of palatal, mesiobuccal and distobuccal canals were all Vertucci's Type I. MB2 (mesiobuccal 2) canal was observed in 40% of the teeth and second distal canal in 2.5% of the teeth. Permanent mandibular second molars showed the presence of two roots in all the cases with the most common type of mesial canal being Vertuccis's Type IV and distal canal Type I. Middle mesial canal was present in 7.5% of the teeth

examined and one out of the forty teeth examined had a C shaped canal.

Conclusion: From the present study, we can conclude that a majority of the maxillary second molars have three roots and three canals and that of the mandibular second molars have two roots and three canals. Further consideration of additional canal patterns is vital and would enhance endodontic treatment outcome.

Cone Beam Computed Tomography, Endodontic therapy, Maxillary second permanent molars, Mandibular second permanent molars, Root canal morphology, South Indian Population, Vertucci's classification.

Introduction

Success of endodontic treatment is directly dependent on an accurate access, complete mechanical and chemical debridement of the root canal system and a three dimensional seal of the prepared canal (1). To achieve this, a clinician must have a thorough understanding of the root canal morphology in order to locate all the canals present. This is however a challenge due to the complexity of the root canal system and its anatomic variations (2). Thus, a complete knowledge on the canal morphology becomes crucial to avoid clinical failures (3).

Literature evidence shows the prevalence of marked variations in canal morphology of maxillary and mandibular second permanent molars. Several studies have reported that these morphological variations would be due to ethnicity and genetic differences (4, 5). Such population based literature, within the Indian community is very less. It therefore becomes imperative to identify and record the root canal anatomy patterns in the Indian population to provide a standardized data to the dentists for successful endodontic treatment.

The study of anatomy of root canals has been carried out by several researchers using various techniques including sectioning, canal staining by dye penetration and tooth clearing, plastic resin injection, conventional radiography, digital and contrast medium-enhanced radiography, post treatment clinical examination, in vitro macroscopic examination, in vivo root canal therapy with magnification , scanning electron microscopy evaluation, computed tomography techniques, micro-Computed Tomography and cone beam computed tomography (CBCT) (6-10).

Currently, cone beam computed tomography is the technique that is widely used to study the tooth anatomy. The limitations of traditional radiography includes inability to manipulate images, requirement of higher radiation dosage, and increased time between exposure and image interpretation have been largely overcome by the introduction of CBCT, which is capable of providing three-dimensional images of the teeth and their surrounding structures with regard to the three orthogonal planes in space (11-13). It has been a potential diagnostic tool with several advantages like lower effective radiation dose, shorter exposure time, less expensive than conventional computed tomographic imaging, high resolution, high accuracy and minimal distortion (14,15).

The aim of this study was to evaluate the root canal morphology of maxillary and mandibular second permanent molars in the Indian population using cone beam computed tomography.

Materials and Methods

The study was designed as an *ex vivo* study. It was conducted with a total of 80 freshly extracted sound second permanent molar teeth (40- Maxillary second permanent molars, 40- Mandibular second permanent molars). As the samples were not extracted for the purpose of this study, the exact data about age and sex of individual sources were unknown. Extracted teeth were collected, washed in water and cleaned with hydrogen peroxide. Fractured teeth, teeth with open apex and external root resorption were excluded from the study.

The selected maxillary and mandibular teeth were arranged as rows and columns in separate sheets of modelling wax and were ready to be imaged. CBCT images were taken using a Kodak 9500 (France) with standard exposure settings (60480mGy.cm^2 dose, 200µm*200µm* 200µm voxel size, 90kV, 10mA, 14.2s) and were viewed using software CS 3D Imaging v3.5.18. The teeth were analyzed in axial, coronal and sagittal planes. The number of roots and the number of canals in each root were recorded. The canal morphology of the root canal system was evaluated according to Vertucci's classification. The data thus obtained was tabulated and descriptive statistics was used to determine the frequency of occurrence of each class using IBM SPSS Statistics v 22.0 licensed package (IBM, Chicago, IL, USA).

Results

Table 1 shows the frequency of occurrence of the configurations of canals according to Vertucci's classification in the maxillary second permanent molars. The most common type of palatal, mesiobuccal and distobuccal canals are all Type I. The palatal canals showed Vertucci's Type I in 95% of the cases, 2.5% each of type II and type IV. 60% of the mesiobuccal canals are of Vertucci's type I, 22.5% Vertucci's type II and 17.5% vertucci's type IV. Majority of the distaobuccal canals (97.5%) are of the type I pattern and the remaining 2.5% of type IV.

Table 2 shows the configurations in the mandibular second permanent molars. A vast majority of the mesial canals were of type IV (57.5%), 10% of type III, 7.5% each of type I, type II, type V and type VIII. 77.5% of the distal canals were of Type I, 7.5% each of Type III and Type IV and 5% of Type II. There was one C shaped canal among the 40 teeth assessed.

Discussion

Diagnosis with advanced diagnostic aids and concomitant treatment planning play an integral role in patient management. Considering endodontic therapy, the number and location of root canals is of greater importance than the number of roots. Among the various techniques proposed to study the internal root morphology, tooth clearing techniques have generally been considered the golden standard. However, this technique is in-vitro that can be performed only in extracted teeth and is not useful clinically. With the advent of technology, it is possible for computed tomography to be used in the clinical evaluation of endodontic anatomy (16). Cone-beam computed tomography as an exceptionally accurate and non-invasive imaging modality is highly efficacious for the evaluation of root canal morphology and its variations.

Literature evidence has revealed more variations in the root number and root canal patterns of the second molars than the first molars (17,18). Assessment of the canal morphologies of maxillary and mandibular second molars among Indian population has been very less in the past. The present study evaluated the morphological variations in the root canal systems of maxillary and mandibular second permanent molars using Vertuccis's classification among South Indian population. The system of canal configurations proposed by Vertuccietal (19) together with supplemental configuration types has been the most widely used and commonly incorporated classification in literature, and thus was used in this study.

Among all the maxillary second permanent molars assessed, all teeth have 3 roots. This demonstrates a higher prevalence of the three root configuration in the second maxillary molars compared to the studies conducted in the Thai, Burmese and Polish population (20-22). Such differences emphasize the influence ethnic background has on tooth root morphology. Considering the number of

root canals present, 60% had 3 canals, 37.5% had 4 canals and 2.5% had 5 canals.

The results of the current study showed that according to Vertucci's classification, the most common type of palatal, mesiobuccal and distobuccal canals were all Type I. A similar study in the Iranian population by Mandana et al (23) demonstrated Type I as the most common type in the distobuccal and palatal roots, whereas most of the mesiobuccal canals were 2 in number.

In the present study MB2 (mesiobuccal 2) canal was observed in 40% of the teeth and second distal canal in 2.5% of the teeth. A similar study conducted among the Irish population reported a higher prevalence of the MB2 canal in the second maxillary molars (58%) compared to the present study (24); however, in the contrary, a clinical study in the Saudi Arabian population concluded a low frequency of MB2 in second molars (19.7%) (25).The outcome of endodontic therapy is largely dependent on the identification and treatment of the MB2 canal (26,27). When left undetected, it leads to irresolution of the periapical inflammation (27). Shetty et al (27) has reported the presence of periapical radiolucencies in unfilled MB2 canals in 88.8% of the maxillary second molars.

Analysis of permanent mandibular second molars showed the presence of two roots (mesial and distal) in all the cases. Pawar et al (28), in his in vivo study in the Indian population has recorded that the two root configuration was most common (79.35%) and 7.53% had three roots, whereas 13.12% of the studied teeth had fused roots with C-shaped canals. The most common type of mesial canal in our study was Vertuccis's Type IV (57.5%), followed by Type III (10%); whereas the most common type of distal canal is Type I (77.5%) followed by Type III and Type IV (7.5%). Middle mesial canal was present in 7.5% of the teeth examined.

In the current study, one out of the forty teeth examined had a C shaped canal, whereas Aishwarya et al's (29) study among the Asian population concluded that East Asians showed the maximum prevalence of C-shaped canal of 93.1% from China, 52% from Hong Kong, and 45.5% from Korea followed by West Asia of 34.37% from UAE, Southeast Asia of 22% from Burma and least in the South Asian population of 7.5% from India.

Knowledge of such unique canal configurations promote the efficiency of canal identification and aid in prevention of unnecessary removal of healthy tooth structure in the attempt of searching missing canals. Meticulous diagnosis and complete understanding of the canal configuration not only help in treatment planning but also improve the overall prognosis of the case. The results of this study would help dentists have a valuable perspective of the root canal morphology and its variations in the maxillary and mandibular second permanent molars. However, CBCT involves higher radiation exposure than two dimensional imaging. Thus justification of CBCT usage for clinical cases must be more substantiated. It is also imperative to consider a wider sample size for superior clinical establishment.

Conclusion

Within the limits of the current study, it can be concluded that the variations in canal configurations in the maxillary and mandibular second permanent molars are unique to the Indian Population and are different from the other communities. A majority of the maxillary second molars have three roots and three canals and that of the mandibular second molars have two roots and three canals. Consideration of additional canals namely MB2, middle mesial and C shaped canals are important during root canal treatment as they largely determine the success of endodontic therapy.

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Table 1: Frequency of occurrence of canals according to Vertucci's classification in maxillary permanent second molars

Maxillary Molars						
Vertuccis's	Palatal canal		Mesial Canal		Distal Canal	
Classification	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	38	95	24	60	39	97.5
2	1	2.5	9	22.5		
4	1	2.5	7	17.5	1	2.5
Total	40	100	40	100	40	100

Table 2: Frequency of occurrence of canals according to Vertucci's classification in mandibular permanent second molars

Mandibular Molars				
Vertucci's	Mesial Canal		Distal Canal	
Classification	Frequency	Percent	Frequency	Percent
1	3	7.5	31	77.5
2	3	7.5	2	5
3	4	10	3	7.5
4	23	57.5	3	7.5
5	3	7.5		
8	3	7.5		
C Shape		2.5	1	2.5
Total	40	100	40	100