Published online: 2019-09-23

Original Article

Retrospective study of root canal configurations of maxillary third molars in Central India population using cone beam computed tomography Part- I

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ABSTRACT

Objective: The aim of this study was to investigate the root and canal morphology of maxillary third molars in Central India population using cone-beam computed tomography (CBCT) analysis. **Materials and Methods:** CBCT images of 116 maxillary third molars were observed, and data regarding the number of roots, the number of canals, and Vertucci's Classification in each root was statistically evaluated. **Results:** Majority of Maxillary third molars had three roots (55.2%) and three canals (37.9%). Most MB root (43.8%), DB root (87.5%), and palatal root (100%) of maxillary third molars had Vertucci Type I. Mesiobuccal root of three-rooted maxillary third molars had Vertucci Type I (43.8%) and Type IV (40.6%) configuration. Overall prevalence of C-shaped canals in maxillary third molars was 3.4%. **Conclusion:** There was a high prevalence of three-rooted maxillary molars with three canals.

Key words: C-shaped, cone beam computed tomography, maxillary third molar, root canal morphology, Vertucci

INTRODUCTION

Successful root canal treatment consists of the proper access opening, chemicomechanical preparation and debridement, followed by complete sealing of all the avenues of micro leakage of the root canal system.[1]

Therefore thorough knowledge of root canal anatomy is important. Any variation in root canal morphology should be recognized before or during root canal treatment.[2] An untreated canal, which a clinician fails to detect, may be a cause of failure. Various methods to assess the internal anatomy of root canal systems are: (i) Conventional radiographs (ii) canal staining and tooth clearing (iii) plastic resin injection (iv) digital and contrast medium enhanced radiographic techniques (v) sectioning (vi) *in vitro* microscopic examination (vii) computed tomography (CT) techniques (vii) micro-CT and (viii) cone beam CT (CBCT).[3]

CBCT was developed in the late 1990s by Italian and Japanese groups to produce undistorted three-dimensional images of the teeth and their

How to cite this article: Rawtiya M, Somasundaram P, Wadhwani S, Munuga S, Agarwal M, Sethi P. Retrospective study of root canal configurations of maxillary third molars in Central India population using cone beam computed tomography Part- I. Eur J Dent 2016;10:97-102.

DOI: 10.4103/1305-7456.175690

surrounding tissues.[4,5] It helps in visualizing the number of root canals and their convergence or divergence from each other.

The principle goal of endodontic therapy is to retain every functional component of the dental arch, including third molars.[6] They often require endodontic treatment for restorative, prosthodontic, and orthodontic considerations. They are often used as abutment teeth for fixed partial denture. Third molars are also used in autotransplantation procedures to replace nonrestorable teeth.[7,8]

Few studies have been done to study the morphology of maxillary third molars.[9] When reviewing the literature regarding root and canal morphology using the Pub Med Database (National Library of Medicine), there were no studies on the root canal morphology utilizing CBCT images of permanent maxillary third molar in Indian population.

The aim of this study was to investigate the root canal morphology of maxillary third molars and to evaluate the number of roots and canals and classify them according to Vertucci.

MATERIALS AND METHODS

A retrospective study of CBCT (KODAK CS. 9000C 3D, 70 kVp, 10 mA, 36 s scan time, 10.8 s exposure time, 5 cm diameter–5 cm height scan volume, France) images of 325 patients who presented at a private clinic for various dental problems in Bhopal between June 2011 and March 2015 was done. All CBCT image was observed and evaluated for the presence and absence of maxillary third molars. The scans were produced by a technician according to the manufacturer's recommended protocol using a minimum field of view of 40 mm × 40 mm or 60 mm × 60 mm and lowest dose radiation. The CBCT images were analyzed with the inbuilt CS3D imaging software (NNT) in a HP workstation (HP Compaq LE 1911) with a 19 inch HP LED screen with a resolution of 1280 × 1024 pixels on a dual monitor. The images were visually enhanced by adjusting contrast, brightness and grey scale using the image processing tool in the software to ensure better visualization. Three endodontists and a trained technician concurrently evaluated all the images to reach an agreement in the interpretation of the radiographic findings. Type of canal configuration, presence of extra root and numbers of canals were evaluated using the NNT toolbar by carefully rolling downward through the images from the pulp chamber to the root apex at the axial tomographic slices. The images were rotated in the entire axis, and slices were taken in all the three planes, coronal, sagittal, and axial planes to confirm the findings.

Selection criteria for the third molar were (i) Completely erupted maxillary third molars (ii) third molars with no periapical lesions; (ii) no endodontic treatment performed (ii) no root canals with open apices, resorption or calcification; and (iii) the CBCT images of good quality. The teeth with root canal fillings, restorations, posts, or crowns were excluded from the study. The final sample group included data from 116 patients (66 males and 50 females).

Following information from the individual images was recorded (i) the number of roots and their morphology; (ii) the number of canals per tooth; (iii) the canal configuration in each root using Vertucci's classification;[10] and (iv) the frequency of additional roots and the frequency of C-shaped canals in the third molars. Frequency and percentage of variables were calculated using Statistical Package for Social Sciences (SPSS v.21.0, IBM, Armonk, New York) version 21.0 and data was further analyzed by Pearson Chi-square test and Fisher's exact test.

RESULTS

The study was performed on 116 maxillary third molars using CBCT scans. 56.9% of the teeth belong to males, and 43.1% were of females, 43.1% were of right side, and 56.9% were of the left side. Maximum maxillary third molars (n = 116) had three root (55.2%) followed by one root (31.0%) and two roots (13.0%). Analysis of number of canals revealed that maximum number of maxillary third molars had 3 canals (37.9%) followed by 04 canals (24.1%) and 1 canal (19%), 3.4% of teeth had 5 canals. In single rooted maxillary third molar, Vertucci Type I (47.1%) was predominant. Most of the double-rooted teeth have Vertucci Type I (42.9%) and Type IV (42.9%) in buccal root and Type I in the palatal root (62.5%). Mesiobuccal root of three-rooted maxillary third molars had Type I (43.8%) and Type IV (40.6%), distobuccal root and palatal root had Type I (87.5% and 100%), respectively [Table 1].

Comparison of Vertucci classification revealed that Type I was prevalent in both males and females in single rooted maxillary third molars, and the difference was statistically significant.

The percentages of other Vertucci Types in males were Type IV (14.3%), V (28.6%), and VI (14.3%) and in females were Type II (30.0%) and Type III (20.0%). In double-rooted teeth, buccal root had Type I (75%) predominant in males as compared to females where Type IV (66.7%) was predominant. In distobuccal root, Vertucci Type I was predominant in both males (85.7%) and females (90.9%) [Table 2].

When Vertucci classification of canals in maxillary third molars was compared between the right and left side of the oral cavity, it showed that in single rooted teeth Type I was predominant in both the sides. Type II was present in 14.3% right side and 20% left side teeth. Type V classification was observed in 28.6% of right side single rooted teeth whereas in left side 20% were Type III, 10% were and Type IV. Chi-square test showed a significant difference between the right and left side of the oral cavity. In double-rooted maxillary third molar, Vertucci Type I and Type IV was predominant in left side whereas on the right side Type I, Type II, and Type IV were equally present, and the difference was not statistically significant.

In three-rooted maxillary third molars in mesiobuccal root, Vertucci Type IV (46.7%) was predominant on right side as compared to left side whereas Type I (58.8%) were predominant, and the result was statistically significant ($P = 0.013$). In distobuccal root on both sides, Type I was predominant (left = 82.4% and right 93.3%). Moreover, it was not significant statistically [Table 3]. Overall prevalence of C-shaped canals in maxillary third molars was 3.4%. None of the 3 rooted third molars had C-shaped canal.

DISCUSSION

Third molars have been associated with greater variation in root patterns and canal morphology.[11] These variations in the root canal morphology are thought to be racially and genetically determined.[12] Therefore, it is necessary to investigate variations in tooth anatomy and their characteristic features in different racial groups.

The multiplanar CBCT scans obtained from axial sections of 116 maxillary third molars revealed that frequency of three-rooted maxillary third molars was maximum (55.2%) followed by one root (31.0%) [Figure 1] and two roots (13.8%). Similar results were observed in Burmese population by clearing technique where 51% of teeth had three

Table 1: Vertucci classification of canals in maxillary third molars

No. of roots	Root type	Vertucci classification						Total
		Type I	Type II	Type III	Type IV	Type V	Type VI	
01	-	16 (47.1)	06 (17.6)	04 (11.8)	02 (5.9)	04 (11.8)	02 (5.9)	34 (100.0)
02	Buccal	06 (42.9)	02 (14.3)	00 (0.0)	06 (42.9)	00 (0.0)	00 (0.0)	14 (100.0)
	Palatal	10 (62.5)	00 (0.0)	00 (0.0)	06 (37.5)	00 (0.0)	00 (0.0)	16 (100.0)
03	Mesio-buccal	28 (43.8)	10 (15.6)	00 (0.0)	26 (40.6)	00 (0.0)	00 (0.0)	64 (100.0)
	Disto-buccal	56 (87.5)	02 (3.1)	00 (0.0)	06 (9.4)	00 (0.0)	00 (0.0)	64 (100.0)
	Palatal	64 (100.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	64 (100.0)

Table 2: Vertucci classification of canals in maxillary third molars according to gender

No. of roots	Root type	Gender *n* (%)	Vertucci classification							Test of significance
			Type I	Type II	Type III	Type IV	Type V	Type VI	Total	
01	-	Male	06 (42.9)	00 (0.0)	00 (0.0)	02 (14.3)	04 (28.6)	02 (14.3)	14 (100.0)	χ^2=18.518
		Female	10 (50.0)	06 (30.0)	04 (20.0)	00 (0.0)	00 (0.0)	00 (0.0)	20 (100.0)	*P*=0.002, S
02	Buccal	Male	06 (75.0)	00 (0.0)	00 (0.0)	02 (25.0)	00 (0.0)	00 (0.0)	08 (100.0)	χ^2=8.556
		Female	00 (0.0)	02 (33.3)	00 (0.0)	04 (66.7)	00 (0.0)	00 (0.0)	06 (100.0)	*P*=0.014, S
	Palatal	Male	06 (60.0)	00 (0.0)	00 (0.0)	04 (40.0)	00 (0.0)	00 (0.0)	10 (100.0)	Fisher's exact test
		Female	04 (66.7)	00 (0.0)	00 (0.0)	02 (33.3)	00 (0.0)	00 (0.0)	06 (100.0)	*P*=1.000, NS
03	Mesio-buccal	Male	16 (38.1)	06 (14.3)	00 (0.0)	20 (47.6)	00 (0.0)	00 (0.0)	42 (100.0)	χ^2=2.504
		Female	12 (54.5)	04 (18.2)	00 (0.0)	06 (27.3)	00 (0.0)	00 (0.0)	22 (100.0)	*P*=0.286, NS
	Disto-buccal	Male	36 (85.7)	02 (4.8)	00 (0.0)	04 (9.5)	00 (0.0)	00 (0.0)	42 (100.0)	χ^2=1.095
		Female	20 (90.9)	00 (0.0)	00 (0.0)	02 (9.1)	00 (0.0)	00 (0.0)	22 (100.0)	*P*=0.578, NS
	Palatal	Male	42 (100.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	42 (100.0)	Not applicable
		Female	22 (100.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	22 (100.0)	

*χ^2=Chi-square test, S: Significant, NS: Not significant

separate roots, and 49% had fused roots.[13] A study conducted by Ng *et al*. in the same population using canal staining and tooth clearing technique showed 25% had three roots, and 31% had fused roots.[14]

In the present study, maximum maxillary third molars showed 3 canals (37.9%) followed by 4 canals (24.1%) [Figures 2 and 3] and 1 canal (19%). 3.4% of teeth had 5 canals. The majority of palatal (100%) and distobuccal (96%) roots possessed one canal (Type I). According to literature, Vertucci Type I was more common in distobuccal root (98.1%) and palatal root (100%).[13,14]

Mesiobuccal root shows considerable morphological variations in Vertucci classification. A conventional radiograph can detect only 55% of MB2 due to the superimposition of anatomic structures in a buccolingual plane which fail to detect small structural density changes.[15] Stropko[16] found 20.0% of third molars had MB2, whereas it was 37% in a study done by Green.[17] Most of MB2 were Vertucci Type II and Type IV. The prevalence of mesiobuccal roots with two canals molars was 39% with Vertucci Type II and Type IV configurations.[14]

Study conducted on maxillary molars in South Asian Indian population using clearing technique showed that mesiobuccal roots of maxillary third molars exhibited 57.4% had Type I, 32% had Type II, 2.1% had Type III, 8.5% had Type IV, and 1% had Type V canal anatomy.[18]

In this study, single rooted maxillary third molars, the palatal root of double-rooted maxillary third molars, and all three roots of a triple rooted maxillary third molars most common type of canals were Vertucci Type I according to Vertucci classification. In buccal root of double-rooted maxillary teeth, the most common type was Vertucci Type I and Type IV.

Table 3: Vertucci classification of canals in maxillary third molars according to tooth position

No. of roots	Root type	Gender *n* (%)	Vertucci classification							Test of significance
			Type I	Type II	Type III	Type IV	Type V	Type VI	Total	
01	-	Right	08 (57.1)	02 (14.3)	00 (0.0)	00 (0.0)	04 (28.6)	00 (0.0)	14 (100.0)	χ^2=11.981
		Left	08 (40.0)	04 (20.0)	04 (20.0)	02 (10.0)	00 (0.0)	02 (10.0)	20 (100.0)	*P*=0.035, S
02	Buccal	Right	02 (33.3)	02 (33.3)	00 (0.0)	02 (33.3)	00 (0.0)	00 (0.0)	06 (100.0)	χ^2=3.111
		Left	04 (50.0)	00 (0.0)	00 (0.0)	04 (50.0)	00 (0.0)	00 (0.0)	08 (100.0)	*P*=0.211, NS
	Palatal	Right	02 (33.3)	00 (0.0)	00 (0.0)	04 (66.7)	00 (0.0)	00 (0.0)	06 (100.0)	Fisher's Exact Test
		Left	08 (80.0)	00 (0.0)	00 (0.0)	02 (20.0)	00 (0.0)	00 (0.0)	10 (100.0)	*P*=0.118, NS
03	Mesio-buccal	Right	08 (26.7)	08 (26.7)	00 (0.0)	14 (46.7)	00 (0.0)	00 (0.0)	30 (100.0)	χ^2=8.681
		Left	20 (58.8)	02 (5.9)	00 (0.0)	12 (35.3)	00 (0.0)	00 (0.0)	34 (100.0)	*P*=0.013, S
	Disto-buccal	Right	28 (93.3)	00 (0.0)	00 (0.0)	02 (6.7)	00 (0.0)	00 (0.0)	30 (100.0)	χ^2=2.426
		Left	28 (82.4)	02 (5.9)	00 (0.0)	04 (11.8)	00 (0.0)	00 (0.0)	34 (100.0)	*P*=0.297, NS
	Palatal	Right	30 (100.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	30 (100.0)	Not applicable
		Left	34 (100.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	00 (0.0)	34 (100.0)	

*χ^2=Chi-square test, S: Significant, NS: Not significant

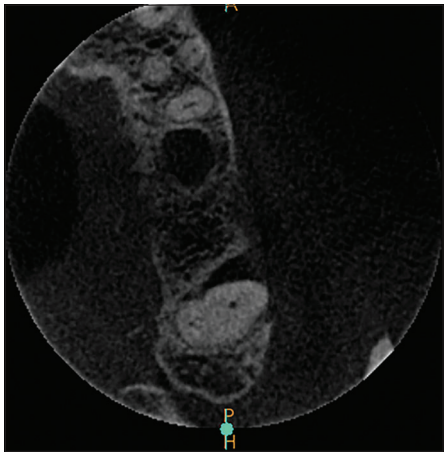

Figure 1: Cone beam computed tomography image showing two canals in single rooted third molar

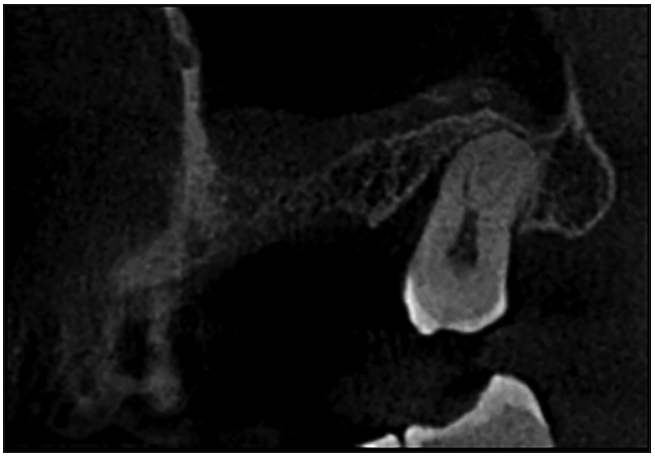

Figure 2: Cone beam computed tomography image of maxillary third molar showing Vertucci V configuration

This is consistent with the findings of previous studies.[19]

A similar retrospective study in mandibular molars in a Turkish population using CBCT showed that majority of mandibular molars were two rooted with three canals. Mesial roots had more complex canal systems with more than one canal, whereas most distal roots had a Type I configurations.[20]

Gender predilection for the prevalence of Vertucci Type showed that Vertucci Type I was predominant in single rooted teeth in both males and females. Few studies have reported the prevalence of Vertucci Type in maxillary third molars.[21] Previous reports found no significant difference in third molar development between males and females.[22] Topological predilection of Vertucci classification revealed that three rooted maxillary third molars showed mesiobuccal root Vertucci Type IV (46.7%) predominant on right side in mesiobuccal root as compared to left side whereas Type I (58.8%) were predominant and the result was statistically significant (P = 0.013).[23]

Prevalence of C-shaped canals in maxillary third molars was 3.4% in this study [Figures 4 and 5]. According to Sidow *et al*., 4.67% were identified in maxillary third molars (all of them were double-rooted).[24]

CBCT offer high-resolution isotropic images which helps in identification of canals which is not possible in conventional radiograph if canal cortication is lost. It offers three-dimensional geometric accuracy compared with conventional radiographs without superimposition of anatomical structures where data can be reoriented in their true spatial relationships.[24] However, consideration to use CBCT should only be done when the conventional periapical radiographs fail to provide adequate information about the area of interest, as CBCT views may also show some misleading findings.[25,26]

CONCLUSION

According to this study, maxillary third molars show great anatomic variability. There was a high prevalence of three-rooted maxillary molars with three canals in Central India population. Vertucci Type I classification was most common in single rooted maxillary molars, Distobuccal roots and palatal roots of three-rooted maxillary third molars. Mesiobuccal roots show maximum variations by having Vertucci Type I and Type IV. C-shaped canal in maxillary third molar was a rare finding. Further studies should be performed to confirm the findings in Central India population.

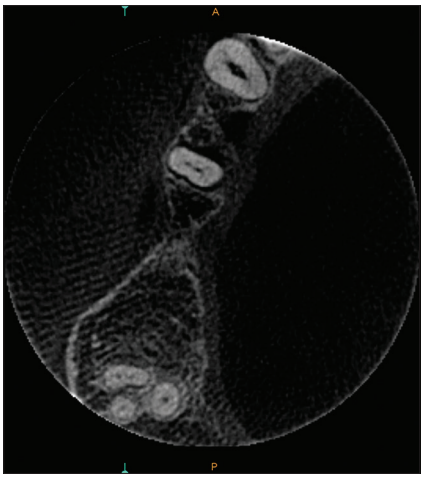

Figure 3: Cone beam computed tomography image showing maxillary third molar with MB2

Figure 4: Cone beam computed tomography image showing C-shaped canal in maxillary third molar

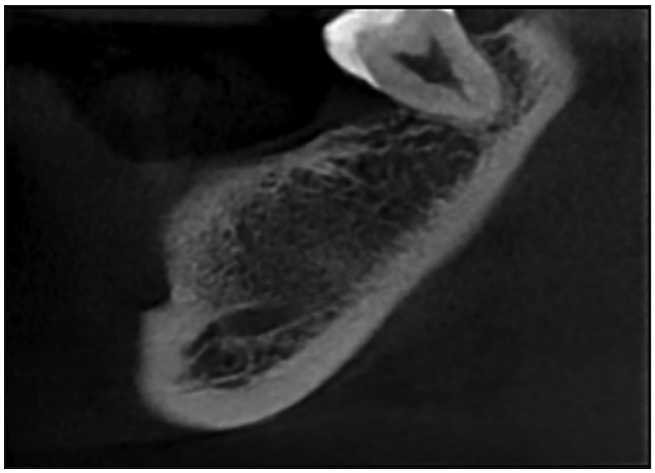

Figure 5: Cone beam computed tomography image of sagital view of C-shaped canal

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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