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Evaluation of The Root Morphology of Maxillary Permanent First And Second Molars in An Indian Subpopulation Using Cone-Beam Computed Tomography.

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Abstract:
Introduction
Teeth included were radiographically examined by Cone-beam computed tomography (CBCT) for
1. *Number and Morphology of roots.*
2. *Primary variations in the morphology of the root canal systems.*
3. *The presence of MB2 canals in molars according to patient's age and gender.*
Result: *The most common morphologic feature was three separate roots. Its percentage was higher in maxillary first than second molars.*
Maxillary second molars showed higher root morphologic variations. Variations such as one root with one/three/five canals, two fused with one separate root were seen in maxillary second molars.
Presence of MB2 canal was seen in 55.72% and 17.39% in mesio-buccal root of maxillary first and second molars respectively. Presence of MB2 canal was seen more in age group between 15-34 years. Prevalence of MB2 canal in both molars was found to be almost equal in males and females.
Conclusion: *CBCT scans can be useful diagnostic tools in endodontic practices. CBCT facilitates the identification of root and canal configuration. Anatomic variations should be considered during root canal treatment of maxillary molars, which could potentially facilitate root canal therapy.*
Key words: C*BCT, Maxillary molars, root canal anatomy*

I. Introduction

The ultimate objective of endodontic therapy is to restore the integrity and state of good health of the treated tooth. The long-term success of endodontic therapy depends greatly on ability to locate and identify all canals present. A thorough knowledge of both the external and internal anatomy of teeth is required. Extra roots and root canals if not detected are the major reason for failure of root canal treatment. [1] CBCT imaging has the potential to become the first choice for endodontic treatment. [2]In this study, CBCT has been used to study complexities in root canal anatomy of maxillary first and second molars in an Indian subpopulation.

II. Materials and methods

2.1 Source of data

CBCT images of 201 maxillary first molars and 207 maxillary second molars were collected from 179 patients' cone beam computed tomography reports. These patients required tomographic examination using CBCT imaging during process of their diagnosis and treatment planning.
Written and verbal consent from each patient was obtained. The data was collected from the Department of Oral Medicine and Radiology, D. Y. Patil University, School of Dentistry (Navi Mumbai) and Radiological & Imaging center (Mumbai).
There were 84 women and 95 men with a mean age of 37.36 years (ranging from 16 years to 72 years).

2.2 Selection criteria

- 201 maxillary first molars and 207 maxillary second molars with fully developed roots.
- No root canals with open apices, absorption or calcification.
- No root canal treated teeth.
- Good quality of CBCT images.

2.3 Armamentarium

- 179 patients' cone beam computed tomography reports.
- Kodak 9000 3D Extraoral imaging system. (CS 3D imaging software)
- iCAT Platinum CBCT machine. (i-CAT vision) (1.9.3.14)
- Laptop to view the reports. (Macbook Pro 13inch)

Depending on the system employed, maxillofacial CBCT can be performed with the patient in three possible positions: (1) sitting, (2) standing, and (3) supine. Units were used in this study were sitting and standing. The CBCT images taken using a Kodak 9000 3D extraoral imaging system using CS 3D imaging software 3.3.11 at 88 kV and 8 mA, and the exposure time was 10.8 sec. The voxel size was 76µ. According to examination requirements the field of view 5cm × 3cm was selected.

CBCT images were also taken with iCAT Platinum machine using i-CAT vision (1.9.3.14 version) at 120kV and 5mA, and the exposure time was 7 sec. Field of view 8cm × 8cm was selected. The voxel size was 1.25µ.

CBCT Sans were made according to the manufacturer's recommended protocol. All the CBCT imaging was carried out by an appropriately licensed radiologist with the minimum exposure necessary for the adequate image quality. The ALARA (as low as reasonably achievable) protocol was strictly followed. The lowest dose radiation and radiation field was guaranteed.

2.4 Evaluation of the images

The CBCT images were viewed and analyzed using a MacBook Pro workstation (Mac OS X, Apple), with a 13-inch LCD screen. Contrast and brightness of images were adjusted using the image-processing tool of the software to ensure optimal visualization. Teeth were viewed and studied using orthogonal slicing, oblique slicing and curved slicing.

Teeth included were radiographically examined by CBCT for

1. Number and Morphology of roots in the maxillary first and second molars. [3]
2. Primary variations in the morphology of the root canal systems of maxillary first and second molars. [4]
3. The presence of MB2 canals in Maxillary first and second molars according to patient's age and gender.

2.5 Statistical Analysis

The statistical analysis was performed by using the Chi-square test.

III. Result

The results from 179 patients showed many variations. According to Yemi Kim's classification, the morphology of roots is not equally distributed in the maxillary first and second molars.[3] 3 separate roots (3S) are significantly more in maxillary first and second molars. [Graph 1]

Primary Variations in the morphology of the root canal systems of Maxillary First and Second Molars according Emmanuel Silva's classification are not equally distributed.[4] Variant 9 is significantly more in maxillary first & second molars. [Graph 2], [Fig 1]

Presence of MB 2 canal in maxillary molars is not equally distributed in all the age groups. It is significant in the age group of 15-34 yrs in maxillary first molars; whereas in maxillary second molars it is significant in the age group of 15-34 yrs and 35 – 54 yrs. [Table 1, 2]

p-value for the maxillary first molars with 3 roots is greater than that of 0.05 indicates that they are almost equally distributed in Males and Females, while p-value for the maxillary second molars is less than that of 0.05 indicates that they are significantly more in males than females.[Graph 3 & 4]

The presence of MB2 canal in maxillary first and second molars is equally distributed in Males and Females [Graph 3 & 4]

IV. Discussion

According to classification given by Yemi Kim et al and results given in [table 3 & 4], 3 separate roots was the most common morphology found in maxillary first (97.5%) and maxillary second molars (82.6%). The evidence of this morphology found in maxillary first and second molars is in concurrence with previous studies. [5,6,7] In comparison to an earlier study in an Indian population, in this study percentage of three separate roots in maxillary second molars was less (82.6%).[6] It was statistically significant ($p<0.05$). The percentage of single rooted molar teeth was 0.5% in maxillary first and 4.8% in maxillary second molars. Single- rooted first and second molars were identified in 0.9% of the teeth in an earlier study.[6]

2 separate roots, a buccal and a palatal, with 1 canal in each root was the second most common root morphology found in maxillary first molar (1.0 %) and second molar (7.2%). This type of root morphology was noticed in an Irish population by Shalabi et al. In his study there was fusion of roots associated with increasing

age was noted. [8] A higher percentage (42.25%) of fused roots in maxillary second molars was reported in a Chinese population by Zhang et al. In our study the incidence of fused roots in maxillary second molars (5.3%) was higher in comparison to the maxillary first molars (1.0%). Fusion of roots was an interesting finding in our study, as earlier studies among an Indian population have reported no evidence of fused roots in maxillary molars. [6,9]

In our study, (1.0%) maxillary first molars and (5.3%) maxillary second molars showed 2 fused roots with 1 separate root. Yemi Kim et al also reported the incidence of this morphology in Korean population.[3]

Infrequently, but on occasion maxillary first molars can exhibit extra canals in their roots. [10] Randy L. Ball reported a case of Taurodontism in the maxillary first molar with five canals using Kodak 9000 CBCT machine. [11]In this study out of 179 patients only one patient (Tooth no. 26, 27) showed taurodontism. Maxillary first molar (tooth no.26) showed one root with 5 canals and maxillary second molar (tooth no.27) showed one root with 3 canals. [Fig. 2]

The mesiobuccal root has generated more research and clinical investigation than any other root in the human dentition. Not all MB-2 orifices lead to a true canal. A true MB-2 orifice in which secondary orifice was identified was present in 84% of the molars.

Certain factors contribute to the wide variations reported in the incidence of an MB2 canal in MB roots of maxillary molars. These include race, age, and gender of the population studied, as well as the methods of research. [12] In present study the percentage of MB2 (Variant 9) was 55.72% in maxillary first molars and 17.39% in maxillary second molars. [Table 4] It was noted in our study that the percentage of MB2 in the maxillary first molars was higher than the maxillary second molars. [Table 5] This was seen in previous studies reporting presence of MB2 canals.[5,12] According to Qing- hua et al most reported incidences MB2 in the mesiobuccal root exceeds 50%. [7] In a North-East Indian population Atool Bhuyan et al reported the prevalence of more than 65% of MB2 canals in maxillary first molars. [9] The presence of two MB systems communicate frequently along their lengths and terminate separately in two or more ports of exit greater than 58% of the time. Hence, the clinician must assume that all maxillary first molars have four canals until proven otherwise. [10]

Age was found to have an effect on the incidence of MB2 canal of mesiobuccal root. In present study, age group (15-34 yrs.) and (35-54 yrs.) showed more number of MB2 canal in maxillary first and second molars than age group above 54 years. (Table 1 & Table 2) The mesiobuccal root of first molars in patients between 20 and 30 years of age showed a significantly higher prevalence of additional canals than those of the other age groups. The lowest frequency (40%) of additional canals was found in the group of patients who were more than 60 years of age. [7] Jin-Hee Lee et al stated that frequency of MB2 canals decreased with age in maxillary first and second molars. The maxillary first molars in subjects 30-40 year old and the maxillary second molars in subjects 10-20 years old showed the highest frequency of the MB2 canals. [12] In this study too, age has an influence on the presence or absence of extra canals in the root canal system and was found to be statistically significant ($p<0.05$).

Sert and Bayirli concluded that gender and race were important factors to consider in preoperative evaluation of canal morphology for root canal therapy. [13] Qing-hua Zheng et al found the incidence of additional canals in the mesiobuccal root was 54.27% for men and 50.00% for women. [7] Jin-Hee Lee et al showed a significant relationship between gender and the incidence of the MB2 canal only in maxillary second molars (48.7% in men and 30.8% in women). [12] In present study, prevalence of MB2 canal in mesiobuccal root is almost equally distributed in males and females for maxillary first and second molars. [Table 6 & 7] However, the percentage of presence of 3 separate roots (3S) in maxillary second molars was higher in males compared to females and on chi-square test, it was statistically significant. [Table 7 & Graph 4] So, the gender of patient is an important consideration in observing the morphology of roots of second molars.

CBCT favors the detection of anatomical details with more accuracy when compared to other techniques as it allows a three-dimensional view, facilitating the recognition of the number of channels as well as the ability to form a large number of sections of images in the sagittal, coronal & axial axis. [14]

However, the risk of radiation should be considered while planning a CBCT evaluation. [15]

Increasing availability of this technology provides the dental clinician with an imaging modality capable of providing a 3-dimensional representation of the variations while treating the population in a particular region.

V. Conclusion

CBCT facilitates the identification of root and canal configuration. The present retrospective study shows that the Indian subpopulation has a higher prevalence of 3-rooted first and second molars. The MB roots of maxillary molar teeth had more variation in their canal system than the other roots. The root canal configuration of the maxillary second molars was more variable than that of the first molars in an Indian subpopulation. These anatomic variations should be considered during root canal treatment of maxillary molars, which could potentially facilitate root canal therapy.

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Table 1: The presence of MB2 canals in First Maxillary Molars according to patient's age.

Age (Y)	No. Of Patients	No. Of teeth	Presence of MB2	Percentage
15-34	79	110	67	60.91%
35-54	54	70	38	54.28%
55-74	15	21	7	33.33%

Table 2: The presence of MB2 canals in Second Maxillary Molars according to patient's age.

Age (Y)	No. Of Patients	No. Of teeth	Presence of MB2	Percentage
15-34	65	104	18	17.31%
35-54	60	85	16	18.82%
55-74	13	18	2	11.11%

Table 3: Number and Morphology of roots in the Maxillary First and Second Molars according to Yemi Kim et al.[3]

No. & Morphology	Maxillary 1st Molar (n)	Percentage	Maxillary 2nd Molar (n)	Percentage
1S	1	0.5%	10	4.8%
2S	2	1.0%	15	7.2%
3S	196	97.5%	171	82.6%
2F 1S	2	1.0%	11	5.3%
4S	0	0%	0	0%
2F 2S	0	0%	0	0%
2F	0	0%	0	0%
3F	0	0%	0	0%
Chi-square test value	563.677		366.662	
d. f.	3		3	
P-value	.000		.000	

% -Percentage of total number of teeth examine

Table 4: Primary Variations in the morphology of the root canal systems of Maxillary First and Second Molars according to Emmanuel Silva et al.[4]

Variants	Maxillary 1st Molar (n)	Percentage	Maxillary 2nd Molar (n)	Percentage
1	0	0%	8	3.8%
2	0	0%	1	.5%
3	0	0%	1	.5%
4	2	1.0%	16	7.6%
5	2	1.0%	0	0%
6	0	0%	4	1.9%
7	0	0%	0	0%
8	84	42.0%	134	63.8%
9	112	56.0%	36	17.1%
10	0	0%	0	0%
11	0	0%	10	4.8%
Total	200*		210**	
Chi-square test value	192.160[a]		540.095[a]	
d.f.	3		7	
P-value	.000		.000	

% - Percentage of total number of teeth examined.

* – 1 maxillary first permanent molar could not fit into this classification hence the number 200 and not 201

** – 3 maxillary second molars showed double variations hence the number 210 and not 207.

Table 5: Distribution of MB2 in Maxillary First & Second Molars

	Maxillary First Molar	Maxillary Second Molar
Total no. Of Teeth	201	207
No. Of teeth with MB2	112	36
Percentage	55.72%	17.39 %

Table 6: Distribution of three separate roots and MB2 canals in maxillary first molar teeth according to patient's sex.

Sample	Female (n)	%	Male (n)	%	Total (n)	%	Chi-square test value	p-value
Total Teeth	101		100		201			
Teeth with 3 separate roots	100	99	96	96	196	97.51	0.043	0.830
MB2 Present	57	56.43	55	55	112	55.72	0.036	0.850

Table 7: Distribution of three separate roots and MB2 canals in maxillary second molar teeth according to patient's sex.

Sample	Female (n)	%	Male (n)	%	Total (n)	%	Chi-square test value	p-value
Total Teeth	94		114		208			
Teeth with 3 separate roots	71	75.53	99	86.84	170	81.73	4.612	0.032*
MB2 Present	13	13.83	23	20.18	36	17.31	2.778	0.096

Fig. 1: Variants in maxillary molars

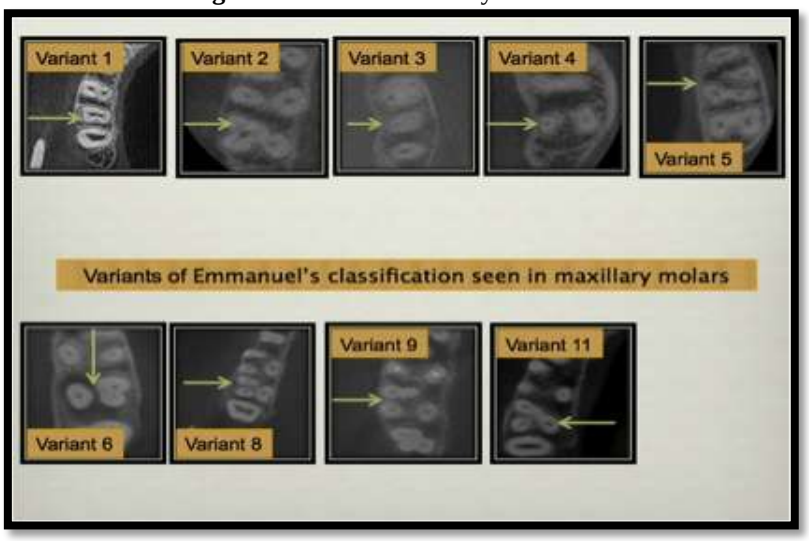

Fig. 2: Taurodontism

Fig. 3