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Original Article

Dentistry Section

Cone Beam Computed Tomography of Mesiobuccal Root and Canal Morphology of Maxillary Molars in Delhi-NCR Population- A Retrospective Study

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ABSTRACT

Introduction: Adequate knowledge of the anatomic variation and root canal morphology is paramount for long term endodontic success. The presence of two canals in Mesiobuccal (MB) root is commonly associated with maxillary molars in various populations.

Aim: To retrospectively evaluate the prevalence of a second mesiobuccal canal (MB2) in maxillary first and second molars in Delhi-National Capital Region (NCR) population using Cone Beam Computed Tomography (CBCT) analysis.

Materials and Methods: This retrospective study evaluated the records of complete maxillary CBCT scans of 204 maxillary first and second molars from January 2016 till May 2019 from different CBCT centres in Delhi-NCR region to determine the anatomy and morphology in June 2019. The prevalence of second MB2 canals was recorded and associated with age, gender and symmetry. The z-test for proportions was used to assess the differences among the subgroups.

Results: The number of roots in 204 teeth in both maxillary molars were determined. The prevalence of 3-rooted configuration was 98.55% in maxillary first molars and 79.4% in maxillary 2nd molars. Also, in maxillary 2nd molars, 7.4% were single rooted and 13.2% had 2-rooted configuration. Three rooted configuration and variable canal number was commonly reported in maxillary molars. Prevalence of MB2 canal was 87.2% in maxillary 1st molars and 64.2% in maxillary 2nd molars. Also, the prevalence was 87.2% bilaterally in maxillary first molars and 65.7% on the right and 53.9% on the left in maxillary second molars respectively. Type IV canal configuration was most prevalent in 44.60% of maxillary first molars and type 1 configuration (35.78%) for the maxillary second molars.

Conclusion: Prevalence of MB2 canals in maxillary first and second molars was found to be high in North Indian population and the clinician should suspect its presence in all cases. Prevalence of MB2 had bilaterally symmetrical distribution without any association with age or gender. The MB roots were more likely to exhibit type IV and type II canal configurations in maxillary first molars and type I and type II configurations in second molars.

Keywords: National capital region, North Indian population, Root canal configuration, Second mesiobuccal canal

INTRODUCTION

Adequate knowledge of the anatomic variation and root canal morphology is paramount for long term endodontic success [1]. Majority of root canal failures are associated with maxillary molars, probably as a result of their complex root canal system as well as presence of an extra canal in the Mesiobuccal (MB) root. These teeth present a clinical challenge in locating and disinfecting the intricate complexities [2].

The incidence of MB root canals varies in the range of 37-96% in different studies [3,4]. The high frequency of two canals in the MB root could be attributed to the large size of the MB root as well as the presence of palatal concavity [5]. The wide variations of prevalence reported among various studies could be the result of differences in age, gender, ethnicity as well as the variations in methodology employed for identification of root canal morphology [6].

Numerous methods have been documented in several studies for assessing the root canal anatomy [7,8]. CBCT imaging provides a noninvasive, 3-Dimensional view for enhanced visualisation that has gained increased significance for diagnosis and morphological evaluation in endodontics [7].

In endodontic literature, limited studies have been conducted to assess the presence of second MB canals in Indian population [8,9]. However, to the best of our research on the topic, there has been no study that has investigated the root and root canal morphology as well as MB2 canal configuration in both maxillary first and second molars using CBCT in Delhi-NCR region. Hence, the present study was conducted to retrospectively investigate the prevalence of a second MB canal in maxillary first and second molars in Delhi-NCR population using CBCT analysis. Also, the influence of several variables (sex, age, side, and number of roots) were evaluated and compared.

MATERIALS AND METHODS

The present retrospective study was carried out in ITS Centre for Dental Studies and Research, Muradnagar, Ghaziabad, Uttar Pradesh, India, Department of Conservative Dentistry and Endodontics under protocol number ITSCDSR/IIEC/RP/2018/017 in collaboration with CBCT centers around Delhi-NCR after receiving the approval from the Ethical Review Board. A retrospective evaluation was done by analysing the records of all the patients who underwent complete maxillary CBCT scans as part of the dental diagnosis and treatment planning from January 2016 till May 2019 in three weeks duration in June 2019.

Inclusion and Exclusion criteria: The study included bilateral scans of fully developed permanent maxillary first and second molars. The teeth with evidence of apicectomy, odontogenic or non odontogenic pathology, root resorption, root fractures, canal calcification, previous root canal treatment, extensive coronal restorations, posts or crown restorations, root caries were excluded.

Sample size calculation: The sample size was estimated on the basis of a pilot study which was conducted in same department where 20 CBCT images of the patients were evaluated (not included

in the main study) which revealed that the prevalence MB2 canal in MB root in maxillary 1st and 2nd molars was found to be 92.4%. Thus, for expected prevalence of 88%, using the following formula for evaluation of sample size, we found it to be 163 teeth [10].

$$N=\frac{Z^2\times P(1-P)}{d^2}$$

Where, N=Sample size

Z=Z statistic for level of confidence=1.96

P=Expected prevalence or proportion=92.4%(=0.924) (From the pilot study)

d=Precision=5%(=0.05)

Study Procedure

A total of 102 patients (61 males and 41 females), in the age group 15-77 years with 204 maxillary first molar and 204 maxillary second molars were included in the study. The CBCT machine used for scanning was NewTom GiANO (NewTom, Verona, Italy). All the CBCT scans included were acquired at a resolution of 150 microns, 8×5 cm Field of View (FOV), 90 KVp, 10 mA and 3.6 seconds exposure time.

Assessment of the roots and canal morphology in maxillary molars was done with the multi-planar mode of the manufacturer's software (NNT viewer, version 7.0) in all three orthogonal planes i.e., axial, coronal and sagittal planes. The tooth of interest and plane were oriented by aligning in the axial, coronal and sagittal planes. For evaluating the number or roots, root canals and prevalence of MB canals of the selected teeth, the axial plane was dragged from coronal aspect of the tooth to the root apex.

The analysed teeth were classified according to the following criteria:

1. Total number of roots in maxillary first and second molar
2. Number of root canals in MB root of maxillary molars
3. Prevalence of the MB2 root canal and its association with:
   - Age
   - Gender
   - Tooth side
4. Root canal system configuration of the MB root according to the criteria:
   - Vertucci FJ et al., into eight categories [11]:

   Type I (1), Type II (2-1), Type III (1-2-1), Type IV (2), Type V (1-2), Type VI (2-1-2), Type VII (1-2-1-2), Type VIII (3), Type 0 (none of these).
   - Root canal system was also categorised as [12]:

   First MB1 only (single canal), MB1 and MB2 completely independent from each other (two independent canals) and MB1 and MB2 confluent canals (isthmus, merging, splitting).

A professional oral radiologist and an Endodontist with required knowledge and competence for CBCT diagnosis evaluated the sample simultaneously.

STATISTICAL ANALYSIS

The collected data were assessed using Statistical Package for the Social Sciences (SPSS) software (Version 22.0). The primary outcome was the proportion of MB2 root canals in maxillary molars in Delhi-NCR region, which was calculated and expressed with a 95% confidence interval. The z-test for proportions was used to assess the differences among the subgroups. The p-value <0.05 was considered significant.

RESULTS

The CBCT scans of 102 patients (61 males and 41 females) were analysed from the age group 15-77 years.

Number of roots in maxillary molars: The number of roots in 204 teeth in both maxillary molars were determined. The prevalence of 3-rooted configuration was 98.55% in maxillary first molars and 79.4% in maxillary 2nd molars. Also, in maxillary second molars, 7.4% were single-rooted and 13.2% had 2-rooted configuration [Table/Fig-1].

Variables		1st Molar (n,%)	2nd Molar (n,%)
Number of roots	1	1, 0.5%	15, 7.4%
	2	2, 1%	27, 13.2%
	3	201, 98.5%	162, 79.4%
Number of canals	1	0, 0	1, 0.5%
	2	0, 0	5, 2.5%
	3	26, 12.7%	70, 34.3%
	4	147, 72.1%	112, 54.9%
	5	21, 10.3%	12, 5.8%
	6	7, 3.4%	2, 1%
	7	3, 1.5%	2, 1%

[Table/Fig-1]: Number of roots and root canals in maxillary molars.
Total n=204 both in first and second molar

Total no. of canals in maxillary first and second molars: For the maxillary 1st molars, variable canal number was reported. The most frequent being the presence of 4 canals (72.1%), followed by 3 canals (12.7%) and 5 canals (10.3 %). A minor percentage of 6 (3.4%) and 7 canals (1.5%) were also reported [Table/Fig-1]. In maxillary 2nd molar, the most frequent was the presence of 4 canals (54.9%), followed by 3 canals (34.3%). We also observed a minor percentage of 5 canals (5.8 %), 2 canal (2.5%), 6 canals (1%), 7 canals (1%) and 1 canal (0.5%) during the analysis [Table/Fig-1].

Overall prevalence of MB2: An overall prevalence of the MB2 canal found in our study was 87.2% in 1st maxillary molars and 64.2% in maxillary 2nd molar [Table/Fig-2].

Variables	MB2 Canals	1st Molar	2nd Molar
	Overall prevalence	87.2%(178/204)	64.2% (131/204)
Gender	Males	87.7% (107/122)	67.2% (82/122)
	Females	86.5% (71/82)	59.75% (49/82)
	p-value	0.8587	0.4425
Sides	Left	87.2% (89/102)	53.9%(55/102)
	Right	87.2%(89/102)	65.7%(67/102)
	p-value	0.7426	0.698
Age (years)	15-20	80.0% (32/40)	60.0%(24/40)
	21-30	93.3% (99/106)	71.6%(76/106)
	31-40	72.7%(16/22)	63.6%(14/22)
	41-50	92.8%(13/14)	50%(7/14)
	51-60	75.0%(6/8)	75%(6/8)
	61-70	100.0%(8/8)	25%(2/8)
	71-77	66.7%(4/6)	33.3%(2/6)
	p-value	0.227	0.227

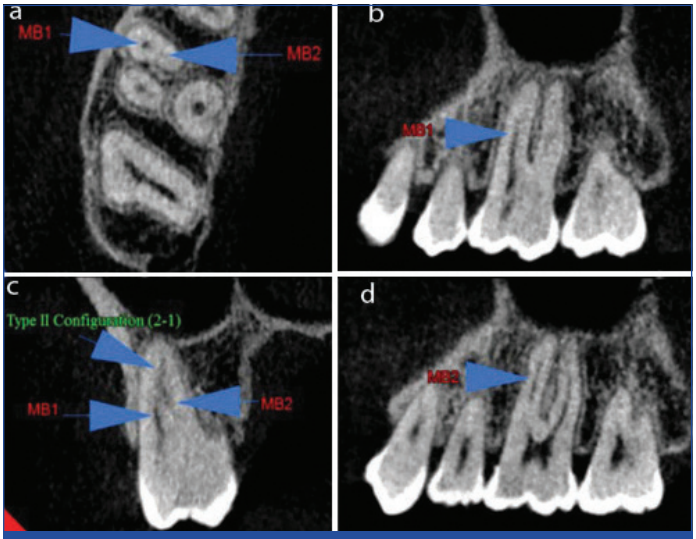
[Table/Fig-2]: Prevalence of MB2 canals in molars with respect to gender, side, age. Z-test for proportions was used to assess the differences among the subgroups.
p-value <0.05 was considered significant

Association of MB2 in right versus left side: The prevalence of the MB2 canal was 87.2% bilaterally in maxillary first molars and 65.7% in right and 53.9% in left side respectively for maxillary second molars. However, the results were not significant. (p-value=0.7426 and 0.698 for first and second molars, respectively) [Table/Fig-2].

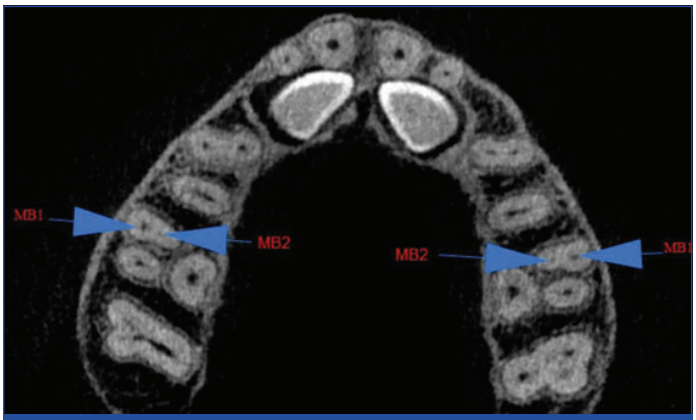
Association of MB canal of the maxillary first and second molars with age: The prevalence of MB2 canal in maxillary molars was found to be similar in all age groups. The prevalence of MB2 canal in 51-60 years and 71-77 years age groups was reported to be 75% and 66.7%, respectively for the maxillary first molars. In maxillary second molars, the prevalence was reported to be 25% for 61-70 years and 33.3% for 71-77 years age groups [Table/Fig-2]. However, the results were statistically non significant (p-value=0.227).

Association of MB of the maxillary first and second molars with gender: For maxillary 1st molar, the prevalence of the MB2 canal in male patients (87.70%) was more than that of female patients (86.5%). Similarly, in maxillary 2nd molars, MB2 canal was reported in 59.70% and 67.2% of females and males, respectively. However, both these results were statistically non significant (p-value=0.8587 and 0.4425 for first and second molars, respectively) [Table/Fig-2].

Root canal configuration of MB root in maxillary first and second molars: In case of maxillary first molars, the MB root was found to have Type I canal configuration in 12.74% cases bilaterally [Table/Fig-3a-d,4]. Type IV canal configuration was prevalent in 44.60% of maxillary first molars. The MB1 and MB2 with connections between them (isthmus, merging, splitting) were found in 34.80% of the MB root of maxillary first molars [Table/Fig-5].



[Table/Fig-3a-d]: Right Maxillary first molar with type II configuration and presence of MB 2. a) Axial section, b) Coronal Section, c) and d) Sagittal section.



[Table/Fig-4]: Bilateral presence of MB1 and MB2 canals in maxillary first molar.

DISCUSSION

The present study provides a report of root and canal morphology of maxillary molars in Delhi-NCR population evaluated using CBCT. The CBCT imaging allows for a 3D visualisation, providing an efficient method for studying root canal anatomy particularly in cases of extra canals or complex anatomy [12] and hence, was employed for the present study.

Majority of maxillary first and second molars exhibited a 3-rooted configuration. Maxillary second molar showed greater anatomic variation in the root number compared to maxillary first molars. These findings were in accordance with Chinese [12], Korean [13] and Iranian [14] populations. Most of the maxillary second molars were found to have four canal configuration in this study, which was in contrast with the Chinese [12], Korean [13], Iranian [14], and Spanish [15] population. In our study, four canals were found to be the most prevalent (72.1%) in maxillary 1st molars. The presence of complex root canal system with variable number of canals increases the chance of missing the extra canals when overlooked, thereby decreasing the success rates of endodontic therapy.

The prevalence of MB2 canal in MB roots was 87.2 % in maxillary first molars. The results were higher than reported in other studies by Lee JH et al., (70.5%), Kim Y et al., (63.59%), Zheng QH et al., (52%) and Betancourt P et al., (68.75%) using CBCT as the diagnostic aid [13,16-18]. For the maxillary second molars, the overall prevalence of MB2 canal was 64.2%. This finding was also higher than the other prevalence studies by Zhang R et al., (22%), Betancourt P et al., (48%), by Silva EJ et al., (34.32%) [12,18,19]. These results could be attributed to the differences in the methodology as well as CBCT parameters employed in different studies.

For both maxillary first and second molars, the second MB canals were found to have a bilateral distribution as shown in [Table/Fig-4]. This was in accordance in studies by Lee JH et al., and Betancourt P et al., [13,18]. In our study, MB2 canal was found to be less in female population than the males. However, the results were insignificant in our population and are in contrast with study by Kim Y et al., and Sert S and Bayirli GS [16, 20]. The lower percentage of the MB2 canal detected in women could be explained by the greater demineralisation and reduction of bone mass in women, thus preventing observation of the canal due to lack of contrast [21].

The results showed MB2 canals to be prevalent across all age groups without any significant differences. This could be due to the unequal distribution of sample size in each of age groups in our study population. However, with increasing age, the continued deposition of secondary dentine, leads to dentinal sclerosis and pulpal recession. As a result, the canals may become obliterated, causing reduction in pulpal volume, hence, making it difficult to locate the MB2 canal in the older population [22,23].

Most of the MB roots of maxillary first molars presented with a Type IV canal configuration which is consistent with the Taiwanese [23] and Korean [13] populations. For the maxillary second molars, type I root canal configuration in the MB root was found to be most prevalent which is also in accordance with the Chinese, Iranian, Spanish and Korean populations [12,14-16]. MB1 and MB2 with connections between them (isthmus, merging, splitting) were found in both

	Vertucci classification										Type of canal system		
Teeth	Type I (1-1)	Type II (2-1)	Type III (1-2-1)	Type IV (2-2)	Type V (1-2)	Type VI (2-1-2)	Type VII (1-2-1-2)	Type VIII (3-3)	Miscellaneous (Configuration other than classified)	Total	Single canal	Two completely independent canals	Two confluent canals
1st Molar (n, %)	26, 12.74%	66, 32.35%	1, 0.49%	91, 44.60%	1, 0.49%	1, 0.49%	1, 0.49%	1, 0.49%	16, 7.84%	204, 100%	26, 12.74%	91, 44.60%	71, 34.80%
2nd Molar (n, %)	73, 35.78%	48, 23.52%	6, 2.94%	47, 23.03%	16, 7.84%	1, 0.49%	2, 0.98%	1, 0.49%	10, 4.90%	204, 100%	73, 35.78%	47, 23.03%	74, 36.27%

[Table/Fig-5]: Root canal configuration of mesiobuccal root according to Vertucci classification [11].

For the maxillary second molars, the MB root was found to have Type I canal configuration (35.78%). A 23.03% of the maxillary 2nd molars reported with Type IV canal configuration. MB1 and MB2 with connections between them (isthmus, merging, splitting) were found in 36.26% of maxillary 2nd molars [Table/Fig-5].

maxillary first and second molars suggesting the presence of the pulp tissue or necrotic products in these areas which may be difficult to clean with conventional endodontic techniques and an inadequate knowledge on such aberrant anatomy may lead to increased risk of endodontic failure [24]. The prevalence of MB2 canal in various populations is enlisted in [Table/Fig-6] [9, 12,13, 15-19, 25-39].

S. No.	Author's name	Place of study	Sample size number of subjects	Number of tooth	Prevalence of MB2 canal (%)	Root canal morphology most commonly seen associated with MB2 (Vertucci classification)
International population studies						
1.	Zhang R et al., 2011 [12]	China	269	1st Molar- 299 2nd Molar- 210	1st Molar- 52.2 2nd Molar- 22	1st Molar- IV 2nd Molar- IV
2.	Lee JH et al., 2011 [13]	Korea	276	1st Molar- 457 2nd Molar- 467	1st Molar- 71.8 2nd Molar- 42.2	1st Molar- IV 2nd Molar- IV
3	Perez-Heredia M et al., 2017 [15]	Spain	112	1st Molar- 142 2nd Molar- 142	1st Molar- 86.2 2nd Molar- 47.3	1st Molar- II 2nd Molar- II
4.	Kim Y et al., 2012 [16]	Korea	415	1st Molar- 814 2nd Molar- 821	1st Molar- 63.6 2nd Molar- 34.4	1st Molar- IV 2nd Molar- IV
5.	Zheng QH et al., 2010 [17]	China	624	1st Molar- 627	1st Molar- 52.2	-
6.	Betancourt P et al., 2016 [18]	Chile	-	1st Molar- 550 2nd Molar- 550	1st Molar- 69.8 2nd Molar- 46.9	-
7.	Silva EJ et al., 2014 [19]	Brazil	294	1st Molar- 314 2nd Molar- 306	1st Molar- 42.6 2nd Molar- 34.3	
8.	Martins JNR et al., 2018 [25]	Australia	250	1st Molar- 224	1st Molar- 53.1	-
		Brazil	127	1st Molar- 250	1st Molar- 82.4	-
		China	127	1st Molar- 248	1st Molar- 76.2	-
		China	120	1st Molar- 238	1st Molar- 58.4	-
		Costa Rica	156	1st Molar- 249	1st Molar- 57.8	-
		Egypt	180	1st Molar- 233	1st Molar- 61.4	-
		England	250	1st Molar- 241	1st Molar- 91.7	-
		France	204	1st Molar- 233	1st Molar- 81.1	-
		Greece	164	1st Molar- 218	1st Molar- 60.1	-
		Iceland	250	1st Molar- 236	1st Molar- 80.5	-
		Italy	126	1st Molar- 226	1st Molar- 79.6	-
		Kuwai	163	1st Molar- 242	1st Molar- 79.8	-
		Mexico	250	1st Molar- 250	1st Molar- 84.0	-
		Portugal	670	1st Molar- 516	1st Molar- 71.3	-
		South Africa	150	1st Molar- 244	1st Molar- 96.7	-
		Spain	168	1st Molar- 234	1st Molar- 70.1	-
		Syria	131	1st Molar- 250	1st Molar- 95.2	-
		Netherlands	250	1st Molar- 234	1st Molar- 60.7	-
		USA	250	1st Molar- 215	1st Molar- 74.9	-
		Venezuela	250	1st Molar- 220	1st Molar- 48.6	-
9.	Reis AG et al., 2013 [26]	Brazil	100	1st Molar- 158 2nd Molar- 185	1st Molar- 88.5 2nd Molar- 83.5	
10.	Jing YN et al., 2014 [27]	China	-	1st Molar- 630 2nd Molar- 519	1st Molar- 30.9 2nd Molar- 13.9	1st Molar- IV 2nd Molar- II,V
11.	Albarca J et al., 2015 [28]	Chile	508	1st Molar- 802 2nd Molar- 572	1st Molar- 73.4 2nd Molar- 42.4	1st Molar- II 2nd Molar- II
12.	Naseri M et al., 2016 [29]	Iran	149	1st Molar- 149	1st Molar- 86.6	1st Molar- IV
13.	Ghobashy AM et al., 2017 [30]	Egypt	657	1st Molar- 605	1st Molar- 74.5 2nd Molar- 50%	1st Molar- II 2nd Molar- II
14.	Olczak K and Pawlicka H 2017 [31]	Poland	112	1st Molar- 185 2nd Molar- 207	1st Molar- 59.5 2nd Molar- 23.1	
15.	Alves Gomes CR et al., 2018 [32]	Brazil	287	1st Molar- 362	1st Molar- 68.2	1st Molar- II
16.	Fernandes NA et al., 2018 [33]	South Africa	200	1st Molar- 400 2nd Molar- 400	1st Molar- 89.5 2nd Molar- 67%	-
17.	Candeiro GTM et al., 2019 [34]	Brazil	512	1st Molar- 700 2nd Molar- 801	1st Molar- 48.5 2nd Molar- 22.72	1st Molar- II 2nd Molar- II
Indian population studies						
18.	Kewalramani R et al., 2019 [9]	Karnataka	310	1st Molar- 598	1st Molar- 61.9	-
19.	Martins JNR et al., 2018 [25]	Kochi	140	1st Molar- 247	1st Molar- 65.6	
20.	Neelakantan P et al., 2010 [35]	Indian subpopulation	425	1st Molar- 220 2nd Molar- 205	-	1st Molar- I 2nd Molar- I

21.	Karunakar P et al., 2015 [36]	Hyderabad	75	1st Molar- 75	1st Molar- 47.1%	-
22.	Azad A et al., 2016 [37]	Ahmedabad , Gujarat	133	2nd Molar- 217	2nd Molar- 56.2%	2nd Molar- II
23.	Mohan RP et al., 2017 [38]	Karnataka	282	1st Molar- 143 2nd Molar- 139	1st Molar- 64.1% 2nd Molar- 23%	-
24.	Nurul Husniyah binti Che Soh and Mahesh, 2019 [39]	Chennai	40	1st Molar- 40	-	1st Molar- I/II
25.	Present study	Delhi-NCR	102	1st Molar- 204 2nd Molar- 204	1st Molars- 87.2% 2nd Molars- 64.2%	1st Molars- Type IV 2nd Molars- Type 1

[Table/Fig-6]: List of International and National Studies assessing prevalence of MB2 canal [9, 12,13, 15-19, 25-39]

Limitation(s)

One of the shortcomings of the present study includes the convenience sample taken from the CBCT centers, without taking into consideration the ethnic background since countries nowadays comprise of a mixture of ethnicities. Also, the sample size was small and taken during a specified time period. Hence, future studies with larger populations which are observed over a period of time to evaluate the changes in MB canal with ageing may be of interest.

CONCLUSION(S)

Within the limitations of the present retrospective CBCT analysis, three rooted configuration was common in maxillary molars. Atypical number of canals in both the maxillary molars was reported in high number. Prevalence of MB2 canals in maxillary first and second molars was found to be greater in North Indians and its presence should be suspected in every case. Prevalence of MB2 had no association with age and gender. Prevalence of MB2 canal had bilaterally symmetrical distribution. The MB roots were more likely to exhibit type IV and type II canal configurations in maxillary first molars and type I and type II configurations in second molars. The MB1 and MB2 with connections between them (isthmus, merging, splitting) were commonly reported.

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