Original Research Paper

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Prevalence & Location of Mid Mesial Canal Based on Interorifice Distance Between Mb-ml Canals in Permanent Mandibular 1st, 2nd Molars in West Bengal Population – "A Cone Beam Computed Tomography Study"

Abstract:

Background: Effective endodontic therapy necessitates thorough knowledge of pulp anatomy for proper root canal treatment. Missed canals, particularly middle mesial canals (MMC), are a primary cause of therapy failure and apical periodontitis.

Aim: To assess the prevalence of MMC and predict its presence based on the inter-orifice distance (IOD) between the mesiobuccal (MB) and mesiolingual (ML) canals in mandibular first and second molars.

Materials and Methods: This retrospective study used CBCT scans selected by specific inclusion criteria and classified MMCs per Pomeranz et al. The data was analyzed employing descriptive statistics and ROC curve analysis to determine the IOD cut-off values for predicting MMC presence.

Results: The prevalence of MMC was 21.9% in first molars and 5.53% in second molars. In first molars, the most common MMC configuration was confluent (57.14%), followed by fin (34.29%). The median IOD was significantly greater in teeth with MMC, with cut-off values of ≥ 3.1mm for first molars and ≥ 2.9mm for second molars. ROC curve analysis revealed an AUC of 0.766 for first molars and 0.713 for second molars, indicating acceptable discrimination.

Conclusion: MMC is prevalent in the West Bengal population, especially in first molars. The IOD between MB and ML canals is a significant predictor of MMC, enhancing detection and improving endodontic outcomes. The findings underscore the importance of using IOD measurements in identifying MMC during endodontic procedures.

Key-words: Cone beam computed tomography(CBCT), mid mesial canal (MMC), Inter orifice distance (IOD), mesiocentral canal, third mesial canal.

Introduction:

Endodontic therapy seeks 3-D obturation, needing thorough pulp anatomy knowledge for effective root canal cleaning and shaping.[1] Studies show that the main cause of endodontic therapy failure in molars is missed canals. Canals are often missed due to a lack of anatomical knowledge, negligence, or lack of expertise.[2] There is a strong link between untreated canal spaces and apical periodontitis. Literature indicates that molars typically have two roots (mesial and distal) and three or four canals [mesiobuccal (MB), mesiolingual(ML), and distal(D), often subdivided into Distobuccal(DB) and Distolingual(DL) canals]. Despite extensive studies on mandibular molar anatomy, variations, especially in the mesial canal, are common. Aberrations such as C-shaped canal systems in the second molar.[3] Small middle mesial canal (MMC) orifices, deep in the isthmus between MB and ML, are often missed and known as "accessory", "third mesial canals" or "mesiocentral" etc. [4]

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MMC is defined as a narrow, partial, or complete canal present between MB and ML canals (American Association of Endodontics [AAE]) [5]

Multiple classifications for MMC have been proposed using various methods: sectioning and microscopic examination, staining, modeling, and imaging techniques like radiography, CBCT, and micro-CT etc.[6] In 1981, Pomeranz et al. identified three MMC variants in root canals: fin (where the file passes between mesial canals and MMC), confluent MMC merges with mesial canals), and independent (MMC) has its own orifice and foramen).[7] Technological Advances have given the clinician ample opportunity to identify and treat these aberrations successfully.[8] The possibility of additional canals should be explored with newer technologies like loupes, dental operating microscopes (DOMS), CBCT imaging, and guided troughing with DOM to access MMCs.[6,9] MMC is usually found at the CEJ or 1-3mm below it or developmental groove between MB-ML root canal by troughing method or less commonly under the dentinal projection between MB-ML canal.[10]

The occurrence of MMC[11] based on a preoperative diagnostic indicator such as difference in IOD of root canal in the mesial root of Permanent Mandibular First Molar(PMFM) and Permanent Mandibular Second Molar(PMSM) is a concept that is to be explored in depth, justifying the need for this study.[12]

AIM: The Primary Aim of this retrospective study is to evaluate the prevalence and prediction of the MMC based on IOD between MB-ML canal in mandibular 1st and 2nd molars. The secondary aim is to correlate the incidence of MMC with the variables of molar types, its classification, sex, age in the population of West Bengal.

Materials and Methodology:

This study was conducted after ethical clearance from the institution. [*Ethical Committee Reg. no.* – EC/NEW/INST/2023/3191]

The sample size determination was based on the results of study by Weinberg et al., sample size estimation was done using *G* Power software* (version 3.1.9.7, University of Duesseldorf, Germany).The total sample size was calculated as 640 (N=640) with power of 80%, and a type 1 error rate of 0.05.

The CBCT machine used in the present study was SkyView 3D (MyRay, Cefla Dental Group, Imola, Italy), tube voltage of 90 kvp and a pulsed beam current 1-10 mA. The Digital Imaging and Communication in Medicine format image was exported from Skyview CBCT Scanner TM and imported into iRYS viewer software to view the scans.

CBCT scans that were basically indicated for various other dental procedures for different treatment procedures were taken for this study. Patients age in between 14-65 years and the patient's scans which were having *PMFM* and *PMSM*with complete root and apex formations were included in the study. The patients scan that were picked as samples were of different Indian ethnicities from West Bengal. Scans having resorption, fractured roots, C shaped canal, single roots, open apex, calcified/obliterated canals, fused roots, partially or completely endodontically treated molars, presence of crowns and presence of any restorations were excluded.

Cone beam computed tomography analysis:

Analysis was performed with CBCT CD's on Windows 10 operating laptop system. After finding MMC again it was classified according to Pomeranz et al. classification: fin, confluent, independent.[7] [Fig.1a] The number of the MMC was recorded for sex (male or female), age of the patient(<35 years and >35 years), molar type i.e PMFM, PMSM.

IOD which was taken in this study is defined as "cross-sectional distance as measured in transverse slice from buccal wall of MB canal orifice to lingual wall of ML canal orifice." [5,12,13][Fig.1b]

The four canal configuration category of the molars were analyzed for IOD. Orthogonal slices from pulpal floor to 1-3 mm [Fig.1c] below were used to measure mean IOD from buccal wall of MB canal orifice to lingual wall of ML canal orifice using digital ruler tool on the CBCT software (NNT viewer software iRYSviewer)

Statistical Analysis:

The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using GraphPad Prism for Windows, Version 9.5 (GraphPad Software, La Jolla California USA).

Descriptive statistics were used to report:

i) Categorical variables in terms of frequencies and percentages.
ii) Quantitative variables were reported in terms of median (central tendency) and Inter-quartile range (IQR) (measures of dispersion).

A Receiver Operating Characteristic (ROC) curve was plotted to obtain the area under the curve (AUC) for the inter-orifice

distance to predict the presence of an MMC. AUC was interpreted as >0.5:no discrimination;0.5-0.7: inadequate discrimination; 0.71-0.8: acceptable discrimination; 0.81-0.9: excellent discrimination and >0.9: outstanding discrimination.[14]

The *P* value of ≤ 0.05 was considered as the *level of significance.*

Results:

In the current study, 160 CBCT scans, totaling 640 teeth, for the MMC presence were evaluated.

The overall prevalence of MMCs in 1st and 2nd molar was 21.9% and 5.53%. In the mandibular first molars, the most common canal configuration was confluent (57.14%) followed by fin (34.29%), with the independent type being the least prevalent (8.57%), and this difference was statistically significant (P<0.001).

In contrast, the mandibular second molars had no teeth with an independent configuration; the confluent type (55.6%) was slightly more common than the fin type. Unilateral prevalence was higher for both mandibular 1st molars (87.1%) and 2nd molars (87.5%), where (P<0.001).

In [Table 1], mandibular first molars, the median inter-orifice distance (IOD) was 3.3 mm (2.9-3.5 mm) in teeth with an MMC, compared to 2.8 mm (2.7-3 mm) in teeth without an MMC. For mandibular second molars, teeth with an MMC had an IOD of 2.9 mm (2.78-3.15 mm), whereas teeth without an MMC had an IOD of 2.8 mm (2.6-2.9 mm). The IOD was significantly greater in teeth with an MMC than in those without (P<0.01).

The highest IOD was observed in the confluent variant for both types of teeth, followed by the fin variant, with the independent variant (found only in first molars) having the smallest IOD.

Additionally, in first molars, the MMC was typically located at the midpoint between the MB and ML canals. In second molars, however, the MMC orifice was positioned more lingually, as determined by the measured distances from the MMC orifice to the MB and ML orifices. The distance from the pulpal floor to the MMC orifice was found to be 1.1(0.8-1.4) in the case of the first molar and 0.9(0.775-0.925) in the case of 2nd molars.

Table 1: Descriptive statistics for the various outcome parameters for the MMC and Non-MMC groups in Mandibular 1st and 2nd molars respectively

Mandibular 1st Molar				
Outcome variables	**MMC(*n*=70)**		**Non-MMC(*n*=250)**	***P* value**
Interorifice distance(mm)	Overall	3.3(2.9-3.5)	2.8(2.7-3)	<0.001**
	Fin	3.15(2.72-3.7)		
	Confluent	3.3(2.92-3.5)		
	Independent	2.9(2.6-4.8)		
MB-MM(in mm)	1.5(1.3-1.8)			
MM-ML(in mm)	1.5(1.3-1.8)			
MM-Pulpal floor(mm)	1.1(0.8-1.4)			
Mandibular 2nd Molar				
Outcome variables	**MMC(*n*=18)**		**Non-MMC(*n*=302)**	***P* value**
Interorifice distance(mm)	Overall	2.9(2.78-3.15)	2.8(2.6-2.9)	0.017**
	Fin	1.45(1.15-1.75)		
	Confluent	1.7(1.325-2.15)		
MB-MM(in mm)	1.6(1.25-1.83)			
MM-ML(in mm)	1.3(1.1-1.43)			
Pulpal floor-MM(mm)	0.9(0.775-0.925)			

Descriptive statistics have been depicted as Median (Interquartile range), MB:mesio-buccalorifice, ML:mesio-lingualorifice, MM:middle mesial orifice

***:Highly statistically significant(P<0.01)*

In [Table 2], ROC curve analysis revealed that the AUC was 0.766; 95% CI:0.69-0.8495% (*P*<0.001). In the Mandibular first molar and 0.713,95% CI:585-0.841(*P*=0.002)in the Mandibular second molar. Furthermore, the sensitivity and specificity values obtained were employed to find the cut-off values for the optimum inter-orifice distance to predict the presence of an MM canal. It was found to be ≥ 3.1mm in the case of first molars and ≥ 2.9 in the case of second molars. ROC curve graphs for PMFM & PMSM were also plotted as shown in [Fig.(2a)(2b)]

Table 2:ROC curve showing the area under the curve (AUC) and sensitivity, specificity values in Mandibular 1st and 2nd molars respectively for the inter-orifice distance parameter

Outcome variables	Cut-off values	Sensitivity(%)	Specificity(%)	AUC(95% CI)	*P* value
Mandibular 1st Molar	3.1	57.14	88.88	0.766(0.69-0.84)	<0.001**
Mandibular 2nd Molar	2.9	55.56	73.5	0.713(585-0.841)	0.002**

CI:Confidence Interval

**:Highly statistically significant(P<0.01)

Discussion:

The prevalence of MMC has been established to vary with age, ethnicity, penetrance of atavistic genes, and environmental factors.[5,15]

In this study, the overall prevalence of MMC in the Kolkata population was 15.3%, with a higher prevalence in first

molars (21.9%) compared to second molars (5.53%), aligning with the findings by Iqbal S.[17], Mahajan S.[5], and Shakeri et al[18]. Conversely, Azim et al. reported a higher prevalence in second molars.[19] In mandibular first molars, the confluent configuration (57.14%) was most common, followed by fin (34.29%), and independent (8.57%). Second molars had no independent types, with confluent (55.6%) slightly more common than fin.

In this study, we examined the relationship between the interorifice distance of the MB and ML canal orifices and the presence or absence of an MMC. In the Mandibular first molar, the median IOD was found to be 3.3(2.9-3.5) mm in the teeth where the MMC canal was present, while it was found to be 2.8(2.7-3) mm in the teeth where it was absent. In the case of second molars, teeth with an MM canal present showed an inter-orifice distance of 2.9(2.78-3.15) mm and 2.8(2.6-2.9) where it was absent. It was found that the inter-orifice distance was significantly higher in the teeth containing the MM canal than where it was absent. However,this study does not align with Weinberg et al. study, which reported no statistically significant difference in the mesial intracanal distance between teeth with and without an MMC. Furthermore, their results indicated no correlation between the presence of an MMC and variations in the mesial intracanal distance.[20]

The distance from the pulpal floor to the MM orifice was found to be 1.1(0.8-1.4) in the case of the first molar and 0.9(0.775-0.925) in the case of second molar which is in accordance to the study done by KeleşA *et al* and Yang Y *et al*.This occurrence of MMC under the dentinal shelf, between MB and ML canals, has posed challenges to its identification and instrumentation.[21,22] Thus, in this study, measurements of IOD using three successive transverse image slices from the pulpal floor up to 4 mm below, was used to calculate the mean IOD.

The location of the MM canal is in the mid-point of MB and ML canal, while in the second molar, the location of the canal orifice was placed more lingually, as adjudged by the distance calculated from the MM orifice to MB and ML orifice respectively. According to the finding of Karapinar-Kazandag*et al*., [23] it is proposed to startfrom the ML canal orifice and progress systematically along the subpulpal groove towards the MB canal. Furthermore, de Carvalho and Zuolo[15] showed in their study that the middle mesial orifice approaches the ML more frequently than the MB orifice.[17]

The morphology of mandibular molars is influenced by various factors, including genetics, race, gender, and age.[5,15] Research has indicated that middle mesial canals (MMCs) are more frequently identified in younger patients.[24] A significant association was found between the presence of MM canal and age distribution in both the first molar (P=0.008) and the second molar (P=0.04), implying that the propensity of the presence of an MM canal is more in younger individuals that is lesser than 40 years of age but no significant association was found between the presence of MM canal and gender distribution in both the teeth type and this result was similar to the result of study done by Sherwani *et al*. and Srivastava *et al*.[24]

In the current study, it was observed that the overall prevalence of MMC is higher on the right side than on the left side of the jaw in the population of Kolkata and Unilateral prevalence was found to be higher for both the PMFM & PMSM ,which is in accordance to the study done on the Kerman population[25] shows higher prevalence on the right side than on the left side.

LEGENDS:

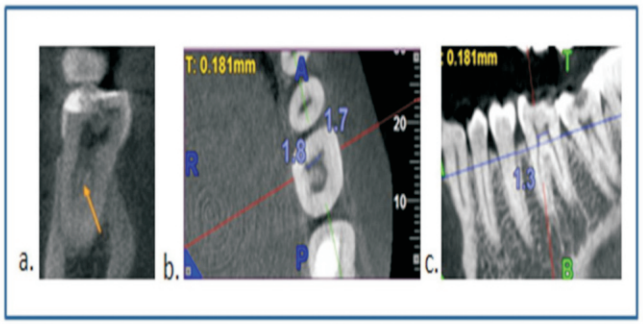

Figure 1: CBCT images – a) Confirmation of MMC b) Measurement of inter-orifice distance between MB-MM and MM-ML, c)Measuring of the distance from the pulpal floor to MMC orifice

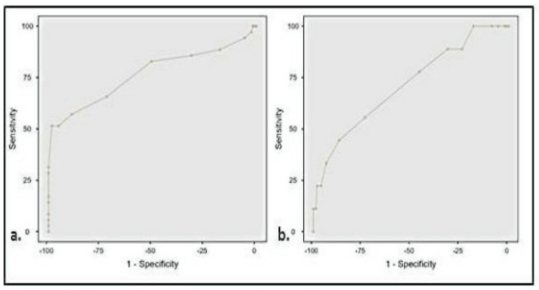

Figure 2: A Receiver Operating Characteristic (ROC) curve showing the diagnostic accuracy of inter-orifice as a predictor for the presence of MM canal in the a) Mandibular 1st Molar b) 2nd Molar

Conclusion:

Within the limitations of the study, it can be concluded that MMC was found to be highly prevalent (21.9%) in PMFM in West Bengal subpopulation, as per this study, with confluent and fin variants showing higher prevalence in the younger population (≤40 years) and should be anticipated in both first and second mandibular molars with mandibular first molar having higher prevalence than mandibular second molar. The overall prevalence of MMC is higher on the right side than on the left side, unilaterally present than bilaterally in the subpopulation of West Bengal. However, this study also demonstrated a cut value i.e ≥ 3.1mmin the case of first molars and ≥ 2.9 in the case of second molars which can actually help us to know the presence and absence of MMC. Finally, the intraorifice distance between MB and ML canals in mandibular molars can be used a significant predictor to detect the presence or absence of the MMC.

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