Section: Dentistry

Original Research Article

MEASUREMENT OF INTEROFFICE DISTANCE BETWEEN MESIOBUCCAL AND PALATAL CANAL TO PREDICT PRESENCE OF MB2 CANAL IN MAXILLARY 1ST MOLAR

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Received *: 16/06/2026*
Received in revised form *: 12/08/2026*
Accepted *: 21/08/2026*

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DOI: 10.70034/ijmedph.2026.3.641

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 4112-4116

ABSTRACT

Background: The second mesiobuccal canal (MB2) is a common anatomical variation of the maxillary first molar and is frequently difficult to identify during endodontic treatment. Failure to locate and treat an additional canal may compromise endodontic treatment outcomes. Cone-beam computed tomography (CBCT) provides three-dimensional visualization of root canal anatomy and may assist in identifying MB2 canals and anatomical features associated with their presence. The objective is to evaluate whether interorifice distances between the mesiobuccal, distobuccal, and palatal canal orifices can predict the presence of an MB2 canal in maxillary first molars using CBCT.

Materials and Methods: A cross-sectional descriptive study was conducted at the Institute of Dentistry, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh, Pakistan. A total of 400 CBCT images of permanent maxillary first molars from patients aged 16–70 years were evaluated. CBCT examinations were assessed in the axial plane from the cementoenamel junction to the root apex for the presence of an MB2 canal. The distances between the MB1, distobuccal (DB), and palatal (P) canal orifices were measured. The MB1-P/DB-P ratio was also calculated. Associations between MB2 presence and age and sex were evaluated using Pearson's chi-square test. Receiver operating characteristic (ROC) curve analysis was performed to assess the predictive performance of the measured distances and the MB1-P/DB-P ratio.

Results: The mean age of the participants was 29.29 ± 12.34 years (range, 16–66 years). Females constituted 206 (51.5%) participants and males 194 (48.5%). An MB2 canal was identified in 250 (62.5%) maxillary first molars, whereas 150 (37.5%) did not demonstrate an MB2 canal. The mean MB1-DB distance was 2.57 ± 0.72 mm, the mean MB1-P distance was 5.23 ± 1.13 mm, and the mean DB-P distance was 3.87 ± 0.92 mm. The mean MB1-P/DB-P ratio was 1.32 ± 0.61. ROC analysis demonstrated an area under the curve (AUC) of 0.535 for MB1-DB distance, 0.636 for MB1-P distance, 0.579 for DB-P distance, and 0.614 for the MB1-P/DB-P ratio. The presence of MB2 was significantly associated with age (p=0.001), but not with sex (p=0.278).

Conclusion: MB2 canals were identified in 62.5% of the evaluated maxillary first molars. Among the assessed anatomical measurements, MB1-P distance demonstrated the highest AUC, followed by the MB1-P/DB-P ratio. Although these measurements showed some discriminatory ability, their predictive performance was limited. CBCT may serve as a useful complementary imaging modality for assessment of maxillary molar canal morphology and identification of MB2 canals.

Keywords: Cone-beam computed tomography (CBCT), Interorifice distance, Maxillary first molar, root canal morphology, Second mesiobuccal canal.

INTRODUCTION

Successful nonsurgical root canal treatment depends on adequate identification, cleaning, shaping, and obturation of the complete root canal system. Anatomical variations, particularly additional canals that remain undetected or untreated, represent an important challenge in endodontic practice. The maxillary first molar is among the teeth with the greatest complexity of root canal anatomy, particularly because of the frequent presence of a second canal in the mesiobuccal root (MB2).[1] The presence of an untreated MB2 canal may allow persistence of microorganisms and infected tissue, potentially contributing to persistent symptoms and apical disease. Reported prevalence of MB2 canals varies considerably between populations and studies, partly because of differences in methodology, imaging techniques, age, sex, ethnicity, and criteria used to define canal presence.[2]

The maxillary first molar generally has three roots: mesiobuccal, distobuccal, and palatal with the mesiobuccal root frequently containing two canals. The MB2 canal is generally positioned palatal to the MB1 canal and may be difficult to locate clinically because of its small diameter, calcification, and anatomical position. Knowledge of the expected location of MB2 is therefore important when performing endodontic access and canal negotiation.[3] Several techniques have been used to investigate root canal morphology, including tooth clearing, sectioning, microscopy, conventional radiography, micro-computed tomography, and CBCT. Many conventional techniques are either invasive or limited by two-dimensional visualization. CBCT allows three-dimensional assessment of dental structures and reduces the superimposition associated with conventional radiography.[4]

The identification of MB2 has improved with the use of magnification and advanced imaging. Previous studies have demonstrated considerable differences in MB2 detection according to the diagnostic method employed. CBCT has consequently become an important complementary imaging modality for evaluating complex root canal anatomy.[5] Although numerous studies have investigated the prevalence and anatomical configuration of MB2 canals, relatively fewer studies have evaluated whether the spatial relationship among the major canal orifices can assist in predicting MB2 presence.[5-8] Measurements involving the MB1, DB, and palatal canal orifices may provide clinically useful anatomical information.

Therefore, the present study was conducted to evaluate the interorifice distances between the mesiobuccal, distobuccal, and palatal canal orifices and determine their ability to predict the presence of an MB2 canal in maxillary first molars using CBCT. The study also evaluated the association of MB2 presence with age and sex.

MATERIALS AND METHODS

Study design and setting: A cross-sectional descriptive study was conducted at the Institute of Dentistry, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, Sindh, Pakistan. The study was conducted over a period of six months following approval from the institutional Research Ethics Committee.

Sample size and sampling: The study included 400 maxillary first molars. The sample size calculation yielded an initial sample size of 381, after which 19 additional cases were included, resulting in a final sample of 400 cases. A non-probability convenience sampling technique was used.

Eligibility criteria: CBCT images were eligible when they represented permanent maxillary first molars in patients aged 16–70 years and were of adequate diagnostic quality. Images obtained for diagnostic purposes before surgical, orthodontic, or endodontic treatment were considered.

Teeth with open apices, resorption, root fractures, intraradicular fillings, posts, metallic restorations, fixed prostheses, or primary teeth were excluded.

CBCT examination: Digitized CBCT images were selected from the available records at the Institute of Dentistry, LUMHS. The reported CBCT acquisition parameters included 110 kVp and 10 mA, a voxel size of 0.15 mm, a field of view of 18 × 16 cm, an exposure period of 3.6–4.8 seconds, and a minimum slice thickness of 0.3 mm.

Continuous axial-plane evaluation was performed along the mesiobuccal root from the cementoenamel junction to the apex to identify the presence of an MB2 canal. The pulpal floor was assessed by identifying the center points of the MB1, DB, and palatal canal orifices.

Interorifice measurements: The distances between the centers of the major canal orifices were measured on axial CBCT images. The following measurements were recorded:

- MB1–DB distance
- MB1–P distance
- DB–P distance

The MB1-P/DB-P ratio was subsequently calculated. The presence or absence of MB2 was recorded at the pulpal-floor level.

Statistical analysis: Statistical analysis was performed using SPSS version 26. Descriptive statistics were used to summarize demographic characteristics and interorifice measurements. Pearson's chi-square test was used to assess associations between MB2 presence and demographic variables, including age and sex. ROC curve analysis was performed to assess the ability of the interorifice measurements and MB1-P/DB-P ratio to discriminate between molars with and without an MB2 canal. A p-value <0.05 was considered statistically significant.

RESULTS

Participant characteristics: A total of 400 maxillary first molars were evaluated. The mean age was 29.29 ± 12.34 years, with a median age of 25 years and an age range of 16–66 years. Among the participants, 206 (51.5%) were females and 194 (48.5%) were males. The left maxillary first molar was represented in 208 (52.0%) cases, while the right maxillary first molar accounted for 192 (48.0%) cases [Table 1].

An MB2 canal was identified in 250 (62.5%) maxillary first molars, whereas 150 (37.5%) did not demonstrate an MB2 canal [Table 2].

The mean MB1–DB distance was 2.57 ± 0.72 mm, while the mean MB1–P distance was 5.23 ± 1.13 mm. The mean DB–P distance was 3.87 ± 0.92 mm. The mean MB1-P/DB-P ratio was 1.32 ± 0.61. [Table 3]

Table 1: Demographic and tooth-site distribution

Variable	n (%)
Sex	
Female	206 (51.5)
Male	194 (48.5)
Tooth site	
Left	208 (52.0)
Right	192 (48.0)
Total	400 (100.0)

Table 2: Presence of MB2 canal

MB2 canal	n (%)
Present	250 (62.5)
Absent	150 (37.5)
Total	400 (100.0)

Table 3: Interorifice measurements

Measurement	Mean ± SD	Median
MB1–DB distance (mm)	2.57 ± 0.72	2.59
MB1–P distance (mm)	5.23 ± 1.13	5.29
DB–P distance (mm)	3.87 ± 0.92	3.93
MB1-P/DB-P ratio	1.32 ± 0.61	1.41

The MB1–DB distance produced an AUC of 0.535 (95% CI: 0.476–0.595; p=0.235). The MB1–P distance demonstrated the highest AUC among the assessed variables, at 0.636 (95% CI: 0.576–0.696; p<0.001). The DB–P distance demonstrated an AUC of 0.579 (95% CI: 0.517–0.642; p=0.008). The MB1-P/DB-P ratio yielded an AUC of 0.614 (95% CI: 0.558–0.671; p<0.001). [Table 4]

Table 4: ROC curve analysis for prediction of MB2

Predictor	AUC	95% CI	p-value
MB1–DB distance	0.535	0.476–0.595	0.235
MB1–P distance	0.636	0.576–0.696	<0.001
DB–P distance	0.579	0.517–0.642	0.008
MB1-P/DB-P ratio	0.614	0.558–0.671	<0.001

Among the assessed measurements, MB1–P distance demonstrated the highest discriminatory performance, followed by the MB1-P/DB-P ratio. However, the AUC values indicate that these variables should be regarded as supplementary anatomical indicators rather than highly accurate standalone predictors. MB2 presence differed significantly across age groups (p=0.001). Among participants aged 16–30 years, MB2 was present in 176 (44.0%) cases and absent in 88 (22.0%). In the 31–45-year group, MB2 was present in 66 (16.5%) and absent in 37 (9.3%). No MB2 canals were recorded in the 46–60-year group, while 8 (2.0%) MB2-positive and 16 (4.0%) MB2-negative cases were reported among participants older than 60 years. [Table 5]

Table 5: MB2 distribution according to age

Age group	MB2 present n (%)	MB2 absent n (%)	Total n (%)
16–30 years	176 (44.0)	88 (22.0)	264 (66.0)
31–45 years	66 (16.5)	37 (9.3)	103 (25.8)
46–60 years	0 (0.0)	9 (2.3)	9 (2.3)
>60 years	8 (2.0)	16 (4.0)	24 (6.0)
Total	250 (62.5)	150 (37.5)	400 (100.0)

No statistically significant association was observed between sex and MB2 presence (p=0.278). MB2 was identified in 134 (33.5%) males and 116 (29.0%) females. [Table 6]

Table 6: MB2 distribution according to sex

Sex	MB2 present n (%)	MB2 absent n (%)	Total n (%)
Male	134 (33.5)	72 (18.0)	206 (51.5)
Female	116 (29.0)	78 (19.5)	194 (48.5)
Total	250 (62.5)	150 (37.5)	400 (100.0)

DISCUSSION

The present study evaluated the prevalence of MB2 canals in maxillary first molars and examined whether interorifice distances could provide anatomical information useful for predicting their presence. In 400 evaluated cases, an MB2 canal was identified in 250 (62.5%) of maxillary first molars. This finding confirms the frequent occurrence of an additional mesiobuccal canal and highlights the importance of careful assessment of the mesiobuccal root during endodontic treatment.

The observed prevalence is broadly comparable with findings reported in previous CBCT-based investigations. Betancourt et al,[9] (2016) reported MB2 detection in 46.91% of their evaluated cases, while Tonelli et al,[10] (2021) reported MB2 in 69.35% of maxillary first molar roots. A systematic review and meta-analysis reported a pooled CBCT detection rate of approximately 64.76%, while a large multicenter CBCT study reported a global prevalence of approximately 73.8%. These differences are expected because MB2 prevalence is influenced by population characteristics, imaging parameters, observer experience, age distribution, and methodological differences.

The prevalence observed in the present study is also higher than that reported in some populations. For example, previous research has demonstrated considerable geographic and ethnic variation in MB2 prevalence. In the present study, MB2 canals were identified in 250 (62.5%) of 400 maxillary first molars. This prevalence was lower than the 384 (69.8%) of 550 maxillary first molars reported by Betancourt et al,[9] (2016) using CBCT, but higher than the 56 (56.0%) of 100 cases reported in Pakistani populations in previous CBCT-based studies (Yasser et al. 2022).[11] Such differences support the need for population-specific anatomical investigations rather than assuming that findings from one population can be directly generalized to another. The mean MB1–DB distance in the present study was 2.57 ± 0.72 mm, while the mean MB1–P distance was 5.23 ± 1.13 mm and the mean DB–P distance was 3.87 ± 0.92 mm. The mean MB1-P/DB-P ratio was 1.32 ± 0.61. These measurements provide quantitative information about the spatial arrangement of the principal canal orifices on the pulpal floor.

Previous studies have similarly examined interorifice anatomy. Lee et al,[12] (2020) reported distances between MB1 and MB2 orifices of approximately 2.10 ± 0.44 mm in maxillary first molars, whereas Magat et al,[13] (2019) reported an average MB1–MB2 distance of 2.95 ± 0.58 mm and an MB2–palatal distance of 5.81 ± 1.09 mm for maxillary first molars. Differences between studies may reflect variations in tooth populations, imaging techniques, measurement definitions, and whether measurements were obtained in vivo or from extracted teeth.

In the present study, the MB1–P distance showed the highest AUC (0.636) among the assessed measurements. The MB1-P/DB-P ratio demonstrated an AUC of 0.614, while DB–P and MB1–DB distances demonstrated AUC values of 0.579 and 0.535, respectively. These findings suggest that the spatial relationship between the MB1 and palatal canal orifices may contain more information regarding MB2 presence than the other individual measurements evaluated. However, the magnitude of the AUC values should be interpreted cautiously. Although MB1–P distance and the MB1-P/DB-P ratio showed statistically significant ROC results, their discriminatory performance was modest. Therefore, these measurements should not be interpreted as sufficiently accurate to replace direct CBCT evaluation or meticulous clinical exploration of the pulp chamber floor. Rather, they may serve as additional anatomical indicators that increase clinical awareness of the possibility of an MB2 canal.[14]

Age demonstrated a statistically significant association with MB2 presence in the present study (p=0.001). The highest proportion of MB2-positive cases occurred in the youngest age group. This observation is consistent with previous studies reporting reduced MB2 detection with increasing age. Age-related dentin deposition and progressive canal narrowing or calcification may make MB2 canals increasingly difficult to visualize.[15] The current study also notes that secondary or tertiary dentin formation and canal calcification may reduce the visibility of small additional canals in older individuals.

In contrast, gender was not significantly associated with MB2 presence (p=0.278). This finding agrees with previous research in which differences between males and females were observed descriptively but did not reach statistical significance. The absence of a significant sex association suggests that clinicians should not use sex alone as a meaningful determinant when deciding whether an MB2 canal is likely to be present. The differences between clinical and laboratory investigations are also relevant when interpreting MB2 prevalence. Previous research by Ghobashy et al,[16] (2017) has demonstrated substantially higher detection rates when extracted teeth are examined using sectioning, clearing, microscopy, or other high-resolution techniques compared with routine clinical identification. Similarly, the use of magnification can substantially improve clinical detection. Consequently, prevalence figures obtained using different methodologies

should not be compared without considering the diagnostic technique.

CBCT provides three-dimensional information and may overcome some limitations associated with conventional two-dimensional radiography, particularly superimposition of anatomical structures.[17] Nevertheless, CBCT should be regarded as a complementary rather than routine imaging modality and should be used when clinically justified. In the context of complex maxillary molar anatomy, CBCT can provide useful preoperative information regarding the number and configuration of canals.

Strengths and limitations: A major strength of the study was the use of CBCT to evaluate maxillary first molar anatomy in vivo, allowing three-dimensional assessment of the canal system and quantitative measurement of interorifice relationships.

However, several limitations should be considered. The study used a non-probability convenience sampling approach and was conducted at a single institution. The sample may therefore not represent the broader Pakistani population. The study also relied on CBCT image interpretation, and measurement-related errors may have occurred despite the use of relatively high-resolution imaging. Furthermore, the study did not report complete diagnostic parameters such as sensitivity, specificity, positive predictive value, negative predictive value, or optimal ROC cut-off values. Therefore, the clinical utility of the measurements cannot be fully quantified from the available results. Future multicenter studies involving larger and more geographically diverse populations, standardized CBCT protocols, calibrated observers, and predefined diagnostic thresholds are warranted.

CONCLUSION

The present CBCT study identified an MB2 canal in 250 (62.5%) of 400 maxillary first molars. MB2 presence was significantly associated with age but not sex. Among the anatomical measurements evaluated, MB1–P distance demonstrated the highest ROC performance (AUC 0.636), followed by the MB1-P/DB-P ratio (AUC 0.614). However, the modest AUC values indicate that these measurements have limited ability to predict MB2 presence independently. Therefore, interorifice measurements may provide useful supplementary anatomical information, but they should not replace comprehensive clinical and radiographic assessment. CBCT can serve as a valuable complementary diagnostic modality when assessment of complex maxillary molar anatomy is clinically indicated.

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