

Prediction of Second Mesiobuccal Canal in Maxillary First Molars Based on other Canals Orifice Distribution in Eastern Indian Population – A Cone-beam Computed Tomography Study

Ujjwal Das¹, M. Sakthivel^{2*}, Lugu Buru Murmu³, Amrita Ghosh⁴, Kuntal Chowdhury⁵, Binayak Saha⁶

Department of Conservative Dentistry and Endodontics, Dr. R. Ahmend Dental College and Hospital, Kolkata, West Bengal, India.

Abstract

Background: Thorough shaping and disinfecting followed by three dimensional obturation of the whole root canal system is the key for successful endodontic treatment in maxillary molar teeth. Failure to treat second mesiobuccal (MB) canal is one of the most important reason for persistent or reinfection in maxillary molar teeth. Hence, in our study, we aimed to evaluate the incidence of second MB canal (MB2) and prediction of MB2 canal based on other canals orifice distribution with the help of cone beam computed tomography (CBCT). **Materials and Methods:** Total of 180 patients CBCT among which 300 maxillary first molars were included for this study. The inter-orifice distances between MB, distobuccal (DB) and P canals orifice were measured. Mesiobuccal-distobuccal-palatal canals orifice (MDP) angle was also measured. This inter-orifice distances and MDP angle were measured. Then MB-palatal canal (MB-P) and DB-palatal canal (DB-P) ratio was calculated. MB2 presence has been noted down. Then the presence of MB2 canals and the above factors are correlated. **Results:** The presence of MB2 canal was found in 228 teeth (76%). The incidence of MB2 is increased as the values increase in MB-P distance (>5.5 mm), MB-P and DB-P ratio (>1.2) and MDP angle ($>92^\circ$). **Conclusion:** MB2 presence and these three factors were in positive correlation, which would help in clinical practice to find out the MB2 canals efficiently with the help of actual MB, DB, and palatal canals orifice distribution at the pulpal floor while performing root canal treatment in maxillary first molars for successful endodontic treatment.

Keywords: Cone-beam computed tomography, Endodontics, Inter-orifice distance, Maxillary second molar, MDP angle, Prediction.

INTRODUCTION

Successful endodontic treatment depends on thorough instrumentation and disinfection of entire root canal space. In the past few years, the number of root canals and its configuration of mesiobuccal (MB) root of maxillary molars has been more extensively studied than any other root.^[1] First time in 1925, second MB canal (MB2) existence in MB root was reported maxillary first molar.^[2] The prevalence of MB2 in maxillary first molars ranges from 18% to 96.1%.^[3,4]

Inability to recognize MB2 presence and its inadequate cleaning is the major cause for endodontic failure in maxillary molars.^[5,6] because MB2 canal departs pulp chamber at a sharp mesial inclination, then curved distally, making its detection very challenging. Wolcott *et al.*^[7] reported a higher incidence of MB2 canals in retreatment than in initial root canal treatment. These studies are suggesting that failure of endodontic treatment has happened mainly due to missing out the existing MB2 canals which leads to a poorer prognosis of that tooth.

Cone beam computed tomography (CBCT) imaging can present the internal structures of the teeth three-dimensionally at a high resolution and with accuracy while simultaneously alleviating the superposition and distortion of the surrounding anatomic structures.^[8,9] Gupta and Adhikary^[10] concluded that detection of MB2 canal using CBCT scans and dental operating microscope did not show any significant difference. Vasundhara and Lashkari^[11] study showed that CBCT is showing high incidence (68.3%) of MB2 canal in maxillary first molars and it showed to be a reliable method in detecting

Address for correspondence: M. Sakthivel,
Department of Conservative Dentistry and Endodontics, Dr. R. Ahmend
Dental College and Hospital, Kolkata - 700014, West Bengal, India.
Email: sakthivelmunusamy95@gmail.com

Received: 01-07-2024; **Accepted:** 02-08-2024; **Published:** 20-08-2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.15.6.582>

How to cite this article: Das U, Sakthivel M, Murmu LB, Ghosh A, Chowdhury K, Saha B. Prediction of Second Mesiobuccal Canal in Maxillary First Molars Based on Other Canals Orifice Distribution in Eastern Indian Population – A Cone-beam Computed Tomography Study. J Res Adv Dent 2024;15(6):1-5.

MB2 canal. Hence, CBCT was found to be a reliable tool for the detection of MB2 canal in maxillary first molar teeth.

Previously, various studies were conducted to predict MB2 existence in maxillary first molars based on other canals orifice distribution at the pulpal floor on different populations.^[12-14] In this study, we aimed to find out the relationship between the presence of MB2 canals and different parameters, such as MB-palatal canals (MB-P) inter-orifice distance, MB-P and distobuccal [DB]-palatal canals (DB-P) inter-orifice distance ratio, and mesiobuccal-distobuccal-palatal canals orifice (MDP) angle at the pulpal floor in maxillary first molar in Eastern Indian population with the help of CBCT scans. In regular clinical practice CBCT imaging technique is not feasible everywhere and also not used routinely for endodontic diagnosis especially in suburban areas. Hence, these results would guide the clinicians to find out the MB2 in maxillary first molars more efficiently.

MATERIALS AND METHODS

Sample selection

After obtaining the permission of the Institutional Ethical Committee (Ethics Committee Reg. no. – EC/NEW/INST/2023/3191, Issued under New Drugs and Clinical Trials Rules, 2019 by DCGI and ICMR Guidelines), Digital CBCT images of maxillary first molars were randomly selected from Department of Conservative Dentistry and Endodontics, all of which were taken for various purposes, such as diagnosis and treatment plan of periapical surgeries, orthodontic and regenerative endodontic procedures.

Total of 180 patients CBCT among which 300 maxillary first molars were included for this study. Inclusion criteria: Age is 18–55 years, no open apices, single or two root canal variations, tooth resorption, root fractures, no intraradicular fillings and CBCT images of good quality.

Sample size determination

Sample size estimation was done using G* Power software (Version 3.1.9.7, University Duesseldorf, Germany). It indicated that the minimum total sample size required was 210 ($n = 210$) with a power of 95% and a Type I error rate of 0.05 will be required for maxillary first molars. However, it was decided to screen CBCT scans of 300 maxillary first molars to further decrease the margin of error.

Study methodology

Data in the Digital Imaging (CBCT – CD) were viewed in software NNTViewer. First, brightness and contrast were adjusted to an appropriate value, and then, the axial axis of each maxillary first molar was rectified on the sagittal plane, and images were magnified upto 300%.

MB root is observed from the cementoenamel junction to apex to determine the existence of MB2 canal and MB2 presence was noted down. The center points of the MB canal orifice, DB canal orifice, and palatal canal orifice were defined at the pulpal floor, and the inter-orifice distance of MB-P, DB-P and MB-DB was measured as the inter-orifice distance at the pulpal floor (Figure 1a). The ratio of MB-P to DB-P was calculated. MDP angle was also measured at the pulpal floor (Figure 1b). MB-P and DB-P inter-orifice distance ratio was calculated. Then, the statistical analysis was carried out.

Statistical analysis

The collected data were 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 and (ii) Independent samples t-test was used to compare the outcome variables between the two groups. A Receiver Operating Characteristic (ROC) curve was plotted to obtain the area under the curve (AUC) for the inter-orifice distance, MB-P/DB-P ratio, and the MDP angle to predict the presence of the MB2 canal. 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.

Sensitivity and specificity values obtained from the curve were used to find the optimal cut-off values. Observations were stratified according to the cutoff values and a binary logistic regression analysis^[15] was carried out to obtain the Odds ratio with 95% confidence intervals. The $P \leq 0.05$ was considered as the level of significance.

RESULTS

A total of 300 teeth were scanned by CBCT. In the Maxillary first molars, the presence of MB2 canal was found in 228 teeth (76%), and it was found that MB-P distance, MB-P/

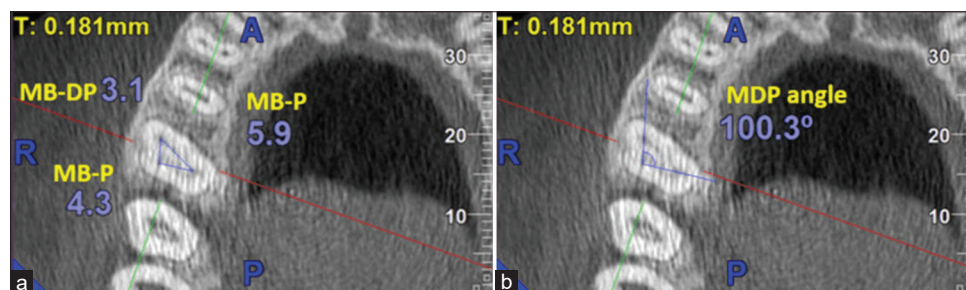


Figure 1: Cone beam computed tomography images - measurements at the floor of the pulp in axial section: (a) mesiobuccal-palatal canal, distobuccal-palatal canal and mesiobuccal-distobuccal inter-orifice distance, (b) Mesiobuccal-distobuccal-palatal canals orifice angle

DB-P ratio, and the MDP angles were significantly higher in the teeth containing MB2 canal than where it was absent ($P < 0.001$). However, in DB-P distance, the statistical evidence was weak (Table 1 and Figure 2a). So DB-P distance is not a significant factor in prediction of MB2 canals in maxillary first molars.

ROC curve analysis revealed that in the maxillary first molars, the greatest AUC was observed in the MDP angle ($AUC = 0.954$, $P \leq 0.001$), followed by MB-P/DB-P ratio ($AUC = 0.937$, $P \leq 0.001$), and then by the MB-P inter-orifice distance ($AUC = 0.9$, $P \leq 0.001$) which were quite comparable to each other, but the least area was seen by the

DB-P distance variable ($AUC = 0.459$, $P = 0.293$) (Table 1 and Figure 2b).

Analysis was further done based on the sensitivity and specificity values to find the cut-off values for the study variables (Table 2). The values with the optimum sensitivity and specificity values were considered as a cutoff measure to stratify the observations and were subjected to logistic regression analysis to predict the presence of the MB2 canal and thus obtain the Odds Ratios. The results of the regression analysis have been tabulated in (Table 2). It was observed that in both the teeth types, MB-P distance, MB-P/DB-P ratio, and the MDP angle were significant determinants in predicting the

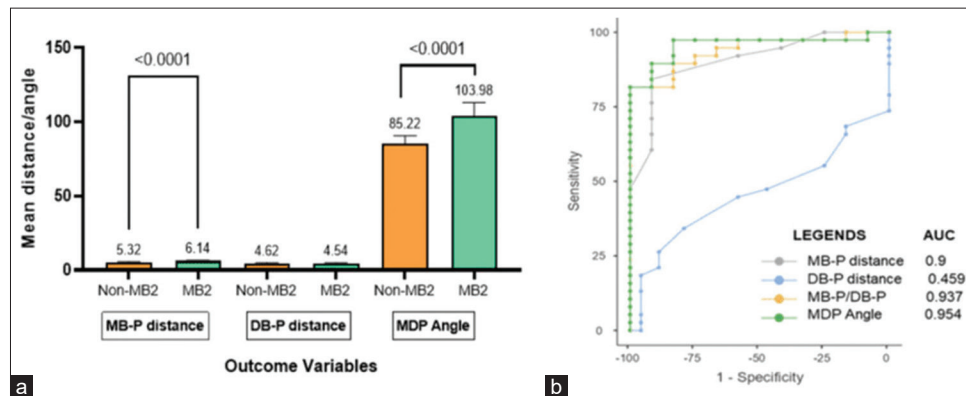


Figure 2: (a) Bar graph - mean and standard deviation for outcome variables along with comparisons, (b) Receiver operating characteristic curve showing the indicators for the presence of second mesiobuccal canal

Table 1: Descriptive statistics for the various outcome parameters for the MB2 and Non-MB2 groups and ROC curve showing the AUC and sensitivity, specificity values

Outcome variables	Non-MB2 (n=72)	MB2 (n=228)	P-value ^a	Sensitivity (%)	Specificity (%)	AUC (95%CI)	P-value
MB-P (mm)	5.32±0.353 (4.7–6.1)	6.14±0.509 (5.1–7.1)	<0.001*	84.2	90.3	0.9 (0.863–0.938)	<0.001*
DB-P (mm)	4.62±0.364 (4.2–6)	4.54±0.507 (3.5–5.8)	0.21	47.8	47.2	0.459 (0.393–0.524)	0.293
MB-P/DB-P	1.15	1.35	<0.001*	91.7	75	0.937 (0.911–0.962)	<0.001*
MDP angle (°)	85.2±5.51 (76.3–94.9)	104±9.06 (77.2–121)	<0.001*	97.37	83.3	0.954 (0.931–0.977)	<0.001*

Descriptive statistics have been depicted as Standard deviation (minimum value-maximum value), ^aAnalyzed according to independent samples t-test, CI: Confidence Intervals, *Statistically significant ($P \leq 0.05$), AUC: Area under the curve, MB: Mesiobuccal, DB: Distobuccal, ROC: Receiver operating characteristic, MB-P: Mesiobuccal-palatal canal, DB-P: Distobuccal-palatal canal, MDP: Mesiobuccal-distobuccal-palatal canals orifice

Table 2: Results of binary logistic regression showing the association between outcome variables and the presence of MB2 canal

Outcome variables	Cut-off values (%)	Non-MB2 (n=72) (%)	MB2 (n=228) (%)	Odds Ratio (95%CI)	P-value
MB-P (mm)	≤5.5 mm (n=102, 34)	66 (91.7)	36 (15.8)	58.667 (23.653–145.511)	<0.001*
	>5.5mm (n=198, 66)	6 (8.3)	192 (84.2)		
DB-P (mm)	≤4.5 mm (n=154, 51.3)	34 (47.2)	120 (52.6)	0.805 (0.474–1.37)	0.424
	>4.5 mm (n=146, 48.7)	38 (52.8)	108 (47.4)		
MB-P/DB-P	≤1.2 mm (n=72, 24)	54 (75)	18 (7.9)	35 (17.062–71.798)	<0.001*
	>1.2 mm (n=228, 76)	18 (25)	210 (92.1)		
MDP angle (°)	≤92° (n=78, 26)	60 (83.3)	18 (7.9)	58.333 (26.614–127.859)	<0.001*
	>92° (n=222, 74)	12 (16.7)	210 (92.1)		

CI: Confidence intervals, *Statistically significant ($P \leq 0.05$), MB-P: Mesiobuccal-palatal canal, DB-P: Distobuccal-palatal canal, MDP: Mesiobuccal-distobuccal-palatal canals orifice

presence of an MB2 canal ($P < 0.001$). For the maxillary first molars, the highest odds ratio was demonstrated by the MB-P distance and the MDP angle, followed by the MB-P/DB-P ratio.

DISCUSSION

Most important factor that leads to endodontic failure in maxillary molar teeth is missed out MB2 canals during initial root canal treatment^[16] because of its detection in maxillary molars is difficult due to its curved and tiny nature and its orifice is often covered by secondary dentin.^[17,18] In fact, the evidence to date suggests that more MB2 canals are found in laboratory studies (approximately 70%) than in clinical practice (approximately 40%).^[19]

In a pilot study, Blattner *et al.*^[16] reported that CBCT scans can accurately confirm or disconfirm the existence of MB2 canals in maxillary molars. Govil *et al.*^[20] and Likhyan *et al.*^[21] confirmed root canal morphology accurately in MB root of the maxillary molars where they had found Vertucci's Type VIII (3-3) and Vertucci's Type XXI (4-1), respectively. Hence, CBCT scans can be useful for MB2 canals detection and we decided to conduct this study using CBCT scans.

In our study, 300 maxillary first molars CBCT scans were taken for analysis. The result shows that the presence of MB2 canal was found in 228 teeth (76%), which was almost consistent with Kashyap *et al.*^[22] study of a Indian population which was 76.5% in maxillary first molar. It was found that MB-P distance, MB-P/DB-P ratio, and the MDP angles were significantly higher in the teeth containing MB2 canal than where it was absent. The DB-P distance was also found to be higher in the MB2 group than the non-MB2 group; however, the statistical evidence was weak.

ROC curve analysis revealed that, the greatest AUC was observed in the MDP angle, followed by MB- P/DB-P ratio, and then by the MB-P inter-orifice distance which were quite comparable to each other, but the least area was seen by the DB-P distance variable.

According to the results of binary logistic regression, "Cutoff values" were determined for all parameters. As per cutoff values, when MB-P inter-orifice distance is greater than 5.5 mm, chances for MB2 canal existence also increased. In Aktan *et al.*^[12] study it concluded that if the MDP angle is more than 90.95°, there was a 78% of chance that MB2 canals could be found. The probability of MB2 presence is high when MB-P/DB-P inter-orifice distance ratio is >1.2. In Zhang *et al.*^[13] CBCT study, non-fused maxillary first molars, a distance ratio >1.26 from the MB and DB canals to the palatal (P) canal was reported as a predictive factor for MB2 occurrence. When MDP angle is >92°, we can expect MB2 canal in that particular tooth. In Keskin *et al.*^[14] CBCT study, it is concluded that MB2 sensitivity (specificity) calculated from the MB-P distances of 4.0, 4.5, and 5.0 mm were 89.2% (36.5%), 76.9% (58.4%), and 44.4% (71.4%), respectively.

Location of MB2 was reported that, the MB2 orifice was always on the mesial aspect of the reference line which

connects DB and palatal canal orifices and approximately 2–3 mm palatal to the main MB orifice.^[4,23-26]

To the best of our knowledge, this is the first study to report the relationship between the MB2 canal existence and the distribution of other canals orifice at pulpal floor based on all the possible parameters together, such as MB-P inter-orifice distance, DB-P inter- orifice distance, MB-P and DB-P inter-orifice distance ratio, and MDP angle in maxillary first molars in East Indian population. Inter-orifice distance measurement became available under the optical magnification system of the microscope.

Although CBCT imaging is valuable endodontic diagnostic method, it is not used in regular clinical practice and also some patients who can be exposed to radiation for only a limited time due to some medical condition.^[27] Hence, our results are expected to be useful for clinicians to treat maxillary first molars with MB2 canal in initial root canal treatment.

CONCLUSION

Treating MB2 canals is the key to success of non-surgical endodontic therapy in maxillary first molars. In this study, as the cutoff values of various significant parameters were increased, the probability of existence of MB2 canals also increased in maxillary first molar. The data of inter-orifice distances and angle at the pulpal floor provide would provide a map for clinicians to efficiently identify and locate MB2 canals in maxillary first molars.

REFERENCES

1. Cleghorn BM, Christie WH, Dong CC. Root and root canal morphology of the human permanent maxillary first molar: A literature review. *J Endod* 2006;32:813-21.
2. Hess W. The Anatomy of the Root-Canals of the Teeth of the Permanent Dentition. Vol. 46. London: John Bale, Sons and Danielsson, Ltd.; 1925. p. 182-3.
3. Buhley LJ, Barrows MJ, Begole EA, Wenckus CS. Effect of magnification on locating the MB2 canal in maxillary molars. *J Endod* 2002;28:324-7.
4. Kulild JC, Peters DD. Incidence and configuration of canal systems in the mesiobuccal root of maxillary first and second molars. *J Endod* 1990;16:311-7.
5. Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S. Clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. *J Endod* 2002;28:477-9.
6. Huuonen S, Kvist T, Gröndahl K, Molander A. Diagnostic value of computed tomography in re-treatment of root fillings in maxillary molars. *Int Endod J* 2006;39:827-33.
7. Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S, Meyers J. A 5 yr clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. *J Endod* 2005;31:262-4.
8. Tian XM, Yang XW, Qian L, Wei B, Gong Y. Analysis of the root and canal morphologies in maxillary first and second molars in a Chinese population using cone-beam computed tomography. *J Endod* 2016;42:696-701.
9. Neelakantan P, Subbarao C, Ahuja R, Subbarao CV, Gutmann JL. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. *J Endod* 2010;36:1622-7.
10. Gupta R, Adhikary HD. Efficacy of cone beam computed tomography in the detection of MB2 canals in the mesiobuccal roots of maxillary first

- molars: An *in vitro* study. J Conserv Dent 2017;20:332-6.
11. Vasundhara V, Lashkari KP. An *in vitro* study to find the incidence of mesiobuccal 2 canal in permanent maxillary first molars using three different methods. J Conserv Dent 2017;20:190-3.
 12. Aktan AM, Yildirim C, Culha E, Demir E, Ciftci ME. Detection of second mesiobuccal canals in maxillary first molars using a new angle of cone beam computed tomography. Iran J Radiol 2016;13:e31155.
 13. Zhang Y, Xu H, Wang D, Gu Y, Wang J, Tu S, *et al.* Assessment of the second mesiobuccal root canal in maxillary first molars: A cone-beam computed tomographic study. J Endod 2017;43:1990-6.
 14. Keskin C, Keles A, Versiani MA. Mesiobuccal and palatal interorifice distance may predict the presence of the second mesiobuccal canal in maxillary second molars with fused roots. J Endod 2021;47:585-91.
 15. Hosmer DW, Lemeshow S. In: Applied Logistic Regression. 2nd ed., Ch. 5. New York: Wiley; 2000. p. 160-4.
 16. Blattner TC, George N, Lee CC, Kumar V, Yelton CD. Efficacy of cone-beam computed tomography as a modality to accurately identify the presence of second mesiobuccal canals in maxillary first and second molars: A pilot study. J Endod 2010;36:867-70.
 17. Betancourt P, Navarro P, Cantin M, Fuentes R. Cone-beam computed tomography study of prevalence and location of MB2 canal in the mesiobuccal root of the maxillary second molar. Int J Clin Exp Med 2015;8:9128-34.
 18. Pecora JD, Woelfel JB, Neto MD, Issa EP. Morphologic study of the maxillary molars. Part II: Internal anatomy. Braz Dent J 1992;3:53-7.
 19. Pomeranz HH, Fishelberg G. The secondary mesiobuccal canal of maxillary molars. J Am Dent Assoc 1974;88:119-24.
 20. Govil SA, Asthana G, Kanodia S, Parmar A. A case report on endodontic management of the rarest Vertucci's Type VIII configuration in maxillary second molar with three mesiobuccal canals. J Conserv Dent 2021;24:404-7.
 21. Likhyan LK, Shivagange V, Sobti G, Gandhi M. Endodontic management of a maxillary second molar with three roots and seven canals using cone-beam computed tomography. J Conserv Dent 2021;24:105-9.
 22. Kashyap RR, Beedubail SP, Kini R, Rao PK. Assessment of the number of root canals in the maxillary and mandibular molars: A radiographic study using cone beam computed tomography. J Conserv Dent 2017;20:288-91.
 23. Hartwell G, Bellizzi R. Clinical investigation of *in vivo* endodontically treated mandibular and maxillary molars. J Endod 1982;8:555-7.
 24. Neaverth EJ, Kotler LM, Kaltenbach RF. Clinical investigation (*in vivo*) of endodontically treated maxillary first molars. J Endod 1987;13:506-12.
 25. Ruddle CJ. Microendodontics: Identification and treatment of MBII system. J Calif Dent Assoc 1997;25:313-7.
 26. Stropko JJ. Canal morphology of maxillary molars: Clinical observations of canal configurations. J Endod 1999;25:446-50.
 27. Special Committee to Revise the Joint AAE/AAOMR Position Statement on use of CBCT in Endodontics. AAE and AAOMR joint position statement: Use of cone beam computed tomography in endodontics 2015 update. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;120:508-12.