ORIGINAL RESEARCH

Location of the Second Mesiobuccal Canal of Maxillary Molars in a Brazilian Subpopulation: Analyzing Using Cone-beam Computed Tomography

Plácido Herlânio Couto Normando[1], José Carlos Macedo Dos Santos[2], Eduardo Akisue[3], Hermano Camelo Paiva[4], George Táccio de Miranda Candeiro[5]

Abstract

Aim: This study aimed to evaluate the spatial location of the second mesiobuccal canal (MB2) of maxillary molars (MMs), using cone-beam computed tomography (CBCT), in a Brazilian subpopulation.

Materials and methods: The CBCT examination of 250 patients performed on the Eagle 3D device was analyzed, totaling 787 MMs. Using the Radiant Dicom Viewer software, measurements were made of the distances, in millimeters (mm), between the first mesiobuccal canal (MB1), MB2, and palatal (P) canal inputs, from the axial sections. The Image J software evaluated the angle formed by the lines. The data obtained were analyzed statistically by Fisher's exact and Chi-square tests with a significance of 5%.

Results: The prevalence of MB2 canals observed was 76.44 and 41.73% in the first and second molars (1MMs and 2MMs), respectively ($p < 0.05$). The average of the distances and angles performed, for the location of the MB2 canals of the analyzed teeth, were MB1-P = 5.83 mm, MB1-MB2 = 2.31 mm, and MB2 for the intersection of the connecting distance from MB2-T = 0.90 mm. The average angle formed between the MB1-P and MB1-MB2 distances was 25.89° and 19.68° for the 1MMs and 2MMs, respectively. It was also observed that 91.4 and 75.4% of the maxillary 1MMs and 2MMs, respectively, presented the MB2 canals mesially located at the line connecting the MB1-P canals ($p < 0.0001$).

Conclusion: The MB2 canals were located mesially to the MB1 canal with an average distance of 2 mm between the canals.

Clinical significance: The anatomical knowledge of the spatial location of the MB2 canal in different ethnicities is important for the planning and execution of endodontic treatment.

Keywords: Anatomy, Cone-beam computed tomography, Endodontics, Maxillary molars, Mesiobuccal canal.

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Introduction

The root canal morphology is essential for an adequate endodontic treatment. One of the frequent causes of failure in endodontics is the incomplete sanitation of the root canal system,[1] where unclogged root canals result in a high frequency of apical periodontitis.[2]

The maxillary 1MMs and 2MMs present one of the most complex root canal morphologies. Due to a large mesiodistal flattening in the mesiobuccal root, the presence of a single flattened canal can give rise to the formation of MB2.[3] The patient's age is an important determining factor for the occurrence of MB2 canals due to the continuous deposition of secondary dentin over the years.[4,5]

The MB2 root canal presents an additional difficulty to be located and treated. Among the different dental groups, the mesiobuccal roots of the maxillary first molars (1MMs) have the highest frequency of untreated canals (74%), with the MB2 missed in 93% of cases.[3]

The high prevalence rate of the MB2 canal in several studies in MMs,[4–8] may justify the prevalence of apical periodontitis associated with the non-localization of these root canals or associated with localized but untreated canals.[2,9]

Periapical radiography is the most commonly used method for diagnosing periapical pathologies and planning endodontic treatment; however, it presents two-dimensional images that do not always clearly reveal this anatomical diversity.[10] Cone-beam computed tomography for making it possible to obtain more detailed three-dimensional images of the structures of the maxillofacial complex and has been widely used to assess the anatomy of the root canals.[8,9,11–18] Therefore, it can be an important tool, especially concerning the identification of the MB2 root canal,[4,19–21] as well as in the study of its geometric positioning in relation to the other canals in different ethnic groups.[7,22,23]

Hence, this study aimed to analyze the spatial location of the MB2 canal in maxillary 1MMs and 2MMs from a Brazilian subpopulation using CBCT.

[1,2,5]Department of Endodontics, Universitary Center Unichistus, Fortaleza, Ceará, Brazil

[3]Department of Endodontics, Santa Cecília University, Santos, São Paulo, Brazil

[4]Department of Endodontics, University of São Paulo, São Paulo, São Paulo, Brazil

Corresponding Author: George Táccio de Miranda Candeiro, Department of Endodontics, Universitary Center Unichistus, Fortaleza, Ceará, Brazil, Phone: +55 85 988858671, e-mail: georgecandeiro@hotmail.com

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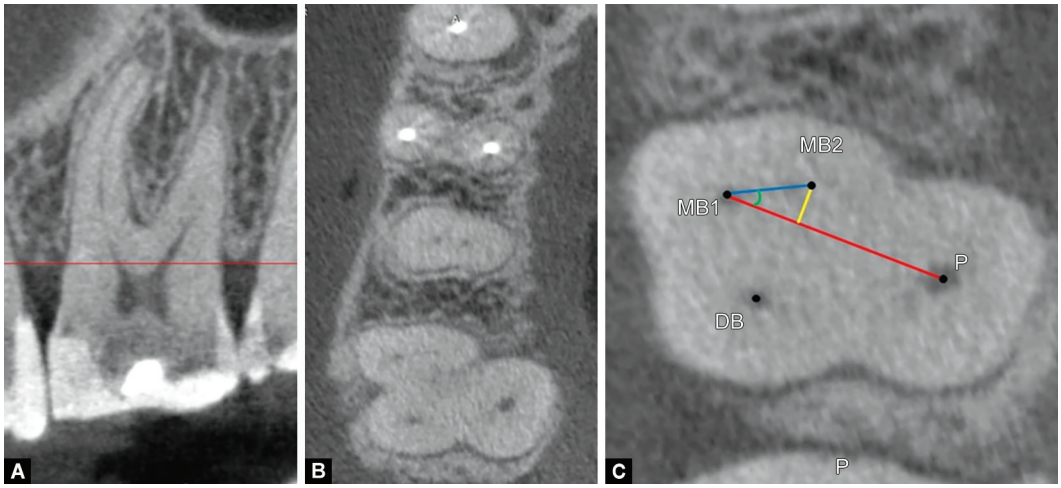

Figs 1A to C: CBCT images. (A) Axial reference section; (B) Confirmation of the presence of MB2 in the coronal section; (C) Measurement of distances between MB1 and P canals (red line), distance between MB1 and MB2 canals (blue line) and distance between MB2 and right angle with red line (yellow line) and the angle between red and blue lines (green angle)

Materials and Methods

This research was approved by the ethics committee of the Christus University, Brazil (Protocol No. 18345019.4.0000.5049).

The sample calculation was carried out by Survey Monkey software (www. surveymonkey.com). A minimum of 250 CBCT examinations were necessary to obtain a 95% confidence level and a 3% margin of error. This study researched a database of CBCT exams, from the image bank of the Imaging Clinic at the University Center Christus, Fortaleza, Brazil, obtained from November 2016 to March 2019. Inclusion criteria that determined CBCT acceptance were having at least one MM completely erupted with fully formed apexes. Exclusion criteria for CBCT teeth with the presence of fractures, dentinal resorptions, pulp chamber calcifications, and previous endodontic and/or restorative treatment.

All CBCT examinations were performed on the Eagle 3D device (Dabi Atlante, Ribeirão Preto, SP, Brazil), operating at 85.0 kV and 6.3 mA, 20.0 s, using the 12 cm × 7.5 cm field of view (FOV). The CBCT images were analyzed on a Dell Precision T5400 workstation (Dell, Round Rock, TX, USA), with a 17-inch Dell LCD screen with 1280 resolution × 1024 pixels with 85-Hz and 0.255-mm dot pitch operated at 24 bits, in a dark environment. Contrast, brightness, sharpness, and zoom were adjusted using the software's tools to ensure better viewing.

The evaluation was performed by a check experient plácido herlânio couto normando (PHCN). Calibration of the examiner, to identify root canals and angles, was performed previously with another check experient george táccio de miranda candeiro (GTMC), presenting a high interexaminer agreement (Kappa test = 0.94). A set of 50 CBCT examinations (180 teeth analyzed) was used for this process. After 1 month, the intraexaminer reliability was assessed with the same CBCT scans, randomly distributed, and the reliability was extremely high (Kappa test = 0.98).

Dicom Viewer software images of the axial plane of each tooth were selected, and the reference cut for the location of the MB2 canal was the first time that the entry of the MB2 canal was seen in the image of the analyzed molars (Fig. 1A), with the protocol to confirm the presence of the MB2 canal, its visualization, also, in the sagittal and or coronal sections (Fig. 1B). Using the axial section of CBCT, mesiobuccal 1 (MB1), mesiobuccal 2 (MB2), and P root canals were identified and used to perform the analysis.

The center points of MB1, P canals and MB2 were located and straight lines were drawn using Radiant Dicom Viewer software (Medixant, Poznan, Poland) connecting these points (MB1-MB2, MB1-P). Another line, MB2-T, was drawn from MB2 perpendicular to the MB1-P line (T point). The distances between the points on the drawn line were measured in millimeters. Using these references, the angles formed between MB1-P and MB1-MB2 lines were also measured using Image J software (National Institutes of Health, Bethesda, Maryland, USA) (Fig. 1C).

Measurements were made in triplicate and the data were analyzed statistically by the Prisma 8 software (GraphPad Software, San Diego, USA). Fisher and Chi-square tests were used for the analysis, applying a significance level of 5% ($p < 0.05$).

Results

In this study, 250 CBCT scans were selected (125 males and 125 females), of patients ranging from 10 to 69 years (mean: 42-years old). A total of 787 MMs, of which 382 1MMs and 405 2MMs, were examined.

The MB2 canals were statistically more prevalent in 1MMs (76.44%) than 2MMs (41.73%) ($p < 0.0001$). Regarding gender, no significant difference was observed in the prevalence of MB2 canals in both MMs ($p > 0.05$). Table 1 shows the prevalence of MB2 canals in MMs.

It was also observed that 91.4 and 75.4% of the maxillary 1MMs and 2MMs, respectively, presented the MB2 canals mesially located to the line connecting the MB1 to the P root canals ($p < 0.0001$). When not mesially positioned, MB2 was on the same line MB1-P (Table 2).

It was observed that the angle formed by the MB1-P and MB1-MB2 lines for the spatial location of the MB2 presented an average value of 25.89° and 19.68° for the maxillary 1MMs and 2MMs, respectively ($p < 0.0001$). Table 3 shows the values of the distances of MB1-P, MB1-MB2, and MB2-T lines, in millimeters (mm) of the present research and previous studies from different regions with similar methodology.

Figures 2 and 3 illustrate the average distances between the canal orifices in first and second MMs, respectively.

Discussion

The endodontic treatment of molars teeth has always been a challenge. The lack of knowledge of the anatomy of this group of teeth can lead to treatment failure.[3] The chance of apical periodontitis was 6.25 times higher for teeth with an untreated canal. The MB2 was the most frequently missed root canal, in 93% of the cases.[2] Generally, the principal difficulty to identify and treat MB2 canals is because their entrance is covered by secondary dentin.[6,23]

Although periapical radiography is the most common examination used in the diagnosis of periapical pathologies and planning of endodontic treatment, currently CBCT is recommended.[2] Before beginning endodontic retreatment, an evaluation with the help of CBCT is indicated in order to check for the presence of treated or untreated root canals, thus facilitating planning.[19] A previous research reported that 72.7% of the maxillary 1MMs and 88.8% of the maxillary 2MMs had apical lesions in the root canals without filling material.[9] So, a missed root canal without suitable disinfection and obturation decreases the success rate for endodontic therapy.

Table 1: Prevalence of MB2 canals in maxillary 1MMs and 2MMs

		n	*MB2*	*Prevalence (%)*	*p-value*
1MM	Male	196	156	79.59[a]	0.1488
	Female	186	136	73.12[a]	
	Total	382	292	76.44[A]	
2MM	Male	214	98	45.79[b]	0.0866
	Female	191	71	37.17[b]	
	Total	405	169	41.73[B]	

Different superscript capital letters indicate the presence of a statistically significant difference in the interdental comparison. Different superscript lower case letters indicate the presence of a statistically significant difference when comparing genders in the same type of tooth

Table 2: Position of MB2 canals concerning the line connecting the MB1 to P root canals, in maxillary 1MMs and 2MMs

	1MM		*2MM*		
	n	*%*	*n*	*%*	*p-value*
Mesial	267	91.4	126	75.4	
Distal	0	0.0	0	0.0	<0.0001
Same line	25	8.6	41	24.6	
Total	292	100.0	167	100.0	

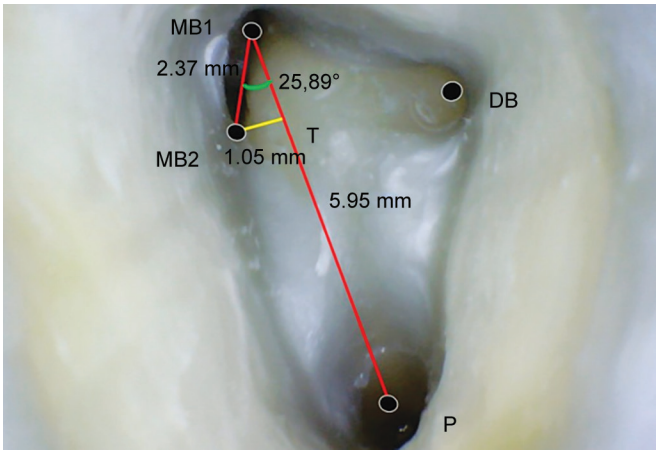

Fig 2: Average of analysis of measures in 1MMs

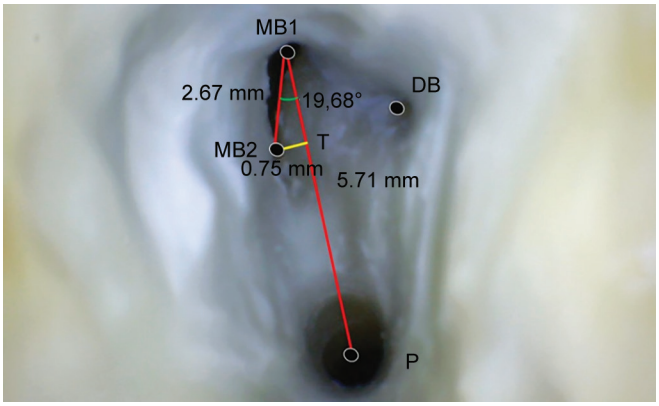

Fig 3: Average of analysis of measures in s2MMs

Table 3: Measurements of the distance between root canal orifices and prevalence of MB2 in different countries in maxillary 1MMs and 2MMs

			1MM			
Reference	*Country*	*n*	*Prevalence (%)*	*MB1-MB2*	*MB2-T*	*MB1-P*
Betancourt et al.[25]	Chile	550	69.8	2.68 ± 0.49	1.25 ± 0.34	7.64 ± 1.04
Su et al.[29]	Taiwan	108	NI	1.91 ± 0.59	1.70 ± 0.61	5.73 ± 0.66
Zhang et al.[23]	China	1008	85.4	1.90 ± 0.52	NI	6.11 ± 0.66
Kewalramani et al.[8]	India	598	61.9	2.50 ± 0.60	1.00 ± 0.40	7.30 ± 0.80
Zhuk et al. (2020)[21]	USA	249	NI	2.03 ± 0.55	1.03 ± 0.33	6.87 ± 1.03
This study	Brazil	382	76.4	2.37 ± 0.51	1.05 ± 0.44	5.95 ± 0.83
			2MM			
Reference	*Country*	*N*	*Prevalence (%)*	*MB1-MB2*	*MB2-T*	*MB1-P*
Betancourt et al.[22]	Chile	225	48.0	2.20 ± 0.54	0.98 ± 0.35	6.70 ± 0.95
Betancourt et al.[25]	Chile	550	46.9	2.41 ± 0.64	0.98 ± 0.33	7.02 ± 1.30
This study	Brazil	405	41.7	2.26 ± 0.49	0.75 ± 0.49	5.71 ± 0.92

NI, not informed

A recent European Society of Endodontology's guidelines recommend CBCT for endodontic treatment of teeth with complex root canal systems and nonsurgical retreatment of cases with possible untreated canals and/or previous treatment complications.[24] Also, CBCT has been used to accurately identify the presence of MB2 canals, in the first and second MMs.[7,21,22,25] So, in this study, the methodology used is suitable for the location of the root canals and the measurement of distances and angles.[21]

The high prevalence rate of the MB2 canal in MMs has been detected in several studies, in the most varied world populations. In the maxillary 1MMs the incidence varies between 39.2 and 92% and between 22.72 and 61% in the maxillary 2MMs.[5–8,12,20,23,25–29] The incidence most often occurs in males.[8,18,20,23,25,29] Regarding age, the presence of MB2 occurs more in adults and less in young people and elderly.[7,8,20,23,30,31]

Previous studies of the internal dental anatomy of MMs with CBCT of the Brazilian population show a variable prevalence of MB2 canals from 42.61% to 87.78% for 1MM and from 22.70% to 79.06% for 2MM.[8,12] In this study, the prevalence values observed were 76.44 and 41.73% in the maxillary 1MMs and 2MMs, respectively, agreeing with the previous studies.[8,12,13]

Although the systematic review by Martins et al.[6] showed a higher prevalence in males, the results of this research work also showed that there are no statistically significant differences in relation to gender in agreement with previous studies.[7,12,27]

Betancourt et al.[22] in a study carried out in Chile, found that the mean location of the MB2 canal was 2.20 ± 0.54 mm palatally and 0.98 ± 0.35 mesially to the MB1 canal in the maxillary 2MMs. In a similar study, Betancourt et al.[25] analyzing the maxillary 1MMs and 2MMs, showed that the average location of MB2 canal was 2.68 ± 0.49 mm palatally and 1.25 ± 0.34 mm mesially to the MB1 canal for the maxillary 1MMs.

The location of MB2 canals in maxillary 2MMs found was 2.41 ± 0.64 mm palatally and 0.98 ± 0.33 mm mesially to the MB1 canal. Similar values were obtained by Kewalramani et al.[8] in a study carried out in India, to find averages of 2.50 ± 0.60 mm palatally and 1.00 ± 0.40 mesially to the MB1 canal. More recently, Zhuk et al.[21] observed in USA population values of 2.03 ± 0.55 mm palatally and 1.03 ± 0.33 mesially. Evaluating only MB1/MB2 distance in Taiwan and China populations, Su et al.[29] and Zhang et al.[23] showed values of 1.91 ± 0.59 mm and 1.90 ± 0.52, respectively, both toward the P canal.

In this study, the spatial location of the MB2 canal was analyzed, obtaining results similar to previous studies with average measurements of 2.37 ± 0.51 mm and 1.05 ± 0.44 mm mesially to the MB1 canal for 1MMs, 2.26 ± 0.49 mm palatally, and 0.75 ± 0.49 mm mesially to the MB1 canal for 2MMs (Table 3).[7,21,22,25]

Moreover, to facilitate the location of MB2 canal, the angle between the MB1-MB2 and MB1-P lines presented values of 25.89° ± 10.35 for the 1MM and 19.68° ± 13.09 for the 2MM (Table 2). This difference can be explained by the greater flattening of the crown of the 2MM, resulting in a change in the spatial position of the MB2 canal. It was also observed that the MB2 canals were located mesially to the line perpendicular to the MB1-P line in 91.4% of the cases in the 1MM and 75.4% in the 2MM, the others being found on this line. Thus, the conventional triangular shape should be slightly modified, making it rhomboid.

The CBCT is an important method to facilitate the location of MB2 canals, functioning as a map to guide professionals during endodontic treatment. However, limitations may be observed using the present methodology, mainly when CBCT method is used, with a big FOV, which shows less accuracy than exams with a small FOV. In this research work, CBCT with a small FOV was used, but possible severe calcifications may have been undiagnostic and MB2 canals may have been missed.

The development of CBCT and software devices that improve the identification of MB2 canals is necessary to decrease failures during its diagnosis and management. According to previous studies, MB2 canals are located more efficiently when combined CBCT with an operating microscope and ultrasonic devices.[32–34]

Conclusion

The results of this study show that the CBCT improves the location of the MB2 canal in the MMs which is in a position in the P canal direction of about 2 mm and the mesial direction of about 1 mm in relation to the MB1 canal. In cases of MMs, the use of CBCT facilitates treatment planning and increases the probability of safety and success in endodontic therapy.

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