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The Correlation Between Crown Size and Presence of MB2 in First and Second Permanent Maxillary Molars Using Cone-Beam Computed Tomography

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Aim: This study investigates the correlation between crown size and the presence of a second mesiobuccal (MB2) canal in the permanent maxillary first and second molars.

Materials and Methods: The study was conducted at Taibah University Dental Hospital (Madinah, Saudi Arabia) using CBCT scans from 331 patients. Two general practitioners examined CBCT scans under the supervision of a radiologist and endodontist. CBCT scans were acquired using a Kodac 9000 machine and measured with Kodac Carestream software. mesiodistal distance and bucco-palatal distance were measured from CBCT scans. In addition, patients' age and gender were recorded. Data was analyzed with IBM SPSS software, and statistical tests were employed to evaluate the presence of MB2 based on gender, crown width, and length.

Results: The overall prevalence of MB2 in the upper first molars was 46.6%, and in the upper second molar was 45.1%. There is a correlation between the prevalence of MB2 and the size of the crown, which is significantly higher when the mesiodistal or bucco-palatal length is longer than 10 mm.

Conclusion: There is a positive correlation between the presence of MB2 and the size of the crown. Further investigation should be performed with a higher number of cases.

Keywords: Second Mesiobuccal Canal; Endodontics; Root canal treatment; CBCT; Tooth anatomy

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Introduction

Root canal therapy aims to prevent infection, stop or reduce periapical inflammation, and eliminate signs and symptoms such as discomfort and swelling.1 It is therefore essential that all root canals achieve good patient outcomes. Unfortunately, some anatomical complexities make it difficult to locate all canals, resulting in unsuccessful root canal therapy.[1] One of the most complicated anatomical structures is the mesiobuccal root of the maxillary molars, which can have two main canals: first mesiobuccal and second mesiobuccal (MB2).[2] Unfortunately, this complexity increases the likelihood that the care provider will miss the MB2 canal, which is thought to be the main reason for the failure of root canal therapy on maxillary molars.[2]

Race, age, and gender of the population studied and the research methods contribute to the wide variation in the prevalence of MB2 canals in maxillary molars.[3] MB2 canals are more prevalent in three-rooted maxillary molars and less prevalent in the middle and apical thirds than in the coronal third.[4] Researchers have used multiple methodologies to investigate anatomical variations in roots; some involve in vivo application, and others incorporate in vitro methods. The in vivo techniques include root evaluation during endodontic treatment, conventional radiographs, and cone beam computed tomography (CBCT). The in vitro methods include root sectioning and using a dye to stain the canal.[5] The gold standard imaging tool for detecting MB2 canals is CBCT. It is considered the most dependable method because it allows for consecutive evaluation of specific anatomical characteristics for all groups of teeth in large populations.[2]

Previous studies have provided extensive insights into factors influencing the detection of MB2 canals. Biradar et al. (2022) demonstrated that CBCT significantly increased the detection rate of MB2 canals compared to clinical analysis and dental microscope methods. They found detection rates of 40% using CBCT, highlighting the superior diagnostic capability of this imaging technique.[6] Vizzotto et al. (2013) explored the effect of voxel size in CBCT, reporting that smaller voxel sizes yielded better detection rates. They also noted that the presence of root fillings could negatively impact the detection of MB2 canals, emphasizing the importance of selecting appropriate CBCT settings.[7] Vizzotto et al. (2015) further examined the reliability of CBCT in detecting MB2 canals, focusing on the influence of operator experience and root conditions. They found that professional experience and the condition of the root significantly affected detection reliability, with kappa values indicating variable agreement among observers.[8] Park et al. (2014) studied factors affecting dental students' ability to locate MB2 canals, concluding that access size and straight-line path of access did not significantly impact detection success, underscoring the critical role of technical proficiency and experience.[9] Manigandan et al. (2020) demonstrated that combining direct vision, dental operating microscope, selective dentin removal, and CBCT achieved high detection rates, with an overall prevalence of MB2 canals at 93%.[10]

No previous studies have investigated the relationship between crown size and the presence of MB2; therefore, our study investigates the correlation between clinical crown size and the presence of MB2 in maxillary first molars (MFMs) and maxillary second molars (MSMs) using CBCT. The null hypothesis was that there is no relationship between the crown size and the presence of the MB2 canal in the permanent MFMs and MSMs.

Materials and Methods

The study was performed at Taibah University Dental Hospital (Madinah, Saudi Arabia). The collected data was anonymous, confidential, and used only for professional research purposes. The Research Ethics Committee of Taibah University College of Dentistry reviewed and approved the study (TUCDREC/071122/TMAQILI). The study adhered to the World Medical Association guidelines set at the Declaration of Helsinki. The obtained data were coded during the data analysis. Participants provided their informed consent for the use of their images in the above study before taking their CBCT scans. Two well-trained general practitioners examined the sample size of 331 CBCTs under the supervision of a radiologist and an endodontist.

This study used data from CBCT scans in the records of Taibah University Dental Hospital. The same machine (Kodak 9000) acquired all selected scans; the volume of scans was not critical to the task at hand. The same software was used to measure all the scans (Kodak Carestram). After the proper alignment of the scans, the hard palate leveled to be parallel with the floor and carried out measurements. Subjective adjustment of the histogram was left to be decided by the reader. Inclusion criteria were: good-quality CBCT scans with clear visualization of anatomical structures without motion artifacts or distortions and at least one MFM or MSM with a fully formed crown and root. Exclusion criteria included: low-quality CBCT images exhibiting motion artifacts, distortions, or poor resolution; lack of at least one MFM or MSM; or maxillary molars with developmental anomalies (such as fusion or gemination), extensive caries on MFMs or MSMs, root restoration, coronal restoration, intracanal post, prosthetic crown, or open apex.

The measurements were carried out at the widest part of the crown in the axial cross-section. The mesiodistal and bucco-palatal distances were measured from the CBCT images at the level of the dentinoenamel junction (Figure 1). These measurements were standardized using calibrated measurement tools within the software and verified by scanning a 15-cm metal ruler and using it as a reference. The viewing conditions were standardized in dim lighting in the same room with the same computer to ensure consistency. The presence of MB2 was examined as shown in Figure 2. The age and gender of each patient were also recorded. The reliability of CBCT scan interpretation was evaluated by different examiners using Cohen's kappa test, which indicated a high level of agreement among the examiners.

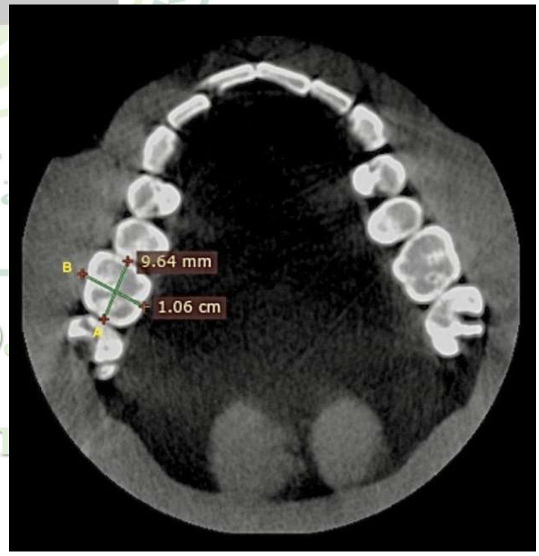

Figure 1: The Mesiodistal and Bucco-Palatal Length Measurement. Line A: Measuring mesiodistal width. Line B: Measuring bucco-palatal length.

The data was entered into a computer and analyzed with IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp.). Qualitative data was presented in terms of numbers and percentages, while quantitative data was presented with minimum and maximum range, mean, standard deviation, and median. The significance of the results was assessed at a 5% level of confidence.

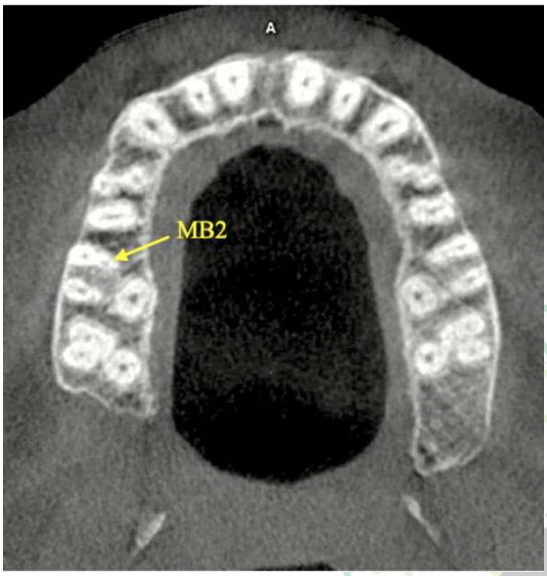

Figure 2: Presence of MB2 Confirmation on Maxillary First Molars. MB2: second mesio-buccal canal (yellow arrow)

Statistical Analysis:

Chi-square Test: Used for comparing categorical variables across groups to determine if there is a significant association between variables.

Fisher's Exact Test or Monte Carlo Correction: Applied with Chi-square in cases where more than 20% of cells had an expected count of less than five, ensuring the accuracy of the statistical inference.

McNemar Test and Marginal Homogeneity Test: Employed to evaluate the presence of MB2 in maxillary molars between different sides of the maxilla, allowing for the comparison of paired categorical data

Results

Out of the 331 CBCT scans examined, 131 scans satisfied the inclusion criteria. Of the participants, 100 (76.3%) were women and 31 (23.7%) were men (Table1). The average age of the participants was 26.92±10.61 years (Table 1).

Table 1: Distribution of the Studied Cases According to Demographic Data (n = 131)

	No.	**%**
Gender		
Male	31	23.7
Female	100	76.3
Age		
Younger than 20	29	22.1
20–29	63	48.1
30–39	20	15.3
Older than 40	19	14.5
Min–Max	10.0–63.0	
Mean ± SD	26.92 ± 10.61	
Median (IQR)	24.0	

In terms of tooth distribution, 399 teeth were screened (MFMs = 195, MSMs = 204; Table 2). There was an extremely high interexaminer agreement regarding the presence and absence of MB2 in maxillary molars (k = 1.000). The overall prevalence of MB2 in MFMs 126 (64.6%) was higher than in MSMs 92 (45.1%; p < 0.001; Table 3).

Table 2: The Presence of MB2 in Maxillary Molars (n = 399)

MB2	**16 (n = 100)**	**17 (n = 104)**	**26 (n = 95)**	**27 (n = 100)**
Not present	32 (32%)	57 (54.8%)	37 (38.9%)	55 (55%)
Present	68 (68%)	47 (45.2%)	58 (61.1%)	45 (45%)

16: Right Maxillary First Molar, 17: Left Maxillary Second Molar, 26: Left Maxillary First Molar, 27: Left Maxillary Second Molar, MB2: Second Mesio-Buccal Canal

Table 3: Comparison Between Maxillary First Molars and Maxillary Second Molars According to Presence of MB2

MB2	**maxillary first molars (n = 195)**	**maxillary second molars (n = 204)**	**χ2**	**McNp**
Not present	69 (35.4%)	112 (54.9%)	24.914*	<0.001*
Present	126 (64.6%)	92 (45.1%)		

McN: McNemar test, p: p-value for comparing between (16+26) vs (17+27), *: Statistically significant at p ≤ 0.05

In terms of gender, there was a significant difference regarding the presence of MB2 in the right MSM (17), being higher in men 13 (72.2%) than in women 34 (39.5%; p = 0.011; Table 4).

Table 4: Relation Between Gender and Presence of MB2

		Gender		c2	p
		Male	Female		
MB2	16	(n = 18)	(n = 82)		
	Not present	7 (38.9%)	25 (30.5%)	0.479	0.489
	Present	11 (61.1%)	57 (69.5%)		
	17	(n = 18)	(n = 86)		
	Not present	5 (27.8%)	52 (60.5%)	6.421*	0.011*
	Present	13 (72.2%)	34 (39.5%)		
	26	(n = 19)	(n = 76)		
	Not present	6 (31.6%)	31 (40.8%)	0.542	0.461
	Present	13 (68.4%)	45 (59.2%)		
	27	(n = 20)	(n = 80)		
	Not present	9 (45%)	46 (57.5%)	1.010	0.315
	Present	11 (55%)	34 (42.5%)		

c2: Chi-square test, FE: Fisher Exact, p: p-value for comparing between the studied groups, *: Statistically significant at $p \le 0.05$

According to the mesiodistal width of the right MSM (17), the MB2 canal was present in 13 (76.5%) of teeth longer than or equal to 10 mm and was present in 34 (39.1%) of teeth less than 10 mm (p = 0.007; Table 5). According to the bucco-palatal length of the right MFM (16), the MB2 canal was present in 63 (72.4%) of teeth longer than or equal to 10 mm and was 5 (38.5%) in teeth less than 10 mm (p = 0.024; Table 5).

Table 5: Relation Between Crown Size and Presence of MB2

		MB2		c^2	p
		Not present	Present		
MD	16	(n = 32)	(n = 68)		
	<10	19 (32.8%)	39 (67.2%)	0.037	0.848
	≥10	13 (31.0%)	29 (69%)		
	17	(n = 57)	(n = 47)		
	<10	53 (60.9%)	34 (39.1%)	8.027	0.007*
	≥10	4 (23.5%)	13 (76.5%)		
	26	(n = 37)	(n = 58)		
	<10	19 (35.8%)	34 (64.2%)	0.484	0.487
	≥10	18 (42.9%)	24 (57.1%)		
	27	(n = 55)	(n = 45)		
	<10	46 (56.1%)	36 (43.9%)	0.222	0.638
	≥10	9 (50%)	9 (50%)		
BP	16	(n = 32)	(n = 68)		
	<10	8 (61.5%)	5 (38.5%)	5.992	$^{FE}p = 0.024^*$
	≥10	24 (27.6%)	63 (72.4%)		
	17	(n = 57)	(n = 47)		
	<10	5 (71.4%)	2 (28.6%)	0.837	$^{FE}p = 0.453$
	≥10	52 (53.6%)	45 (46.4%)		
	26	(n = 37)	(n = 58)		
	<10	5 (50%)	5 (50%)	0.574	$^{FE}p = 0.504$
	≥10	32 (37.6%)	53 (62.4%)		
	27	(n = 55)	(n = 45)		
	<10	6 (85.7%)	1 (14.3%)	2.869	$^{FE}p = 0.125$
	≥10	49 (52.7%)	44 (47.3%)		

MD: Mesio-Distal Width, BP: Bucco-Palatal Length, ≥: Equal or more than 10mm, <: Less than 10mm
c2: Chi-square test, FE: Fisher Exact, p: p-value for comparing the studied groups, *: Statistically significant at $p \le 0.05$

Discussion

The incidence of MB2 canals in maxillary molars is influenced by multiple factors, including the materials and methods used in various studies. In this study, CBCT scans showed that the prevalence of MB2 canals in MFMs and MSMs are 126 (64.6%) and 92 (45.1%), respectively. This prevalence is relatively low compared to the findings of Kulild and Peters, who reported a higher prevalence using microscopic evaluation.[11] However, it is higher than the prevalence reported by Vertucci, who used the clearing technique with decalcification and hematoxylin injections.[12]

Martins et al. conducted a global study and found that the prevalence of MB2 canals in MFMs was 73.8%, with significant variations across different populations: 48.0% in Venezuela and 97.6% in Belgium. They also reported a prevalence of 76.3% in men and 71.8% in women.[3] In contrast, our study found a lower overall prevalence in both genders, highlighting potential regional and methodological differences. For MSMs, the prevalence of MB2 canals ranges widely across different populations: 38% in the Indian population, 67% in the South African population, 17.7% in the Turkish population, and 57.9% in the Egyptian population.[3] Our study's prevalence of 45.1% fits within this broad range, suggesting that geographical and genetic factors may play significant roles. In the Saudi population, previous studies reported MB2 canal prevalences of 46.7% for MFMs and 17.7% for MSMs, with a higher frequency in women.[2] These findings are consistent with our results, indicating similar trends within the same regional population.

Various techniques have been employed to detect root canal morphology. Vertucci's study utilized the clearing technique with decalcification and hematoxylin injections,[12] while Carns and Skidmore used polyester castings.[13] Kulild and Peters relied on microscopic evaluation,[11] and Wein et al. used sectioning.[14] In vitro radiography has also been used historically.[15] More recently, CBCT and micro-CT have become prevalent tools for detecting exact root canal anatomy and morphology.[16] Our use of CBCT aligns with these recent methodologies, providing high-resolution, three-dimensional images that enhance the detection of MB2 canals.

Age-related physiological changes in the pulp, such as increased calcification, can result in the obliteration of MB2 canals, as demonstrated by Bernick and Nedelman.[17] This factor may contribute to the variations in MB2 canal prevalence observed across different studies, as the age of the patient population can significantly influence detection rates. Our study found a significantly higher prevalence of MB2 canals in MFMs when the bucco-palatal width is longer than 10 mm. Similarly, the prevalence of MB2 canals in MSMs is significantly higher when the mesiodistal length is longer than 10 mm. These findings suggest that crown size could be a useful indicator during the access cavity step of root canal treatment, potentially improving the success rate by reducing the likelihood of missing MB2 canals. Missed MB2 canals are known to affect the success rate of root canal treatment.[18] Therefore, this study's findings could be beneficial for clinicians during the access cavity preparation in root canal procedures, emphasizing the importance of considering crown dimensions as part of the diagnostic process.

Limitations

One of the limitations of this study is the use of a large field of view (FOV) in CBCT scans. As highlighted by Hassan et al., the FOV can affect the visibility of root canal anatomy and the resolution of the scan, potentially impacting the accuracy of MB2 canal detection.[19]Additionally, the number of included cases in our study is relatively low, which could affect the statistical power and generalizability of the results. Further investigation with a larger sample size and different imaging methods, such as micro-CT or small-field CBCT, is needed to better understand the correlation between crown size and the prevalence of MB2 canals.

Conclusion

There is a positive correlation between the presence of MB2 canals and larger crown sizes in first and second maxillary molars. This information could be valuable during the access cavity step of root canal treatment to avoid missing the MB2 canal, which is crucial for the procedure's success. Further research with a larger sample size and different imaging methods, such as Micro-CT or small-field CBCT, is warranted to validate these findings.

Funding
None.

Data Availability
The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate: The study was approved by the Research Ethics Committee of Taibah University College of Dentistry (study reference number: TUCDREC/071122/TMAQILI). All participants provided informed consent for the use of their images in this study.

Competing interests: The authors declare that they have no competing interests.

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