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Prevalence of the second mesiobuccal canal in maxillary first molars and its Vertucci classification: A tomographic analysis (April 2023 - April 2025)

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Abstract
Introduction: This study was designed to determine the prevalence of the second mesiovestibular canal (MB2), in maxillary first molars using the analysis of cone-beam tomography (CBCT) images.
Methods: A total of 1,173 tomographs were analyzed, of which 819 were considered valid, considering the following exclusion criteria: images showing internal or external root resorptions, canal calcification, full-coverage restorations, metallic restorations, and crowns, to avoid errors in the analysis. Before analysis, training, and calibration were conducted to detect the presence of the MB2 canal and the Vertucci classification.
Results: After tomographic analysis, the prevalence of the MB2 canal was 73%. According to Vertucci's classification, type II was the most frequent (51.3%), followed by type IV (19.2%). Types III, V, and VI showed low proportions (0.4%, 0.7%, and 1.5%, respectively). The prevalence of MB2 was (77.6%) in men and (70.3%) in women. Regarding age, MB2 was most common in the young group (89.7%), followed by individuals aged 31-45 years (80.9%), and was least common in those older than 46 years (65.9%). Statistical results highlight the importance of carefully examining the MB2 canal in all patients, without limitations based on criteria such as gender or age.
Conclusions: The use of cone-beam computed tomography (CBCT) as a diagnostic tool is of great importance. CBCT provides essential clinical information for endodontic treatment.

Keywords: Cone-beam computed tomography, second mesiovestibular canal, maxillary first molar, endodontics, prevalence, endodontic treatment

Introduction

The maxillary first molar is among the earliest erupting teeth of the permanent dentition and is also one of the most susceptible to dental caries. This tooth plays a crucial role in occlusion; therefore, its premature loss may compromise dental arch stability and lead to malocclusion (Asiri, 2023) [1]. Dental caries, the primary etiological factor of structural damage, is induced by microbial biofilm and results in demineralization of enamel and dentin. When the lesion progresses, it may reach the pulp tissue, triggering defensive responses such as tertiary dentin formation or initial pulpal inflammation. If not managed in a timely manner, carious lesions can advance to deep involvement, causing irreversible pulpal damage and ultimately necessitating endodontic treatment (Bjørndal *et al*., 2019) [2].

The anatomy of maxillary first molars may be influenced by several factors, including age, gender, and ethnic background. Therefore, successful root canal treatment requires thorough knowledge of the potential anatomical variations that may be encountered (Mashyakhy *et al*., 2022) [10].

The radicular anatomy of maxillary first molars typically consists of three roots: palatal, distobuccal, and mesiobuccal. Each root may contain one or more root canals, with the mesiobuccal root being the most extensively studied (Vertucci, 2005) [3]. This root commonly presents a primary mesiobuccal canal (MB1) and shows a high incidence of a second mesiobuccal canal (MB2) (Martins *et al*., 2020) [11].

The second mesiobuccal canal (MB2) is typically located within the subpulpal groove, approximately 3.5 mm from the palatal canal and 2 mm mesial to the MB1 canal. The MB2 canal is generally smaller in diameter, may be partially covered by dentin, and exhibits considerable variation in its canal configuration. Clinically, its identification is often challenging; therefore, the use of magnification or cone-beam computed tomography (CBCT) has become essential for its accurate localization (Zhang *et al*., 2017) [12].

Recent technological advances, particularly the implementation of CBCT, have enabled more precise and non-invasive assessment of internal root canal anatomy. This imaging modality allows three-dimensional visualization of the root canal system without superimposition or distortion from surrounding anatomical structures (Shen & Gu, 2021) [4].

CBCT allows analysis in multiple planes, including axial (cross-sectional view), coronal (visualization of internal structures at different vertical levels), and sagittal (lateral perspective), providing greater diagnostic accuracy than conventional radiography (Talabani, 2021) [17].

Similarly, high-resolution imaging with a small field of view (FOV) enhances image quality for diagnostic purposes. These features support a more conservative access preparation and improve precision in the effective management of the complex root canal system (Patel *et al*., 2019) [5].

Theoretical Framework

Eruption of the maxillary first molar generally occurs around the age of six and may be influenced by factors such as nutrition, hormonal status, systemic diseases, and socioeconomic conditions (Almonaitiene *et al*., 2010). This tooth plays a critical role in maintaining proper occlusion and mandibular positioning in adulthood. Due to its early

eruption, caries development is common, and premature loss may compromise arch stability and lead to malocclusion (Cleghorn *et al*., 2006) [14]. The maxillary first molar typically presents three separate roots: mesiobuccal, distobuccal, and palatal. Of particular endodontic interest is the mesiobuccal root, which exhibits a single mesiobuccal canal (MB1) in 43.1% of cases and a second mesiobuccal canal (MB2) in 56.8% of cases (Alrahabi & Sohail, 2015) [15].

Failure to detect, debride, or obturate the MB2 canal is a leading cause of endodontic failure, as it allows bacterial persistence and may result in sustained inflammatory response. Therefore, all available methods should be employed to locate the root canal system accurately (Vertucci, 2005) [3].

Several systems have been proposed to classify root canal configurations, with the Vertucci classification being the most widely used. This system describes eight canal types, including Type I, in which a single canal extends from the pulp chamber to the apex without division, and Type II, in which two separate canals originate from the pulp chamber and merge in the apical third to form a single canal. Type III presents a single canal that originates from the pulp chamber, bifurcates along the root, and subsequently rejoins to terminate as a single apical canal. Type IV consists of two completely separate canals extending independently from the pulp chamber to the apex. Type V is characterized by a single canal emerging from the pulp chamber that divides in the apical region into two distinct canals, each with its own apical foramen. Type VI involves two canals originating from the pulp chamber, merging along the root course, and then re-separating before reaching the apex, ultimately terminating as two independent canals. Type VII is characterized by a single canal originating from the pulp chamber that divides and rejoins within the root, and subsequently bifurcates again in the apical region into two separate canals. Type VIII consists of three independent canals extending from the pulp chamber to the root apex (Vertucci, 1984) (Fig. 1).

According to previous studies, the most prevalent Vertucci configurations in mesiobuccal roots are Type II (47%), followed by Type I (29.4%), and Types III and IV (11.8% each) (Alrahabi & Sohail, 2015) [15].

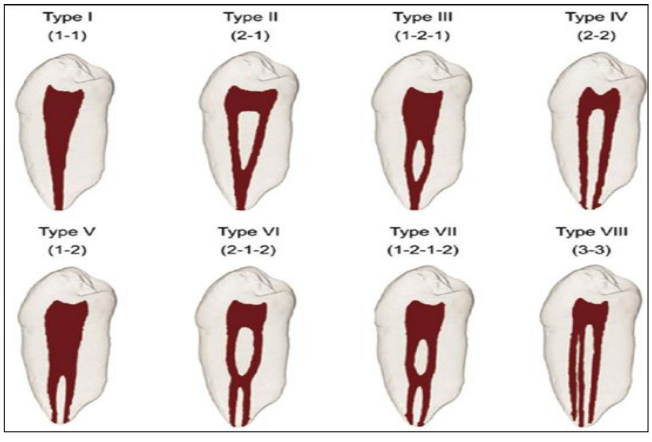

Fig 1: Vertucci canal configuration classification (Alrahabi & Sohail, 2015) [15].

Materials and Methods

This observational study analyzed the morphology of maxillary first molars, focusing on the identification of a second mesiobuccal canal (MB2) through the evaluation of digitalized CBCT scans. The images were obtained from patients who underwent cone-beam computed tomography for diagnostic purposes at the Xplora Radiology Center. The study population comprised CBCT scans acquired between April 2023 [13] and April 2025, resulting in a total sample of 1,175 tomographic images.

Inclusion Criteria

- Female and male patients aged 18 years and older.
- Maxillary first molars with fully developed roots.

Exclusion Criteria

- Tomographic images presenting distortion or artifacts.
- Maxillary first molars with posts, silver cone obturations, or similar intracanal materials.
- Maxillary first molars with internal or external root resorption.
- Maxillary first molars with canal calcifications.
- Maxillary first molars restored with full-coverage restorations, including metallic restorations or crowns.

CBCT scans were obtained using a 3-in-1 MyRay Hyperion X9 MultiFOV unit (90 kV). The imaging parameters included an exposure time ranging from 3.6 to 9.0 seconds and fields of view (FOV) of 5 × 5 cm and 11 × 8 cm. Each tomographic study was independently evaluated using axial, coronal, and sagittal planes.

Prior to image analysis, the principal investigator underwent training and calibration conducted by an expert, including instruction in the use of the iRYS 11 software. This training enhanced the accurate localization of the MB2 canal, determination of the number of canals in the mesiobuccal root, and assessment of Vertucci canal configurations.

The collected data were organized and systematized into tables specifically designed for this study using Microsoft Excel. A descriptive statistical analysis was performed, including the calculation of frequencies and proportions, as well as the distribution of the observed anatomical characteristics. To assess the relationship between variables, the chi-square test was applied to analyze the association between demographic factors, including age and sex, and the identification of the second mesiobuccal canal (MB2). Initially, the prevalence of the MB2 canal in maxillary first molars was determined; subsequently, its distribution according to age and sex was evaluated, and finally, root canal configurations were classified based on the Vertucci classification (Types I-VIII).

Results

From the total sample, 1,173 CBCT scans were obtained, of which 819 were validated for analysis. A total of 354 scans were excluded due to the presence of dental implants instead of teeth 1.6 and 2.6, image distortion, root resorption, canal calcifications, full-coverage or metallic restorations, and patients under 18 years of age.

Table 1: Absolute frequency and percentage of the MB2 canal

MB2 canal	Number	Percentage
Presence of MB2	598	73%
Absence of MB2	221	27%
Total	819	100%

Source: Authors' own elaboration.

The prevalence of the second mesiobuccal canal (MB2) was 73% (n = 598), while absence of MB2 was observed in 27% (n = 221) of the 819 maxillary first molars analyzed. These findings indicate a high prevalence of MB2 in the studied population.

Table 2: Presence of the MB2 canal according to gender

Gender	MB2 Presence	n	MB2 Absence	N	
Female	70,3%	359	29,7%	152	511
Male	77,6%	239	22,4%	69	308
Total					819

Source: Authors' own elaboration.

According to sex, the presence of the second mesiobuccal canal (MB2) was 70.3% (n = 359) in females, with an absence rate of 29.7% (n = 152). In males, MB2 was identified in 77.6% (n = 239), while absence was observed in 22.4% (n = 69). These results indicate a higher prevalence of MB2 in males within the studied sample.

Table 3: Presence of the second mesiobuccal canal (MB2) in relation to age group

Age group	MB2 Presence	n	MB2 Absence	N	Total
18-30 years	89.7%	105	10.3%	12	117
31-45 years	80.9%	165	19.1%	39	204
≥ 46 years	65.9%	328	34.1%	170	498
Total		598		221	819

Source: Authors' own elaboration.

Age-based analysis showed an MB2 canal prevalence of 89.7% in the 18-30-year group, which decreased to 80.9% in the 31-45-year group and to 65.9% in patients aged ≥46 years. These findings indicate a higher frequency of the MB2 canal in younger patients, with a decreasing trend as age increases.

Table 4: Vertucci canal configuration and presence of the second mesiobuccal canal (MB2)

Vertucci Type	MB2 Presence	n	MB2 Absence	n	Total
I	0	0	27%	221	
II	51,3%	420	0	0	
III	0,4%	3	0	0	
IV	19,2%	157	0	0	
V	0,7%	6	0	0	
VI	1,5%	12	0	0	
Total		598		221	819

Source: Authors' own elaboration.

According to the Vertucci classification, Type I (absence of MB2) accounted for 27% (n = 221), Type II for 51.3% (n = 420), Type III for 0.4% (n = 3), Type IV for 19.2% (n = 157), Type V for 0.7% (n = 6), and Type VI for 1.5% (n = 12). No cases of Types VII or VIII were identified. Overall, Types II, I (absence of MB2), and IV were the most prevalent canal configurations.

Table 5: Vertucci canal configuration and prevalence according to sex

Vertucci Type	Female %	n	Male %	n	Total
I	29,7%	152	22,4%	69	
II	49,1%	251	54,9%	169	
III	0,4%	2	0,3%	1	
IV	18,2%	93	20,8%	64	
V	1,2%	6	0	0	
VI	1,4%	7	1,6%	5	
Total		511		308	819

Source: Authors' own elaboration.

Vertucci classification was analyzed according to sex, Type II was the most frequent configuration in both males (54.9%) and females (49.1%). Type I (absence of MB2) was observed in 29.7% of females and 22.4% of males, followed by Type IV, with a prevalence of 20.8% in males and 18.2% in females. Less frequent configurations included Type VI, which showed a similar prevalence in females (1.4%) and males (1.6%), Type III (0.4% in females and 0.3% in males), and Type V, observed only in females (1.2%).

Table 6. Cross-tabulation of Vertucci canal configuration according to age group

Vertucci Type	18-30 years %	n	31-45 years %	N	≥ 46 years %	N
I	10,3%	12	19,1%	39	34,1%	170
II	49,6%	58	52,9%	108	51%	254
III	0,9%	1	0,5%	1	0,2%	1
IV	35,9%	42	24,5%	50	13,1%	65
V	0,9%	1	1%	2	0,6%	3
VI	2,6%	3	2%	4	1%	5
Total		511		308	819	

Source: Authors' own elaboration.

Age-related analysis of the Vertucci classification revealed significant variations in the mesiobuccal root canal system. Type I (absence of MB2) showed a progressive increase with age, with frequencies of 10.3% in the 18-30-year group, 19.1% in the 31-45-year group, and 34.1% in patients aged ≥46 years.

Type II showed relatively stable frequencies across age groups, accounting for 49.6% (18-30 years), 52.9% (31-45 years), and 51% (≥46 years). Type III was infrequent in all age groups, with prevalences of 0.9%, 0.5%, and 0.2%, respectively. In contrast, Type IV showed a marked age-related decrease, from 35.9% in the youngest group to 24.5% and 13.1% in the older groups. Types V and VI exhibited low frequencies across all age categories. Overall, these findings indicate that increasing age is associated with reduced detection of the mesiobuccal canal system, reflecting a predominance of Type I configurations in older patients.

Discussion

The primary objective of this study was to evaluate the prevalence and Vertucci classification of the second mesiobuccal canal (MB2) in maxillary first molars using cone-beam computed tomography (CBCT). A thorough understanding of anatomical variations within the root canal system is essential to prevent complications during endodontic treatment, particularly in maxillary molars, where failure to locate or treat the MB2 canal remains a common cause of treatment failure. Consequently, CBCT has become a valuable diagnostic tool, as it enables accurate detection of additional canals and their anatomical complexities (Anirudhan *et al*., 2022) [19].

Several studies support the effectiveness of CBCT in the endodontic management of maxillary molars, indicating that failure to identify the MB2 canal is one of the main factors associated with treatment failure (Hartwell *et al*., 2007) [20]. Complementarily, Blattner *et al*. (2010) [22] confirmed that CBCT is a reliable method for MB2 localization; however, they recommend its selective use due to higher radiation exposure, limiting its indication to cases with clinical suspicion of additional canals. Likewise, Patel *et al*. (2009)

[21] emphasized that, as a non-invasive technique, CBCT offers significant diagnostic advantages, including early detection of periapical lesions with high accuracy, thereby improving treatment predictability compared with conventional radiography.

Regarding MB2 prevalence, Lee *et al*. (2011) [23] reported a 69.6% occurrence in maxillary first molars, which is comparable to the findings of the present study, where the overall MB2 prevalence was 73%. In addition, a higher prevalence was observed in males (77.6%) compared with females (70.3%). This trend is consistent with previous reports indicating a greater frequency of MB2 in males (69.4%) than in females (62.1%), possibly associated with a higher susceptibility in females to demineralization processes and cortical bone loss (Wang, 2017) [12].

Regarding the relationship between MB2 prevalence and age, Kewalramani (2019) [25] reported that MB2 detection in patients under 20 years of age ranges from 50.56% to 85.70%, with a progressive decrease observed across age groups. Similarly, the present study demonstrated a significant decline in MB2 prevalence, from 89.7% in the 18-30-year group to 80.9% in the 31-45-year group and 65.9% in patients aged ≥46 years. This reduction may be attributed to age-related physiological changes, such as progressive pulp chamber narrowing and root canal calcification, which hinder the identification and management of the MB2 canal (Sue *et al*., 2018) [26].

Regarding the Vertucci classification, the literature demonstrates considerable variability in mesiobuccal root canal configurations, influenced by factors such as geographic region, age, and population characteristics. Pérez *et al*. (2017) reported similar prevalence between Types II and IV. Likewise, Ratanajirasut *et al*. (2018) [28] found that Types II, IV, and VI accounted for 65.5%, 26.9%, and 5.0% of cases, respectively. In another Thai population, the same authors reported distributions of 45.4% for Type II, 4.3% for Type III, 39.7% for Type IV, 8.3% for Type V, and 1.7% for Type VI. In contrast, Mufadhal and Madfa (2023)[29] identified a different pattern, with Type II (30.4%) and Type III (28.1%) being the most prevalent, followed by Type IV (13.7%).

Similarly, Xian *et al*. (2024) reported Type IV as the most frequent configuration (65.0%), followed by Type II (30.9%), while Types III, V, VI, and VII each accounted for approximately 1%. Despite interstudy variability, the findings of the present study show a comparable trend, with Types II and IV being the most prevalent configurations in teeth presenting an MB2 canal, accounting for 51.3% (n = 420) and 19.2% (n = 157), respectively. This consistency suggests that, regardless of the population studied, Types II and IV are the canal morphologies most commonly associated with the presence of an MB2 canal.

Overall, the findings of this study highlight the relevance of CBCT for the anatomical assessment of maxillary first molars and its impact on MB2 identification. The observed morphological variability, as well as its association with factors such as sex and age, reinforces the need for thorough evaluation of the root canal system prior to initiating endodontic treatment. Agreement with multiple previous studies strengthens the validity of these results and underscores the importance of recognizing the MB2 canal as a critical factor for therapeutic success.

Conclusions

The results demonstrated a 73% frequency of the additional mesiobuccal canal (MB2), highlighting the relevance of cone-beam computed tomography (CBCT) as a complementary diagnostic tool. This imaging modality provides detailed and reliable clinical information, facilitating preoperative anatomical assessment of maxillary first molars, particularly for the detection of additional canals. Its diagnostic contribution enables identification of morphological variations that may be overlooked with conventional methods, thereby enhancing treatment planning and execution.

Recommendations

Three-dimensional tomographic analysis using cone-beam computed tomography (CBCT) is recommended in cases with suspected complex anatomy or difficulty in canal identification using conventional methods. CBCT provides accurate three-dimensional visualization, facilitating MB2 localization and optimizing access cavity planning and instrumentation.

Additionally, clinicians should possess thorough knowledge of the internal anatomy of the root canal system, as the morphological variability of the MB2 canal requires specific clinical skills to achieve adequate canal shaping and obturation.

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