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Prevalence of the Middle-Mesial Canal in Permanent Mandibular First Molars. Evaluation with Cone-Beam Computed Tomography

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Abstract

The present study aimed to determine the prevalence of the middle mesial canal (MMC) in permanent mandibular first molars. The methodology was developed through a descriptive cross-sectional study, analyzing the presence or absence of the MMC in the right and left mandibular first molars, and whether it was confluent or independent according to Pomeranz's classification, using Cone-Beam Computed Tomography (CBCT) in IRIS software. A total of 1,000 tomographic scans from patients aged 15–60 years were collected from the Xplora Radiological Center in Quito, Ecuador, and evaluated in three planes (sagittal, axial, and coronal). Data was recorded in Excel and statistically analyzed with SPSS using the Chi-square test.

The statistical analysis showed that the middle mesial canal was present in 17.7% of the 1,000 mandibular first molars evaluated. Among the positive cases, 84.18% of the MMCs presented a confluent configuration, 15.82% were independent, and 6.25% were bilateral. Regarding gender, prevalence was 19.72% in women and 15.10% in men. In terms of age distribution (15–30 years and 31–60 years), prevalence was slightly higher in the younger group (19.44% vs. 16.17%).

The statistical results highlight the importance of carefully exploring the mesiobuccal canal (MMC) in all patients, without limiting the evaluation to sex or age criteria. Given its clinical relevance, notable frequency, and complex morphology, this study emphasizes the need to integrate this knowledge into daily endodontic practice.

Keywords: Middle Mesial Canal, Mandibular First Molar, Endodontics, Prevalence, Treatment, Endodontics.

Introduction

Root canal treatment has as its main objective the complete disinfection of the root canal system through chemical and mechanical procedures, followed by three-dimensional obturation with inert materials that ensure a hermetic seal[1]. During endodontic procedures, there may be factors that delay or modify the treatment plan, among them the presence of supernumerary canals. For this reason, it is advisable to request imaging tests such as tomography, which is much more precise and provides more accurate information[2].

The mandibular first molar presents five cusps, two lingual and three buccal, and has two mesial roots. It usually has a mesiobuccal (MB) and a mesiolingual (ML) canal, while its distal root often has a single central canal.[3] The isthmus is a small connection between two mesial root canals [4] where pulp tissue is present. In this region, anatomical variations may occur, such as the presence of the so-called middle mesial canal[5].

The location and shape of the middle mesial (MM) canal can vary, and its frequency of occurrence is influenced by factors such as age, gender, ethnicity, and whether the canal is confluent or independent according to Pomeranz's classification.[6,7] The complex anatomy found in root canals poses a clinical challenge that frequently makes it difficult to achieve success in endodontic therapy.[8] For this reason, it is essential that the endodontic specialist has detailed knowledge of the root morphology to be treated[9], including aspects such as the number of canals, convergences, divergences, deltas, among others, to perform proper instrumentation and avoid the persistence of toxins and bacteria that could negatively affect treatment success[10].

In Ecuador, there are few studies related to variations in the root anatomy of permanent mandibular first molars. Being the first tooth to erupt [11], it is the most prone to developing caries, which makes it the most frequently treated tooth in endodontics. Therefore, it is important to know its root morphology and anatomical variations, since the success of treatment depends on an in-depth understanding of its anatomy [12].

In the last ten years, Cone Beam tomography has been used as a diagnostic and planning tool due to its ability to analyze three-dimensional images [2,13], such as detailed morphological analysis, which provides a complete image that can be easily explored in different planes sagittal, axial, and coronal[12,14] through self-adjustable software[15]. The purpose of this research is to determine the prevalence and analyze Pomeranz's classification [6] in patients treated at the Xplora Radiological Center for Diagnostic and Maxillofacial Imaging, Quito – Ecuador.

Materials and Methods

Sample Selection

This study was approved by the Ethics Committee of the Faculty of Health Sciences at Universidad de Los Hemisferios. Digitalized CBCT images of mandibular first molars were obtained from patients who underwent computed tomography at the Xplora Radiological Diagnostic and Maxillofacial Imaging Center, with a population of 1,000 scans.

Inclusion Criteria

1. CBCT scans that include permanent mandibular first molars on both right and left sides.
2. Molars with complete crown and roots.

Exclusion Criteria

1. CBCT with first molars that had undergone root canal treatment.

Morphological defects such as fusion, taurodontism, dilaceration, concrescence, or gemination.

Morphological size defects such as macrodontia or microdontia.

Molars with posts and crowns.

Internal or external root resorption, or calcification of root canals.

Images were obtained from patients who attended the Xplora Radiological Diagnostic and Maxillofacial Imaging Center, which is equipped with a 3-in-1 Myray Hyperion X9 multifov unit, Kv 90, plus 10, with a voxel size of 125 µm and an FOV of 5×5, as it allowed us to visualize fine details with greater precision, from January 2023 to January 2025. The scans were evaluated by the principal investigator using Irys 11.5 software, with contrast and brightness adjusted according to the software's processing. The first molars were assessed in the sagittal, axial, and coronal planes to evaluate the presence or absence of the middle mesial canal (MMC) and to verify whether it was on the left or right side. The axial, sagittal, and coronal planes were also examined to correlate results, after which canals were classified according to their morphology. In addition, the patient's sex and age were recorded. To avoid loss of image quality, captures were processed using the Snapseed program.

The data were compiled and cleaned in Excel tables created specifically for this study. A statistical analysis plan was established, including the description of general frequencies and proportions, the creation of contingency tables, the determination of the distribution of anatomical characteristics, and the application of chi-square tests. This test was chosen as it allowed us to analyze the association between categorical variables such as sex/age and the presence of an MMC. First, the prevalence of MMC in mandibular first molars was analyzed. In cases where its presence was recorded, further analysis was performed to determine its relationship with age and sex. Subsequently, classification was carried out according to Pomeranz (confluent – independent) to establish its greater prevalence.

Results

Frequency of Middle Mesial Canal in Mandibular First Molars

The analysis consisted of determining the absolute frequency and percentage of cases in which the middle mesial canal (MMC) was present in the total sample.

Table 1: Absolute frequency and percentage of presence of the middle mesial canal

Presence of MMC	Frequency	Percentage (%)
No	823	82.30%
Yes	177	17.70%

The prevalence of the middle mesial canal was 17.7% (n=177). Clinically, this result is relevant due to the complexity of endodontic procedures.

Distribution of Middle Mesial Canal Presence by Sex

Table 2: Distribution of the middle mesial canal according to sex

Sex	No	Yes	Total	No (%)	Yes (%)
Female	459	90	549	83.61%	16.39%
Male	364	87	451	80.71%	19.29%
Total	823	177	1000		

Men (19.29%) than in women (16.39%), this difference was not statistically significant.

Distribution of Middle Mesial Canal Presence by Age Group

Table 3: Distribution of the middle mesial canal according to age group

Age	No	Yes	Total	No (%)	Yes (%)
15–30	377	91	468	80.56%	19.44%
31–60	446	86	532	83.83%	16.17%
Total	823	177	1000		

The similarity of these figures suggests that age (19.44% in 15–30 years; 16.17% in 31–60 years) does not exert an appreciable effect on the frequency of MMC within the range studied.

Distribution According to Pomeranz Classification

Table 4: Frequency and percentage of morphological type of the middle mesial canal

MMC type	Frequency	Percentage (%)
Confluent	149	84.18%
Independent	28	15.82%

The confluent type was predominant. The independent canal was present in 15.82%, a finding consistent with trends described in previous studies.

Distribution by Laterality (Right, Left)

Table 5: Distribution of the middle mesial canal according to laterality

Side	Frequency	Percentage (%)
Right	98	55.68%
Left	67	38.07%
Bilateral	11	6.25%

Results show that the MMC was more frequent on the right side (55.68%, n=98). This distribution reflects a moderate asymmetry, partially consistent with other series reporting a slight right-side predominance, although some studies describe more balanced proportions.

Cross-Distribution by Sex and Age

Table 6: Contingency table of MMC presence according to sex and age

Sex	Age	No MMC (n)	MMC Present (n)	Total (n)	MMC Presence (%)
Female	15–30	220	62	282	21.99%
Female	31–60	232	49	281	17.44%
Male	15–30	157	29	186	15.59%
Male	31–60	214	37	251	14.74%
Total		823	177	1000	

The highest frequency of MMC was found in women aged 15–30 years (21.99%). This was followed by women aged 31–60 years (17.44%), men aged 15–30 years (15.59%), and men aged 31–60 years (14.74%). Although these differences are not large, the combination of younger age and female sex appears to be associated with a slightly higher proportion of MMC. However, these results correspond to descriptive analysis only and lack inferential value by themselves. The statistical relevance of the observed differences was evaluated through chi-square testing.

Chi-square Test of Independence: Sex and MMC Presence

Table 7: Observed and expected frequencies of MMC presence according to sex

Sex	Observed (No)	Observed (Yes)	Expected (No)	Expected (Yes)
Female	452	111	447.65	115.35
Male	371	66	375.35	61.65

The chi-square statistic was $\chi^2 = 3.28$, with a p-value = 0.0699, indicating no statistical significance ($p > 0.05$). Although a trend toward a higher frequency of MMC in women (19.72%) compared to men (15.10%) was observed, this difference was insufficient to reject the null hypothesis of independence.

Chi-square Test of Independence: Age and MMC Presence

Table 8: Observed and expected frequencies of MMC presence according to age group

Age	Observed (No)	Observed (Yes)	Expected (No)	Expected (Yes)
15–30	377	91	373.84	94.16
31–60	446	86	449.16	82.84

The chi-square test result was $\chi^2 = 1.62$, with a p-value = 0.203, which is well above the threshold of significance. Therefore, the null hypothesis of independence between age and MMC presence was not rejected.

Discussion

The main objective of this study was to evaluate the prevalence of the middle mesial canal (MMC) in mandibular first molars, according to Pomeranz's classification, using cone-beam computed tomography (CBCT).[16] The results obtained allowed us to identify the prevalence of MMC in a sample of 1,000 CBCT scans.[17] It is widely recognized that detailed knowledge of both internal and external anatomical features is directly correlated with the success of endodontic therapy.[18]

The morphology of mandibular first molars has been studied using various diagnostic methods, with variable results. Reported frequencies range between 1–18%, although some studies have described even higher values.[19] Braker was the first to investigate MMCs and, although he did not establish prevalence rates, he identified it as "something quite uncommon." With technological advances such as CBCT and the dental microscope, it has been possible to establish a more consistent classification.[16,20] For example, one CBCT study identified 5 cases of MMCs among 1,435 molars examined. Similarly, Tahmasbi, using CBCT, reported a 26% prevalence of MMCs.[21] In our study, the prevalence was 17.7%, which highlights the importance of using imaging modalities capable of visualizing details with precision.

Regarding Pomeranz's classification, two types are described: the independent type, where the MMC originates as a separate canal from the pulp chamber floor and exits at its own apical foramen without joining the other canals, and the confluent type, where the MMC begins as a separate canal but merges with either the MB or ML canal before reaching the apex.[22,23] The most relevant finding in our study was the predominance of the confluent type, suggesting that in most cases, the MMC shares its trajectory with the mesial canals.[6,24]

In terms of laterality, our results revealed a slight predominance on the right side. However, this should not be interpreted as a criterion for unilateral exploration [20,25] The presence of MMCs on both sides underscores the need for symmetrical and meticulous exploration in both hemiarches. This distribution partially coincides with published studies reporting a mild right-side predominance, although other investigations have described more balanced proportions [26]

Krasner and Rankow [27] noted that factors such as patient age and sex may influence root canal anatomy. In our findings, however, demographic variables such as age and sex did not show significant differences. Therefore, these factors should not be used as selection criteria for MMC exploration. Instead, every patient should undergo thorough diagnostic evaluation regardless of demographic profile[19,28] Literature based on CBCT studies supports the notion that the probability of MMC presence should be considered in all individuals, as demographic factors have little impact on its occurrence.

From a clinical perspective, these results emphasize the need to establish rigorous diagnostic protocols that include meticulous inspection of the pulp chamber, the use of magnification and enhanced illumination, fine-tipped explorers, and detailed analysis of CBCT images. Omission of such protocols may compromise cleaning, shaping, and obturation of the root canal system, thereby negatively affecting treatment prognosis [29]

Furthermore, this study has important implications for the diagnosis and effective treatment planning of mandibular first molars. It reinforces the idea that the MMC should not be regarded as a rare anomaly but rather as a relatively frequent finding. Its detection and successful management depend on both the clinician's expertise and the use of advanced technologies. Incorporating these findings into daily practice may raise the standard of care in endodontics and reduce the rate of treatment failures associated with missed canals.

Conclusions

In the present study, the root and canal configuration of permanent mandibular first molars in an Ecuadorian population demonstrated a prevalence of 17.7%, with a predominance of the confluent type of MMC. Prior knowledge of anatomical variations may improve the success rate of root canal treatment, both surgical and non-surgical, although it does not guarantee endodontic success on its own. CBCT analysis could represent a non-invasive and clinically effective tool to determine root and canal morphology. Conducting a larger population-based study, including several radiological centers, may provide more comprehensive information, particularly regarding the middle mesial canal and C-shaped canals, their location, type, and incidence according to sex and age.

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