Analysis of the occurrence of the mesiobuccal canal in maxillary first molars using cone-beam computed tomography in a Brazilian population

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Abstract

Introduction: Although the success rate of endodontic treatment in molars can reach up to 91.7%, failures may occur due to the anatomical complexity of the canals and the presence of undetected canals, with the second mesiobuccal canal being the most frequently overlooked. Objectives: To assess the morphology of the first upper molar and the incidence of the second mesiobuccal canal using cone-beam computed tomography. Materials and Methods: Retrospective secondary data were collected from patients at a reference radiology clinic in Maringá, Paraná, and then underwent imaging exams with the Prexion 3D tomography machine between December 2015 and May 2016. Results: A total of 174 patients and 221 first upper molars were analyzed, with a higher prevalence of three roots (93%) and the presence of the second mesiobuccal canal in 57.4% of the teeth. The most frequent Vertucci classification was Type IV (38%). Conclusion: The study concluded that the first upper molar tends to have three roots and that the second mesiobuccal canal is present in more than half of the studied population, while the most common classification for this canal was Type IV.

Keywords: Second Mesiobuccal; Molar Tooth; Cone Bean Computed Tomography.

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Introduction

The root anatomy and canal morphology of upper molars have been extensively studied due to their complexity.[1] Published evidence indicates that most upper molars have three roots and four canals. Studies show that approximately half of the mesiobuccal (MB) roots contain a second canal, referred to as mesiobuccal 2 (MB2).[1,2]

The success rate of endodontic treatment in molars can reach up to 91.7%. However, despite the best efforts of clinicians, failures in treatment may still occur.[3,4] The potential reasons for such failures include the root canal's complex anatomy and undetected canals.[4,5] In their study, Mashyakhy *et al.*[6] found an 18% prevalence (30 out of 165) of undetected canals in teeth that had already undergone endodontic treatment, with the highest prevalence observed in

the first upper molars (40.6%). The second mesiobuccal (MB2) was the most frequently missed canal during the procedure.

Despite the existence of several studies on the incidence and prevalence of the MB2 canal, the available research reveals significant variation in the data. In the literature, the percentage frequency of the MB2 canal in upper molars ranges from 10% to 95%, depending not only on the method used in the study, such as radiography, scanning electron microscopy, micro-CT or cone beam computed tomography (CBCT)[7–9], but also on the ethnic and demographic composition of the population.[8,10] Kewalramani *et al.*[11] investigated the prevalence of the second mesiobuccal (MB2) canal in the first upper molars using CBCT images in an Indian population. The authors found a prevalence of 61.9% for the MB2 canal with three roots in the first upper molars. Similarly, Onn *et al.*[12] studied the prevalence of the MB2 canal in the first and second upper molars in a Bruneian population, finding a prevalence of 51.3% and 29.8%, respectively.

On the other hand, Lee *et al.*,[13] in a study conducted with a population from South Korea, identified a prevalence of 86.8% of the MB2 canal in the first upper molars and 28.9% in the second upper molars. In the study by Alnowailaty *et al.*,[14] conducted with a population from Saudi Arabia, the prevalence of the MB2 canal was 46.7% in the first upper molars and 17.7% in the second upper molars.

Given the variability in the prevalence of the MB2 canal in different populations, this study aims to assess and visualize, using cone beam computed tomography, the morphology of the first upper molar and the incidence of the second mesiobuccal (MB2) canal in a Brazilian population from a city in the state of Paraná.

Materials And Methods

Sample

This is a retrospective study based on secondary data collected from cone beam computed tomography images used for diagnostic purposes and treatment planning, obtained from patients treated at a reference clinic (Martinhão) in the northern region of Paraná. The clinic is equipped with a high-precision device, the Prexion 3D scanner (Prexion Inc, San Mateo, CA), which is essential for visualizing intricate details. Data was collected over a period of six months, from December 2015 to May 2016.

Inclusion and Exclusion Criteria

Inclusion Criteria: (a) presence of upper molars; (b) upper molars with fully formed apices; (c) absence of endodontic treatment.

Exclusion Criteria: (a) presence of intracanal posts; (b) presence of fixed prostheses; (c) teeth with internal and/or external resorption; (d) atretic teeth with no canal lumen; (e) residual roots; (f) presence of root fracture.

Tomographic Acquisition

The images were obtained using a small-volume cone beam computed tomography device, model Prexion 3D (Prexion Inc, San Mateo, CA). This device enables the visualization of small details, such as the fourth canal, which makes it eminently suitable for the proposed purpose.[15]

The initial specifications for the device used were operation at 90kV and 4.0mA; exposure time of 33.5 seconds; voxel size of 0.11mm; and a field of view (FOV) of 5.6cm x 5.2cm. It should be noted that none of the scans involved the use of contrast, and all tomographic exams were performed by an experienced technician under the supervision of a responsible radiologist.

Tomographic Evaluation

The images were analyzed dynamically in the axial, sagittal and coronal slices (Appendix I). The reading of the computed tomography images was performed using the CS 3D Imaging Software, on a Dell LCD screen with a resolution of 1920x1080 pixels, in a dark room, by two examiners who were previously calibrated and evaluated simultaneously.

Classification of Canal Morphology

The classification used was that of Vertucci (1984), as outlined in Table 1 below.

Table 1. Vertucci classification

Classification	Description
I	A single canal extends from the pulp chamber to the apex.
II	Two separate canals that join in the apical third.
III	One canal that divides into two, then reunites as one.
IV	Two separate and distinct canals until the apex.
V	One canal that divides just below the apex.
VI	Two canals that join in the root and then divide at the apex.
VII	One canal that divides, reunites, and exits through two foramina.
VIII	Three separate canals in one root.

Source: Vertucci (1984).

Since the Vertucci classification does not cover all teeth, an adaptation was made by adding the following classifications (Table 2):

Table 2. Adapted Vertucci classification

Classification	Description
IX	One canal that soon separates and ends separately.
X	Two canals, one independent and the other beginning below the chamber.
XI	Three canals, one independent and two separates that join near the apex.
XII	Two canals that join in the middle third.

Source: The authors (2024).

Data Analysis

The data were tabulated in Microsoft Excel 2010 spreadsheets (Microsoft Corp., USA) and analyzed descriptively with regard to their variables, such as age, gender, presence of the mesiobuccal canal, and classified according to their morphology.

Ethical Aspects

The study was approved by the Permanent Ethics Committee for Research Involving Human Beings (COPEP) of the State University of Maringá (UEM). (CAAE: 56129616.6.0000.0104 / Ethical Opinion: 1613490/2016).

Results

A total of 174 patients were included in the study, of which 112 (64%) were female and 62 (36%) were male. During the analysis, 221 first upper molars were evaluated, with 110 (49.77%) corresponding to the right first upper molar and 111 (50.22%) to the left first upper molar.

Among the 221 molars analyzed, 207 (93.6%) had three roots, while 14 (6.3%) had only two roots. In addition, of the total molars evaluated, 127 (57.4%) contained a mesiobuccal canal.

In the adapted classification, of the 127 molars that presented the fourth canal, 48 (38%) had a type IV classification, 28 (22%) had a type XII classification, and 19 (15%) had a type II classification (Table 3).

Table 3. Distribution of *n* and % of individuals with the fourth canal according to the adapted Vertucci classification, Maringá-PR, 2016.

VC*	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
N	-	19	7	48	6	5	4	3	-	6	1	28	127
%	-	15	6	38	5	4	3	2	-	5	1	22	100

Legend: VC* - Adapted Vertucci Classification.
Source: The authors (2024).

Discussion

A thorough understanding of root canal morphology and its variations is essential for the success of endodontic treatment.[15,16] Studies indicate that the prevalence of a second mesiobuccal canal (MB2) in upper molars exceeds 50%.[15,17,18] This study aimed to evaluate the prevalence of the second mesiobuccal canal in the first upper molars of a Brazilian population from northern Paraná, using cone beam computed tomography (CBCT) as the detection method. The CBCT technique revealed that 57.4% of the analyzed molars had second mesiobuccal canals (MB2). Regarding the number of roots, 93.6% of the first molars examined had three roots, with the Vertucci type IV classification being the most common.

The literature demonstrates that the prevalence of the second mesiobuccal canal (MB2) ranges from 10% to 95%, depending on the method of analysis used and the demographic characteristics of the sample under study.[7-9] Previous studies, such as those by Kewalramani *et al.*[11] — which found a prevalence of 61.9% in an Indian population — and Onn *et al.*[12] — which found 51.3% and 29.8% for first and second upper molars, respectively, in a population in Brunei —

show that the occurrence of the MB2 canal can vary substantially among different population groups, which highlights the importance of conducting region- and ethnicity-specific studies.

The broad variation in the prevalence of the MB2 canal observed in the literature suggests the influence not only of genetic and ethnic factors but also of the detection method employed. CBCT stands out for providing an effective evaluation of root canal morphology due to its short exposure time, high resolution and accuracy, minimal distortion, three-dimensional visualization, and non-invasive nature.[18,19] In this context, the use of CBCT was crucial in capturing anatomical details with high precision, facilitating the identification of complex canals, such as MB2, with high reliability.

From a clinical perspective, the correct identification of the MB2 canal has direct implications for the success of endodontic treatments. Studies, such as that by Mashyakhy *et al.*,[6] indicate that failure to detect and treat additional root canals is one of the leading causes of the failure of endodontic treatments, with an undetected canal prevalence of 40.6% in upper first molars.[6] This data underscores the importance of using CBCT to enhance diagnosis and treatment accuracy.

In this context, the findings of Blank-Gonçalves *et al.*[20] — who reported a high prevalence of the MB2 canal in 90% of cases — further support the relevance of advanced CBCT imaging protocols. This notably higher detection rate, when compared to other studies, may be attributed to the refined acquisition parameters employed, including a small field of view (FOV) of 5×5cm and a voxel size of 0.085mm. These factors significantly enhanced both image resolution and the ability to detect complex anatomical structures, such as the MB2 canal and its variations.

Regarding the number of roots, 93.6% of the first molars analyzed in this study presented three roots, a result consistent with the study by Mheiri *et al.*,[21] which identified 98.9% of molars with three roots in an Emirati population. Supporting these findings, the study by Lin *et al.*,[19] conducted in a Taiwanese population, found that among the first upper molars examined, three (1.5%) had a single root, two (1.0%) had two roots, and 191 (97.5%) had three distinct roots. On the other hand, analysis of the study by Dibaji *et al.*,[22] showed that, of a total of 311 first upper molars evaluated, 153 (49.1%) had three canals, and 158 (50.8%) had four canals.

The Vertucci technique was an important study that focused on analysis of the internal anatomy of both upper and lower teeth to describe the root canal system (Vertucci, 1984). In his findings, Vertucci demonstrated that 55% of the first upper molars in an in vitro study had a second mesiobuccal canal, also referred to as the fourth canal, in the mesiobuccal root. The technique used for identification was diaphanization, which involved decalcifying the teeth and then staining them with a dye. The results found by Vertucci are consistent with the findings of the present study, although different techniques were used on in vitro teeth. In the current study, the morphology of the mesiobuccal root of the first upper molar, when the second mesiobuccal canal was present, showed the highest occurrence of classification type IV (38%), followed by type XII (22%) and type II (15%). On the other hand, Ratanajirasut et al.,[16] in their assessment of a Thai population, found that the presence of the mesiobuccal canal was most frequent in type I (36.4%), followed by type II (28.8%) and type IV (25.3%). In contrast, a study by Al-Saedi *et al.*,[23] conducted in an Iraqi population, showed that the occurrence of the second mesiobuccal canal was most prevalent in type II, at 44.58%.

The study concluded that the upper first molar has a high prevalence of three roots. The occurrence of the mesiobuccal canal was found in more than half of the population under study. The Vertucci Class IV classification was the most frequent for the mesiobuccal canal. Despite

the limitations of this study, the results contribute to the anatomical knowledge specific to the Brazilian population.

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