

Original Article

Cone-beam computed tomography study of prevalence and location of MB2 canal in the mesiobuccal root of the maxillary second molar

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Abstract: The maxillary second molar (2 MM) has the most complex root canal system, and a high percentage of treatment failures is due to the impossibility of locating, instrumenting and obturating the second mesiobuccal canal (MB2). The aim of this study was to describe *in vivo* the prevalence and location of the MB2 canal in the mesiobuccal root of the permanent maxillary second molar through CBCT image analysis. Two hundred twenty five CBCT images of 2 MM were studied. In the presence of the MB2 canal, the floor of the coronal cavity was located and advanced every 1 mm apically to standardize observation. The geometric location in relation to the primary mesiobuccal (MB1) and palatal (P) canals was done by locating the central points of the canal and projecting a line between them, together with a perpendicular line between MB1-P (point T). The data were analyzed using descriptive statistics, with a value of $P < 0.05$ being statistically significant. The MB2 canal was identified in 48% of the cases. It was located 2.2 ± 0.54 mm palatally and 0.98 ± 0.35 mesially to the MB1 canal. The average age of the subjects where it was found was 26.36 ± 10.85 years. Its location was more frequent in men (63%), and no differences were observed in its appearance in the hemi-arch. It is necessary to know the high probability of finding the MB2 canal in the maxillary second molar, and the CBCT is a good diagnostic tool for its detection and exploration.

Keywords: Maxillary second molar, second mesiobuccal canal, second mesiovestibular canal, MB2, mesiobuccal root, cone-beam computed tomography

Introduction

One of the major causes of failure in endodontic treatment is the impossibility of locating and treating the entire root canal system, a result of the lack of knowledge regarding the dental, internal or external anatomy [1] and the high complexity and variation of the root canal system, with accessory, secondary, recurrent, and apical delta canals, among others [2].

Maxillary molars are the teeth that contain the greatest number of roots, with diverse shapes and formations, which is why their internal canal system is so variable. According to Badole et al. [3] and Zhang et al. [4], the maxillary second molar has the most complex root canal system of all the molars. A high percentage of

treatment failures in these teeth is due to the impossibility of locating, instrumenting and obturating the secondary mesiobuccal canal (MB2), located in the mesiobuccal root [5]. In addition, factors such as race, age and gender determine the anatomical variability and frequency of the MB2 canal [6].

Various studies have shown large differences in the detection of the MB2 canal in the maxillary second molar according to the technique used; in *in vitro* studies it varies between 29% and 100% [7, 8], whereas *in vivo* studies report between 19.7% and 51.1% [9, 10].

The most commonly used imaging method for the *in vivo* study of the dental anatomy and endodontic diagnosis is the periapical x-ray [11].

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However, this provides only limited 2D information sensitive to the superposition of anatomical structures (zygomatic arch, maxillary sinus, dental roots) and distortion of the image because of the angulation used, which is why it is not a reliable method for the detection of accessory canals [4].

Cone-beam computed tomography (CBCT) has the capacity to explore the anatomical structures in a three-dimensional reconstruction [12], from axial, transverse and sagittal planes, and provides adequate information about the root canals in different directions with no anatomical superposition, which cannot be detected clinically or by means of conventional x-rays [4].

The aim of this study was to describe *in vivo* the prevalence and location of the MB2 canal in the mesiobuccal root of the permanent maxillary second molar through CBCT imaging analysis.

Materials and methods

The investigation was approved by the science ethics committee of the Universidad de La Frontera, Temuco, Chile (protocol n°048/13). A cross-sectional observational descriptive study was designed. Maxillary second molars were examined through CBCT images obtained from the imaging service of the Universidad de La Frontera, Temuco, Chile, in patients of both genders, between January and August 2014. All the images were taken for diagnosis and treatment planning using a Vatech Pax Zenith CBCT machine (Korea, 2011) (90 kV and 120 mA, FOV 8 × 6 cm, voxel size 0.12 mm).

The images included were of permanent maxillary second molars with complete root formation from patients between 16 and 75 years of age. Excluded were images of teeth rehabilitated by means of fixed prosthesis, with endodontic fillings or posts, calcified canals, evidence of radectomy or periapical surgery.

Observation methodology

The CBCT images of 225 maxillary second molars (111 right and 114 left) were processed using the Ez3D2009 interface and projected onto a SONY LED screen (model KDL-42W651A) to observe sections in coronal, sagittal and

axial views as well as a 3D reconstruction (**Figure 1**). First, the axial axis of each tooth was rectified on the sagittal plane, and then 1 mm sections were obtained on the axial plane at 0.5 mm intervals for all the samples. A coronal exploration was made throughout the mesiobuccal root to detect the MB2 canal. Where this was present, the floor of the coronal cavity was located, and advanced apically in 1 mm sections (2 sections of 0.5 mm) to standardize observation of the MB2 canal (**Figure 2**).

The geometric location of the MB2 canal was done in relation to the first mesiobuccal canal (MB1) and the palatal canal (P). The central points of each canal were located (PMB1, PMB2 and PP) and straight lines projected between them (PMB1-PP and PMB1-PMB2). A third line was drawn (PMB2-PT), perpendicular to the PMB1-PP line (T point), according to the protocols described by Gorduysus *et al.* [13] and Tuncer *et al.* [14]. The distance of the lines drawn between the points was measured in millimeters (**Figure 3**).

The images were analyzed by 2 examiners (PB, GM) with previous training and using consensus. The data collected in terms of gender, age, side, and distances between the different points were entered into a Microsoft Excel double entry table.

Statistical analysis

The data were analyzed using descriptive statistics (Mean ± SD) and the Chi-squared test to relate the presence of the MB2, gender and position (side) in the maxilla using the software SPSS/PC + v. 20.0 (SPSS, Chicago, IL). In addition, the relation with age was established using an ANOVA test. The average distances between points PMB2, PMB1, PP and T were calculated with 95% and 99% confidence intervals. A value of $P < 0.05$ was chosen as the threshold for statistical significance. Finally, the results were compared with other *in vitro* and *in vivo* studies on different populations.

Results

The MB2 canal was identified in 48% of the second molars (108/225). The average age of the subjects where it was found was 26.36 ± 10.85 years. The presence of the MB2 canal

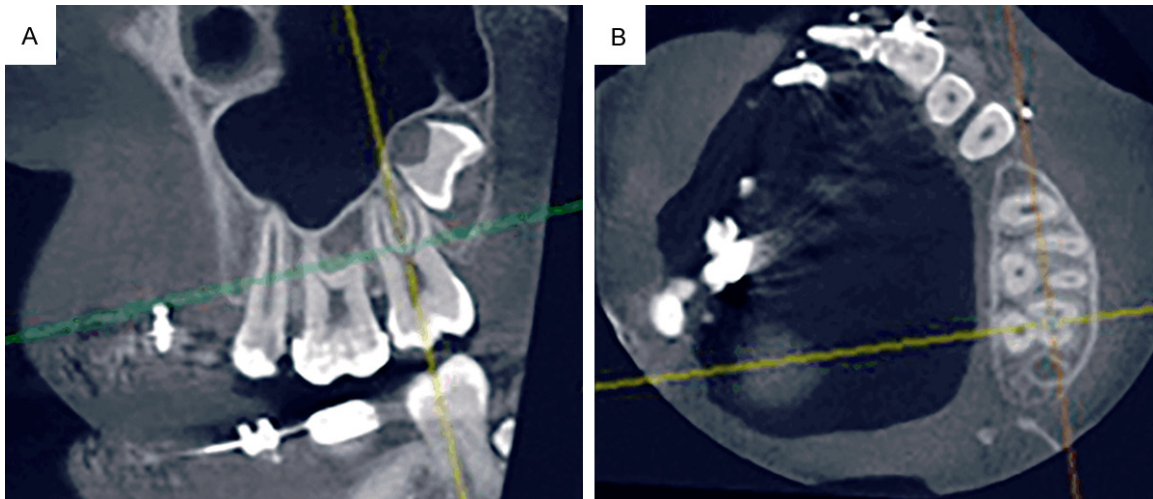


Figure 1. CBCT image of an upper left second molar with 2 canals in the mesiobuccal root using Ez3D2009 interface. A: Sagittal view; B: Axial view.

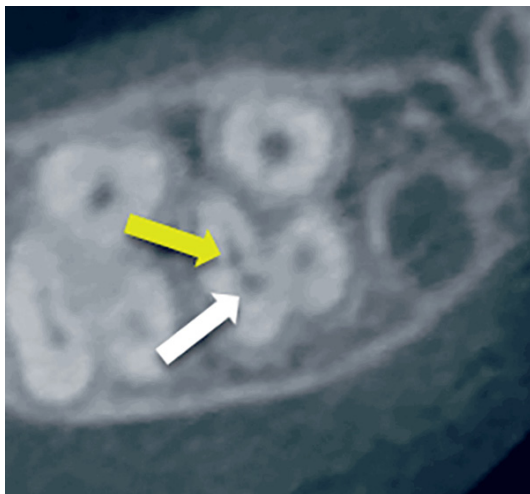


Figure 2. Cross-section of CBCT image of the mesiobuccal root (yellow arrow) of the left maxillary second molar with a second mesiobuccal canal (MB2) (white arrow).

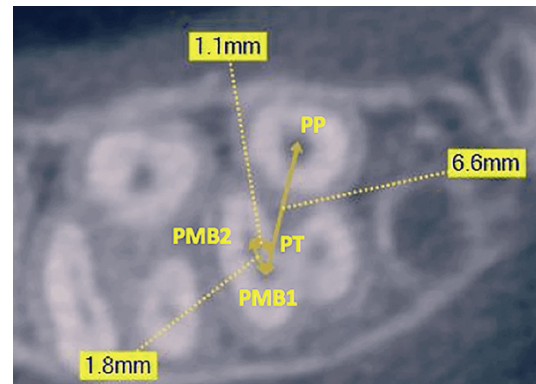


Figure 3. Axial view of left maxillary second molar. PMB1 (center of mesiobuccal canal), PMB2 (center MB2 canal), PP (center palatal canal). Straight lines were projected, joining the different points: PMB1 – PP line and PMB1-PMB2 line. A third line was drawn, PMB2-PT, corresponding to a perpendicular line between PMB2 and the PMB1-PP line (PT point). The distance of the lines drawn between the points was measured in millimeters.

was more frequent in men (63%) than in women (37%), with statistically significant differences between the two genders ($P = 0.001$) (**Figure 4A**). When the presence of the MB2 canal was compared in the left and right sides, no statistically significant differences were observed ($P = 0.848$) (**Figure 4B**).

Analyzed with a 95% confidence, the distances between points PMB1-PP were 6.7 ± 0.95 mm (range 6.6-6.9 mm). For PMB1-PMB2 the average distance was 2.2 ± 0.54 mm (range 2.1-2.3 mm), and for PMB2-PT the average distance

was 0.98 ± 0.32 mm (range 0.9-1.04 mm). For a confidence interval below 99% it was observed that the PMB1-PP distance was 6.7 ± 0.95 mm (range 6.5-7.0 mm); for PMB1-PMB2 2.2 ± 0.54 mm (range 2.1-2.4 mm), and for PMB2-PT 0.98 ± 0.35 mm (range 0.89-1.07 mm).

According to the Kappa index, there was agreement between the examiners ($P = 0.001$) and the strength of this agreement was very good (0.815).

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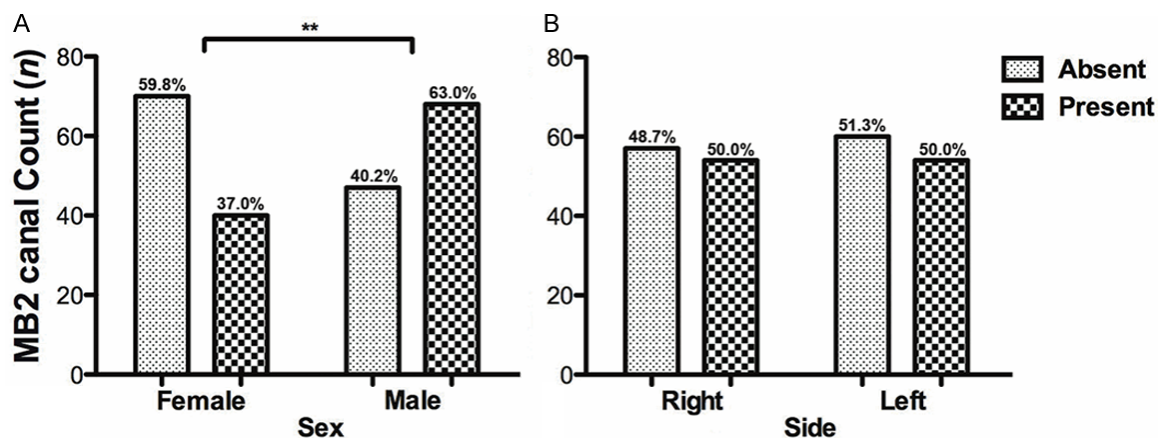


Figure 4. Distribution of the prevalence of the MB2 canal according to side (A) and gender (B). **Refers to $P < 0.05$.

Table 1. Prevalence of the MB2 canal in the mesiobuccal root of the maxillary second molar in previously published *in vitro* studies

Author (s)	Year	Method	Population	Sample (n)	MB2 canal
Vertucci [7]	1984	Clearing	Unreported	100	29%
Gilles & Reader [28]	1990	Clearing	Unreported	37	70.2%
Pécora <i>et al.</i> [1]	1992	Clearing	Brazil	200	42%
Eskoz & Weine [22]	1995	Periapical radiographs and endodontic files	Unreported	732	40%
Alavi <i>et al.</i> [21]	2002	Clearing	Thailand	65	41.5%
Ng <i>et al.</i> [19]	2001	Clearing	Burma	77	49%
Schwarze <i>et al.</i> [8]	2002	2x magnification loupes	Unreported	50	33.3%
		Endodontic microscope		50	95.8%
		Histology		50	100%
Yoshioka <i>et al.</i> [20]	2004	Clearing	Unreported	44	100%
Neelakatan <i>et al.</i> [29]	2010	CBCT	India	205	30.7%

The prevalence of the MB2 canal of the maxillary second molar reported by *in vitro* and *in vivo* studies are in **Tables 1** and **2**, respectively.

Discussion

Few studies have performed an exclusive analysis of the configuration of root canals of the mesiobuccal root of the maxillary second molar, probably because it is assumed to be very similar to the mesiobuccal root of the maxillary first molar, where the MB2 canal is highly prevalent [15-17]. However, *in vivo* studies conducted using CBCT images have revealed that the existence of the MB2 canal in the maxillary second molar is between 22% [4] and 34.32% [18]. Our results showed a higher prevalence, reaching 48% in a Chilean-specific population, almost half of the cases studied, which indicates that time is required to locate it.

Studies using diaphanization have obtained results similar to ours, where Ng *et al.* [19] reported 49%, Yoshioka *et al.* [20] 44%, Pécora *et al.* [1] 42% and Alavi *et al.* [21] 41.5%, showing an MB2 canal detection sensitivity similar to CBCT. This is because both techniques reverse project the structures: the former due to transprentation and the latter to the 3D management. Conversely, Eskoz & Weine [22] reported a frequency of 40% using endodontic files and periapical x-rays, a combined technique that demands dental trepanation and operator expertise to locate the MB2 canal. Other more specific techniques, such as the endodontic microscope and histology have attained prevalence of 95.8% and 100%, respectively [8].

Clinically most studies have been conducted using magnification equipment, such as magnifying loupes and microscopes, describing the

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Table 2. Prevalence of the MB2 canal in the mesiobuccal root of the maxillary second molar in previously published in vivo studies

Author (s)	Year	Method	Population	Sample (n)	MB2 canal
Stropko [10]	1999	Endodontic microscope	Unreported	611	51.1%
Buhrey <i>et al.</i> [30]	2002	Endodontic microscope	Unreported	36	36.1%
		Magnification loupes		45	40.5%
		Naked eye		30	20%
Wolcott <i>et al.</i> [23]	2005	> 3.5x magnification loupes	Unreported	2038	35%
Al-fouzan <i>et al.</i> [9]	2011	Magnification loupes, endodontic microscope, <i>ultrasound</i>	Saudi Arabia	162	19.7%
Lee <i>et al.</i> [25]	2011	CBCT	Korea	467	42.2%
Zhang <i>et al.</i> [4]	2011	CBCT	China	210	22%
Silva <i>et al.</i> [18]	2014	CBCT	Brazil	306	34.32%
Present study	2015	CBCT	Chilean	255	48%

presence of the MB2 canal in the maxillary second molar between 19.7% and 51.1% [9, 10, 23]. Although this is useful for locating the MB2 canal, magnification systems present a series of limitations, such as a limited view of the clinical field, showing only the entrance foramen of the MB2 canal on the cavity floor and not its complete anatomy up to the apical foramen, where morphological variations are also observed [24]. The presence of liquids during access also reduces visibility. However, if access is not gained correctly, then magnification cannot provide an image of the area where the MB2 canal is located. In cases of inclined or rotated molars, magnification becomes less effective, since a severe to moderate angulation of the tooth prevents a good view of the cavity floor. Finally, equipment costs and operator training are important factors that limit the use of magnification. These limitations are currently overcome through the use of CBCT, a simple diagnostic technique that requires only a computer.

The relation between frequency of the MB2, position of the maxillary second molar, gender and age has not been studied very much [25], unlike the maxillary first molar, which has aroused greater interest in the study of these parameters [17, 26]. In this study, no significant differences were found in the distribution of the MB2 canal in relation to the position in the hemi-arch, being distributed homogeneously (50%), a distribution similar to that reported by Lee *et al.* [25], who observed through CBCT a frequency of 45.3% on the right side and 39% on the left side. Although its position had no significant influence on the detection of the MB2 canal, a high tendency toward bilateral

appearance was observed. According to gender, we observed significant differences ($P = 0.001$), where the prevalence was greater in men (63%) than in women (37%). This is consistent with what was reported by Lee *et al.* [25], who found a greater frequency of the MB2 canal in men (48.7%) than in women (30.8%), and is similar to what was reported for the MB2 of the maxillary first molar [26].

The MB2 canal is commonly located palatally or mesiopalatally to the mesiobuccal canal [8], generally mesially to an imaginary line between the MB1 and palatal canals, and commonly 2-3 mm palatally to the MB1 canal [27]. In our case the MB2 was located 2.2 ± 0.54 mm palatally and 0.98 ± 0.35 mesially to the MB1 canal, whereas Gorduysus *et al.* [13] reported its location 1.65 ± 0.72 mm palatally and 0.69 ± 0.42 mesially in a combined study of first and second molars, which could explain these differences.

Conclusion

It is important for the clinician to know the high probability of finding the MB2 canal in the maxillary second molar, and the CBCT is a good diagnostic tool for its detection and exploration. The MB2 canal is located approximately 2 mm palatally and 1 mm mesially to the MB1 canal; therefore, it is recommended that a rhomboid access be made to gain sufficient access to the floor of the coronal cavity.

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Disclosure of conflict of interest

None.

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