Worldwide Analyses of Maxillary First Molar Second Mesiobuccal Prevalence: A Multicenter Cone-beam Computed Tomographic Study

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Abstract

Introduction: Maxillary first molar second mesiobuccal (MB2) root canal prevalence may change among different populations. The aim of this study was to analyze the worldwide prevalence of the MB2 root canal and understand its possible relation with sex, age, side, and root configuration using *in vivo* cone-beam computed tomographic (CBCT) assessment. **Methods:** Observers from 21 regions were calibrated to achieve a similar CBCT assessment methodology and instructed to collect data from 250 maxillary first molars in previously existing examinations. Intra- and interrater reliability tests were performed. The sample size included 5250 molars and was defined by way of a preliminary trial. Data collected included MB2 presence, sex, age, side, number of roots per tooth, and mesiobuccal root configuration. The *z* test for proportions in independent groups was used to analyze the differences among subgroups. $P < .05$ was considered significant. **Results:** The worldwide CBCT-assessed MB2 prevalence was 73.8%, ranging from 48.0% in Venezuela to 97.6% in Belgium. The prevalence in males and females was 76.3% and 71.8%, respectively ($P < .05$). Significantly higher MB2 proportions were found in younger patients and 3-rooted molar configurations. The group intraclass correlation coefficient and the percentage of agreement for the MB2 presence were 0.95 and 0.91, respectively. The intrarater Cohen kappa value was above 0.61 for all observers. **Conclusions:** MB2 prevalence in the analyzed regions varied widely. The differences may be associated with specificities within each region but also patient demographics. Males, younger patients, and 3-rooted configurations were associated with higher MB2 proportions. *(J Endod 2018;44:1641–1649)*

Key Words:

Anatomy, cone-beam computed tomography, molar, morphology, root canal

The importance of the maxillary first molar second mesiobuccal (MB2) root canal has been documented in studies that correlate the presence of periapical lesions with

Significance

The differences in MB2 prevalence may be associated with specificities within each geographic region but also patient demographics. Males, younger patients, and 3-rooted configurations were associated with higher MB2 proportions.

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endodontically treated maxillary molars presenting with unfilled MB2 canals. In a cone-beam computed tomographic (CBCT) study (1), the proportion of unfilled MB2 canals in maxillary first molars with previous root canal therapy was 46.5%, and 72.7% of these molars were associated with periapical lesions. According to the authors, teeth with a missed canal were 4.38 times more likely to be associated with periapical lesions. Wolcott et al (2) performed a clinical analysis of the proportion of MB2 canals found during treatments. The prevalence of untreated maxillary first molar MB2 canals in endodontic treatment failures was 66.0%, whereas the prevalence of MB2 canals in primary treatments was 57.9%. This difference was statistically significant and suggested the cause for persistent disease.

The prevalence of the MB2 root canal varies depending on the geographic region being studied. Taking into consideration only *in vivo* CBCT studies, the MB2 proportions vary from 30.9% in China (3) to 86.6% in Iran (4), with intermediate values in other regions such as Brazil (44.4%) (5), Korea (63.6%) (6), and Portugal (71.0%) (7).

However, all of these previous studies were performed by different research groups, and variations in the CBCT examination assessment present challenges when attempting any direct comparison. Only 2 previous studies have evaluated root canal system configurations in different regions of the world using precalibrated observers. Mandibular molar anatomy was assessed in Chile and Belgium (8), and mandibular second molar C-shaped morphologies were evaluated in 9 different countries (9). No previous multiregional study has ever compared maxillary first molar MB2 prevalence with precalibrated observers. Two recent studies have also evaluated the root canal system configuration in all groups of teeth among sexes (10) and in different age groups (11). Although differences were found among subgroups, the impact of these variables on maxillary first molar MB2 prevalence was unclear. The objective of this study was to perform a worldwide maxillary first molar MB2 analysis and evaluate the influence of several variables (sex, age, side, and number of roots) using the *in vivo* CBCT method.

Material and Methods

Twenty-one observers (20 endodontists and 1 dentist with a master's degree in radiology) from 21 different regions evaluated MB2 root canal prevalence in maxillary first molars using preexisting CBCT examinations from private clinics. The principal researcher (J.M.) provided all observers with identical information, including written guidelines, CBCT images with several mesiobuccal root configurations, bibliographic references, deadlines, and a tutorial video giving step-by-step instructions on how to perform CBCT interpretation with specific visualization software (Planmeca Romexis; Planmeca, Helsinki, Finland) although the instructions were adaptable to any other software application. All of the information was simultaneously delivered to the observer's team, and any questions and answers were shared with all participants. Strict criteria were used to collect all data (detailed later).

A preliminary trial with 30 consecutive maxillary first molars was conducted in Portugal and Belgium. Power analysis of the sample size was calculated, and it was concluded that a total of 160 teeth would be required in both groups to achieve a significant difference in MB2 presence, with an alpha-type error of 0.05 and power of 0.80. Considering there were no plans to repeat the sample size analysis in any other region, it was decided to establish a final sample size requirement of 250 teeth. This was a size that was above 160, and the difference would allow a safety margin for regions in which the final differences would not be so large.

Both inter- and intrarater reliability tests were performed. For the interrater reliability test, the main researcher shared the same 10 CBCT examinations, each one presenting a large field of view (FOV) with both maxillary first molars available to be analyzed. All 21 observers performed the analysis of the same 20 teeth during the same period (June 2017). These 10 initial examinations were used only for calibration proposes and were not included in the final sample of each region. Both the intraclass correlation coefficient and the percentage of agreement were determined for the group regarding the primary outcome. As for the intrarater reliability tests, each observer was instructed to evaluate 30 consecutive teeth in their own region twice with a 1-month interval between evaluations (performed between July and September 2017). The Cohen kappa test was used to evaluate each observer individually. If the kappa value for the primary outcome (presence/absence of the MB2 root canal) was superior to 0.61 (substantial agreement), the observer was instructed to collect the remaining 220 samples with an end date of January 31, 2018. If substantial agreement was not achieved, the observer would be invited to review the delivered supporting material and repeat the reliability test.

This study was approved by the ethics commission of Faculdade de Medicina Dentária da Universidade de Lisboa, Lisbon, Portugal, and accepted by every clinical director of each clinical practice.

CBCT Analysis

The observers were instructed to collect the 250 specimens from CBCT examinations containing at least 1 maxillary first molar. The chosen examinations began in the first available chart and were analyzed in a consecutive manner, following the numeric or alphabetical chart order, until the completion of the 250 specimens. The samples were collected from a preexisting CBCT database, and no patients were exposed to radiation for the purposes of the present study. Any type of CBCT machine, brand, or FOV was acceptable; however, the voxel sizes were required to be equal to or less than 250 μm. Each observer was permitted to access several CBCT databases within their own region; however, only 1 observer was allowed in each region because of calibration and reliability calculations.

All teeth with previous endodontic treatment, root resorption, immature apices, or any radiologic artifacts that prevented a correct analysis were excluded. If there was uncertainty about the tooth numbering, that scan was discarded. The analyzed teeth were classified according to the following criteria:

1. Tooth number
2. Number of roots: a maxillary first molar with fused roots was classified as having 1 or 2 roots depending on the fusion type (12). A root with a bifurcation in the apical one fourth was regarded as a single root (13).
3. Presence/absence of the MB2 root canal (primary outcome)
4. Root canal system configuration in the mesiobuccal root: first mesiobuccal (MB1) only, MB1 and MB2 completely independent from each other, and MB1 and MB2 with connections between them (isthmus, merging, splitting)

Observers were asked to consult with the main researcher if the anatomy of any particular specimen presented challenges during the classification process so a consensus could be reached. All of the observers used the same preprepared Excel (Microsoft, Redmond, WA) sheet to record their final results. The completed sheets from each region were delivered to the main researcher who screened them to identify any nonconformities. All observers were blinded until the end of the research period from any result coming from other observers to avoid any kind of influence during their own evaluation.

Statistical Analysis

The collected data were assessed using SPSS software (Version 22; IBM Corp, Armonk, NY). The primary outcome was the proportion of MB2 root canals in maxillary first molars in each geographic region, which was calculated and expressed with a 95% confidence interval. The z test for proportions in independent groups was used to analyze the differences among the subgroups. $P < .05$ was considered significant.

Results

The geographic location and the CBCT characteristics of each region are shown in Table 1. The group intraclass correlation coefficient and the percentage of agreement for the primary outcome were 0.95 and 0.91, respectively. A global view of the deidentified intrarater reliability test results are detailed in Supplemental Table S1 (available online at www.jendodon.com).

A total of 5250 maxillary first molars from 3935 patients (1723 males and 2212 females) were included in the study. The average patient age was 44.5 years, and most of the included teeth were 3-rooted molars (94.0%). Table 2 summarizes the patient demographics for each region. The proportion of MB2 root canal presence varied from 48.0% (95% confidence interval (CI), 41.8%–54.2%) in Venezuela to 97.6% (95% CI, 95.7%–99.5%) in Belgium (Fig. 1), with a worldwide global prevalence of 73.8% (95% CI, 72.6%–75.0%) (Fig. 2). More than half of the analyzed mesiobuccal roots showed a configuration with confluent MB1 and MB2 root canals (Table 3). Of the 21 regions, 14 presented data from large FOV examinations, allowing bilateral analysis of the anatomy; 1315 patients had both maxillary first molars, 247 (18.8%) had bilateral absence of MB2, 134 (10.2%) had unilateral presence, and 934 (71.0%) had an MB2 root canal in both molars. No significant difference was found between the left and right sides; however, males presented significantly higher MB2 prevalence (76.3%, male global sample) when compared with females (71.8%, female global sample), whereas older patients (≥61 years, global sample) presented significantly lower prevalence when compared with younger patients (≤20 years and 21–40 years, global sample) (Table 4). Although the patient demographics varied greatly from region to region, a perfect understanding of the influence of sex and age could be made. These 2 variables were isolated by performing an analysis of MB2 prevalence in sex groups according to 4 age intervals. This analysis confirmed the lower MB2 prevalence in females and older groups (Table 5). The prevalence of the MB2 root canal was also significantly higher in 3-rooted molars (75.1%) when compared with 2-rooted teeth (55.4%) (Supplemental Table S2 is available online at www.jendodon.com).

Discussion

Extensive research has been performed over the years on the maxillary first molar MB2 root canal (4, 5, 6, 14, 15). The methodologies used vary from *in vivo* techniques such as clinical findings (2), radiographic examinations (16), and CBCT interpretations (17) to *ex vivo* methodologies such as clearing (18) or micro–computed tomographic imaging (19, 20). These methodologies appear to be valid to study the mesiobuccal root anatomy; however, the research methods used depend on the information to be assessed. Anatomic studies assess physical structures of the body, whereas prevalence studies analyze frequencies within a population. If the objective is to study the anatomy, in this particular case the maxillary first molar MB2 root canal, and assess very fine details such as apical constrictions (21), accessory canals (22), or even multiple apical foramina (20), then the *ex vivo* micro–computed tomographic technology appears to be the best option. However, if the objective is to assess the proportion

TABLE 1. Geographic Location and Cone-beam Computed Tomographic (CBCT) Characteristics for Each Region

Region	City	Continent	Observer	CBCT model	CBCT voxel size	CBCT FOV
Australia	Melbourne	Oceania	P.P.	Accuitomo 80 (Morita, Kyoto, Japan)	160 μm	Small
Belgium	Brussels	Europe	M.Z.	Newtom Giano (Newtom, Verona, Italy)	150 μm/250 μm	Small/large
Brazil	Campinas	America	L.S.	i-CAT (i-CAT, Hatfield, England)	200 μm	Large
China	Suzhou	Asia	Y.Z.	Newtom VGI (Newtom)	150 μm	Large
Costa Rica	San Jose	America	W.V.	X Mind Trium (Acteon, Merignac, France)	75 μm	Large
Egypt	Cairo	Africa	M.A.	Promax 3D (Planmeca, Helsinki, Finland)	75 μm/150 μm	Small/large
England	London	Europe	D.F.	Accuitomo 170 (Morita)	80 μm	Small
France	Paris	Europe	F.S.	CS9000/CS8100 (Carestream Dental, Atlanta, GA)	76 μm/150 μm	Small and large
Greece	Athens	Europe	A.C.	Newtom VGI	125 μm	Large
Iceland	Hafnarfjördur	Europe	M.R.	Promax 3D/i-CAT	200 μm/200 μm	Small/large
India	Kochi	Asia	J.K.	Newtom VGI	75 μm/150 μm	Small/large
Italy	Rome	Europe	G.B.	Newtom VGI	200 μm	Large
Kuwait	Salmiya	Asia	H.O.	Promax 3D	150 μm	Large
Mexico	Léon	America	R.R.A.	OP 300 Maxio (Kavo, Charlotte, NC)	85 μm	Small
Portugal	Lisbon	Europe	J.M.	Promax 3D	200 μm	Large
South Africa	Durban	Africa	H.S.	CS8100	150 μm	Large
Spain	Barcelona	Europe	J.G.	CS8100/Promax 3D	150 μm/200 μm	Small/large
Syria	Damascus	Asia	Z.A.	Scanora 3D (Soredex, Tuusula, Finland)	200 μm	Large
The Netherlands	Amsterdam	Europe	M.M.	CS9000	76 μm	Small
USA	San Diego	America	A.M.	CS9000	76 μm	Small
Venezuela	Caracas	America	C.B.	CS9000	76 μm	Small

TABLE 2. Patient Demographics and Number of Roots per Tooth

Region	Sample size (patients)	Average age (y)	Proportion of males, *n* (%)	Proportion of females, *n* (%)	Sample size (teeth)	Single-rooted molars, *n* (%)	2-rooted molars, *n* (%)	3-rooted molars, *n* (%)	4-rooted molars, *n* (%)
Australia	250	54.1	84 (33.6)	166 (66.4)	250	—	26 (10.4)	224 (89.6)	—
Belgium	176	47.8	74 (42.0)	102 (58.0)	250	1 (0.4)	29 (11.6)	220 (88.0)	—
Brazil	127	43.3	53 (41.7)	74 (58.3)	250	—	—	250 (100)	—
China	127	34.3	61 (48.0)	66 (52.0)	250	—	2 (0.8)	248 (99.2)	—
Costa Rica	156	44.1	73 (46.8)	83 (53.2)	250	—	1 (0.4)	249 (99.6)	—
Egypt	180	39.0	74 (41.1)	106 (58.9)	250	1 (0.4)	16 (6.4)	232 (92.8)	1 (0.4)
England	250	50.6	106 (42.4)	144 (57.6)	250	—	9 (3.6)	241 (96.4)	—
France	204	43.0	97 (47.5)	107 (52.5)	250	3 (1.2)	14 (5.6)	233 (93.2)	—
Greece	164	51.0	69 (42.1)	95 (57.9)	250	1 (0.4)	31 (12.4)	214 (85.6)	4 (1.6)
Iceland	250	34.2	110 (44.0)	140 (56.0)	250	1 (0.4)	13 (5.2)	235 (94.0)	1 (0.4)
India	140	32.6	84 (60.0)	56 (40.0)	250	—	3 (1.2)	247 (98.8)	—
Italy	126	47.2	57 (45.2)	69 (54.8)	250	—	24 (9.6)	226 (90.4)	—
Kuwait	163	40.7	67 (41.1)	96 (58.9)	250	2 (0.8)	6 (2.4)	240 (96.0)	2 (0.8)
Mexico	250	45.4	131 (52.4)	119 (47.6)	250	—	—	250 (100)	—
Portugal	173	46.9	70 (40.5)	103 (59.5)	250	1 (0.4)	17 (6.8)	232 (92.8)	—
South Africa	150	41.2	66 (44.0)	84 (56.0)	250	4 (1.6)	2 (0.8)	244 (97.6)	—
Spain	168	41.4	79 (47.0)	89 (53.0)	250	—	16 (6.4)	233 (93.2)	1 (0.4)
Syria	131	22.1	59 (45.0)	72 (55.0)	250	—	—	250 (100)	—
The Netherlands	250	51.5	101 (40.4)	149 (59.6)	250	3 (1.2)	13 (5.2)	234 (93.6)	—
USA	250	55.0	103 (41.2)	147 (58.8)	250	1 (0.4)	34 (13.6)	215 (86.0)	—
Venezuela	250	47.1	105 (42.0)	145 (58.0)	250	1 (0.4)	29 (11.6)	220 (88.0)	—
Total	3935	44.5	1723 (43.8)	2212 (56.2)	5250	19 (0.4)	285 (5.4)	4937 (94.0)	9 (0.2)

of MB2 canals in a particular population (7), CBCT imaging is a more suitable method.

In the present study, the CBCT technology was chosen to assess the prevalence of maxillary first molar MB2 root canals in 21 different regions dispersed worldwide. Most of the analyzed regions had never been studied before, such as Australia, Belgium, Costa Rica, England, Iceland, Kuwait, Mexico, Syria, the Netherlands, and Venezuela. This makes a comparison with previous studies impossible but benefits the already existing literature by introducing new information. There are comparisons that can be made between the results of this study and findings among the regions that had been previously assessed using the *in vivo* CBCT method. The present results in Brazil showed an MB2 prevalence of 82.4%, which is similar to an analysis by Reis et al (23) (88.5%) but higher than other studies (5, 24–26). Greece and the United States presented 58.4% and 74.8%, respectively, which are similar to figures reported previously by Nikoloudaki et al (15) in Greece (53.0%) and Guo et al (14) in the United States (71.7%). The present results for Italy (74.4%) and China (76.4%) are higher than the majority of the previous studies (3, 27–31). In contrast, Spain and Egypt showed prevalences of 68.0% and 62.0%, respectively, which are lower than the studies by Pérez-Heredia et al (32) in Spain (86.2%) and Ghobashy et al (33) in Egypt (74.5%). MB2 prevalence varies substantially worldwide. In the present study, it ranged from 48.0% in Venezuela to 97.6% in Belgium. Previous research using the *in vivo* CBCT method revealed a range of 30.9% in a Chinese study (3) to 86.6% in an Iranian investigation (4).

The comparison of results between 2 regions is difficult to perform because of differences in the patient demographics of each region. For example, Australia presented one of the lowest proportions of MB2 canals (50.8%), whereas Syria presented one of the highest (95.2%).

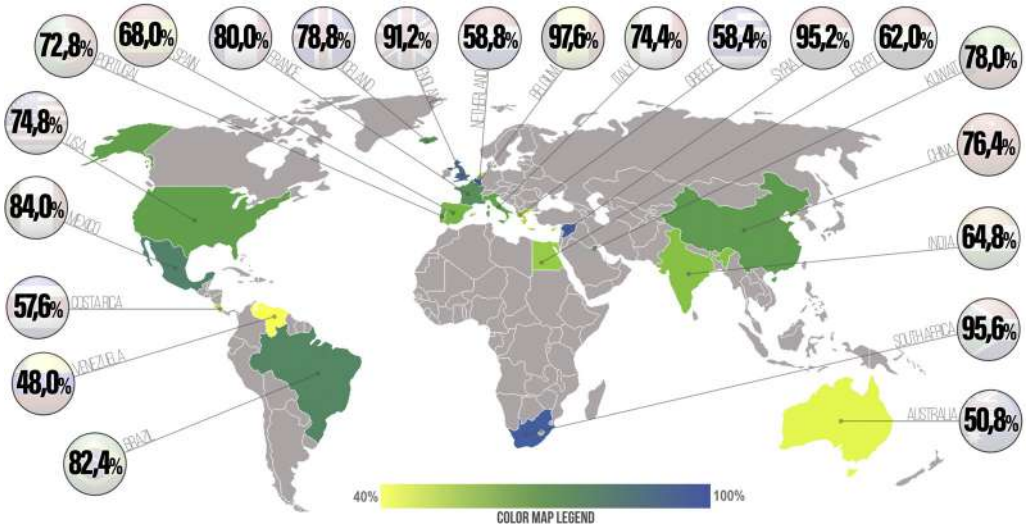

Figure 1. MB2 proportions in each region.

Figure 2. Axial slices of maxillary first molars presenting MB2 root canals. Obtained from Venezuela, China, and Portugal.

However, the average patient age in Australia (54.1 years) was more than double that in Syria (22.1 years). Furthermore, the percentage of females in Australia was 66.4%, whereas in Syria it was only 55.0%. Considering the present study revealed females and older patients had lower proportions of MB2 canals, these demographic differences might somewhat explain the lower percentage of MB2 canals found in Australia when compared with Syria. Findings comparable with Australia were observed in Greece and the Netherlands, which had MB2 prevalences of approximately 58% (almost 15% under the average), average ages of 51 years (above the average), and female proportions of 60% (above the average).

Another concern that cannot be ignored is the differences in CBCT interpretation between the observers. Although efforts were made to calibrate the observer's assessment skills by sharing images, instructional videos, references, and an identical timetable, each observer's past experiences and personal beliefs may have an influence also. The group intraclass correlation coefficient and the percentage of agreement were extremely high but not perfect, which still allows a small space for personal variations. In the present study, more than the standardization of the CBCT scanners, which was not completely possible because of the nonmarketing of all scanner brands at the worldwide level and whose maximum voxel size was set at 250 μm, which has been stated as a resolution with high accuracy (0.82) in the identification of MB2 canals in mesiobuccal roots with canals not instrumented or filled (34), a good standardization of the step-by-step MB2 assessment process was the main concern. One example of this observer interpretation variations can be exemplified in Burklein et al (35), an analysis of premolar anatomy in Germany. According to the authors, the high prevalence of Vertucci type V configurations was caused by a high prevalence of apical deltas. However, apical deltas are comprised of accessory apical canals, and no other author analyzing premolars (36–38) in any other study has reported the inclusion of apical deltas as part of the Vertucci major canal classification. The results of Burklein et al (35), which indicate type V prevalence to be much higher than any other study, are not comparable with the literature because of their distinctive interpretation of the Vertucci classification. Similarly, small variations within the observation team associated with demographic differences in the samples make it difficult to compare prevalence results between regions in the present study. This is a situation that can be salient to other studies already published. Another factor that should be taken in consideration is the multicultural makeup of some countries, such as Australia and the United States. It is not clear at this point if these cultural variations inside a region might influence comparisons with other regions. Prevalence differences between world

TABLE 3. Maxillary First Molar Second Mesiobuccal (MB2) Root Canal Proportion and Configuration

Region	Sample size (teeth)	Presence of MB2 (teeth)	MB2 proportion (%)	Confidence interval (CI 95%)	Single MB1 configuration, *n* (%)	Independent MB1 and MB2 configuration, *n* (%)	Confluent MB1 and MB2 configuration, *n* (%)
Australia	250	127	50.8	44.6–57.0	123 (49.2)	62 (24.8)	65 (26.0)
Belgium	250	244	97.6	95.7–99.5	6 (2.4)	60 (24.0)	184 (73.6)
Brazil	250	206	82.4	77.7–87.1	44 (17.6)	72 (28.8)	134 (53.6)
China	250	191	76.4	71.1–81.7	59 (23.6)	109 (43.6)	82 (32.8)
Costa Rica	250	144	57.6	50.7–62.9	106 (42.4)	11 (4.4)	133 (53.2)
Egypt	250	155	62.0	56.0–68.0	95 (38.0)	34 (13.6)	121 (48.4)
England	250	228	91.2	87.7–94.7	22 (8.8)	65 (26.0)	163 (65.2)
France	250	200	80.0	75.0–85.0	50 (20.0)	51 (20.4)	149 (59.6)
Greece	250	146	58.4	52.3–64.5	104 (41.6)	73 (29.2)	73 (29.2)
Iceland	250	197	78.8	73.7–83.9	53 (21.2)	63 (25.2)	134 (53.6)
India	250	162	64.8	59.3–71.1	88 (35.2)	48 (19.2)	114 (45.6)
Italy	250	186	74.4	69.0–79.8	64 (25.6)	62 (24.8)	124 (49.6)
Kuwait	250	195	78.0	72.9–83.1	55 (22.0)	46 (18.4)	149 (59.6)
Mexico	250	210	84.0	79.7–88.5	40 (16.0)	124 (49.6)	86 (34.4)
Portugal	250	182	72.8	63.3–78.3	68 (27.2)	43 (17.2)	139 (55.6)
South Africa	250	239	95.6	93.1–98.1	11 (4.4)	78 (31.2)	161 (64.4)
Spain	250	170	68.0	62.2–73.8	80 (32.0)	61 (24.4)	109 (43.6)
Syria	250	238	95.2	92.6–97.9	12 (4.8)	32 (12.8)	206 (82.4)
The Netherlands	250	147	58.8	52.7–64.9	103 (41.2)	50 (20.0)	97 (38.8)
USA	250	187	74.8	69.4–80.2	63 (25.2)	12 (4.8)	175 (70.0)
Venezuela	250	120	48.0	41.8–54.2	130 (52.0)	18 (7.2)	102 (40.8)
Total	5250	3874	73.8	72.6–75.0	1376 (26.2)	1174 (22.4)	2700 (51.4)

MB1, first mesiobuccal.

TABLE 4. Sex, Side, and Age Influence on Second Mesiobuccal (MB2) Root Canal Prevalence

Region	Proportion of MB2 root canals (teeth), *n*/*N* (%)							
	Males	Females	Left side (#26)	Right side (#16)	≤20 years	21–40 years	41–60 years	≥61 years
Australia	49/84 (58.3)	78/166 (47.0)	61/123 (49.6)	66/127 (52.0)	0/1 (0)	18/32 (56.3)	72/136 (52.9)	37/81 (45.7)
Belgium	106/108 (98.1)	138/142 (97.2)	123/127 (96.9)	120/123 (97.6)	11/12 (91.7)	68/69 (98.6)	125/129 (96.9)	40/40 (100)
Brazil	81/103 (78.6)	125/147 (85.0)	105/127 (82.7)	101/123 (82.1)	22/30 (73.3)	66/80 (82.5)	76/95 (80.0)	42/45 (93.3)
China	93/118 (78.8)	98/132 (74.2)	95/125 (76.0)	96/125 (76.8)	—	146/193 (75.6)	45/57 (78.9)	—
Costa Rica	72/123 (58.5)	72/127 (56.7)	79/117 (67.5)	65/133 (48.9)	6/6 (100)	67/107 (62.6)	60/112 (53.6)	11/25 (44.0)
Egypt	70/106 (66.0)	85/144 (59.0)	88/129 (68.2)	67/121 (55.4)	14/22 (63.6)	83/132 (62.9)	48/78 (61.5)	10/18 (55.6)
England	100/106 (94.3)	128/144 (88.9)	107/116 (92.2)	121/134 (90.3)	6/6 (100)	56/61 (91.8)	106/115 (92.2)	60/68 (88.2)
France	98/116 (84.5)	102/134 (76.1)	96/118 (81.4)	104/132 (78.8)	11/18 (61.1)	86/109 (78.9)	73/87 (83.9)	30/36 (83.3)
Greece	57/99 (57.6)	89/151 (58.9)	75/124 (60.5)	71/126 (56.3)	3/14 (21.4)	30/54 (55.6)	81/121 (66.9)	32/61 (52.5)
Iceland	94/110 (85.5)[a]	103/140 (73.6)[a]	73/97 (75.3)	124/153 (81.0)	26/36 (72.2)	115/144 (79.9)	32/43 (74.4)	24/27 (88.9)
India	108/152 (71.1)[a]	54/98 (55.1)[a]	79/124 (63.7)	83/126 (65.9)	23/44 (52.3)	120/158 (75.9)	19/44 (43.2)	0/4 (0)
Italy	85/114 (74.6)	101/136 (74.3)	88/125 (70.4)	98/125 (78.4)	8/12 (66.7)	64/76 (84.2)	77/106 (72.6)	37/56 (66.1)
Kuwait	84/103 (81.6)	111/147 (75.5)	97/126 (77.0)	98/124 (79.0)	24/32 (75.0)	68/102 (66.7)	83/93 (89.2)	20/23 (87.0)
Mexico	108/131 (82.4)	102/119 (85.7)	107/125 (85.6)	101/125 (80.8)	0/4 (0)	71/89 (79.8)	120/132 (90.9)	19/25 (76.0)
Portugal	75/99 (75.8)	107/151 (70.9)	83/115 (72.2)	99/135 (73.3)	4/6 (66.7)	70/92 (76.1)	75/107 (70.1)	33/45 (73.3)
South Africa	101/105 (96.2)	138/145 (95.2)	114/120 (95.0)	125/130 (96.2)	51/53 (96.2)	74/78 (94.9)	73/75 (97.3)	41/44 (93.2)
Spain	79/114 (69.3)	91/136 (66.9)	79/118 (66.9)	91/132 (68.9)	9/13 (69.2)	96/117 (82.1)	50/90 (55.6)	15/30 (50.0)
Syria	109/113 (96.5)	129/137 (94.2)	118/123 (95.9)	120/127 (94.5)	110/117 (94.0)	119/124 (96.0)	8/8 (100)	1/1 (100)
The Netherlands	57/101 (56.4)	90/149 (60.4)	79/138 (57.2)	68/112 (60.7)	2/3 (66.7)	31/57 (54.4)	74/127 (58.3)	40/63 (63.5)
USA	78/103 (75.7)	109/147 (74.1)	114/146 (78.1)	73/104 (70.2)	1/1 (100)	32/45 (71.1)	75/102 (73.5)	79/102 (77.5)
Venezuela	61/105 (58.1)[a]	59/145 (40.7)[a]	56/122 (45.9)	64/128 (50.0)	1/5 (20.0)	52/84 (61.9)	51/114 (44.7)	16/47 (34.0)
Total*	1765/2313 (76.3)[a]	2109/2937 (71.8)[a]	1916/2585 (74.1)[b]	1955/2665 (73.4)[b]	332/435 (76.3)[c]	1532/2003 (76.5)[d,e]	1423/1971 (72.2)[d]	587/841 (69.8)[c,e]

[a]Significant difference between sexes ($P < .05$).

[b]Nonsignificant difference between sides ($P > .05$).

[c–e]Significant difference among age groups ($P < .05$).

*Significant tests were performed only among the totals, except for sex groups, which were tested in all regions.

TABLE 5. Proportion of Second Mesiobuccal (MB2) Canals among Sexes in Different Age Groups

	Proportion of MB2 root canals (teeth), *n*/*N* (%)							
	≤20 years		21–40 years		41–60 years		≥61 years	
Region	Males	Females	Males	Females	Males	Females	Males	Females
Australia	—	0/1 (0)	7/14 (50)	11/18 (61.1)	30/48 (62.5)	42/88 (47.7)	12/22 (54.5)	25/59 (42.4)
Belgium	6/6 (100)	5/6 (83.3)	35/35 (100)	33/34 (97.1)	55/57 (96.5)	70/72 (97.2)	10/10 (100)	30/30 (100)
Brazil	9/16 (56.3)	13/14 (92.9)	24/34 (70.6)	42/46 (91.3)	27/29 (93.1)	49/66 (74.2)	21/24 (87.5)	21/21 (100)
China	—	—	64/81 (79.0)	82/112 (73.2)	29/37 (78.4)	16/20 (80.0)	—	—
Costa Rica	—	6/6 (100)	36/54 (66.7)	31/53 (58.5)	31/56 (55.4)	29/56 (51.8)	5/13 (38.5)	6/12 (50.0)
Egypt	10/15 (66.7)	4/7 (57.1)	35/53 (66.0)	48/79 (60.8)	21/32 (65.6)	27/46 (58.7)	4/6 (66.7)	6/12 (50.0)
England	3/3 (100)	3/3 (50.0)	25/27 (92.6)	31/34 (91.2)	45/48 (93.8)	61/67 (91.0)	27/28 (96.4)	33/40 (82.5)
France	7/10 (70.0)	4/8 (50.0)	42/50 (84.0)	44/59 (74.6)	35/41 (85.4)	38/46 (82.6)	14/15 (93.3)	16/21 (76.2)
Greece	1/6 (16.7)	2/8 (25.0)	10/20 (50.0)	20/34 (58.8)	29/46 (63.0)	52/75 (69.3)	17/27 (63.0)	15/34 (44.1)
Iceland	9/13 (69.2)	17/23 (73.9)	58/67 (86.6)	57/77 (74.0)	16/19 (84.2)	16/24 (66.7)	11/11 (100)	13/16 (81.3)
India	18/32 (56.3)	5/12 (41.7)	77/101 (76.2)	43/57 (75.4)	13/19 (68.4)	6/25 (24.0)	—	0/4 (0)
Italy	6/10 (60.0)	2/2 (100)	22/24 (91.7)	42/52 (80.8)	36/46 (78.3)	41/60 (68.3)	21/34 (61.8)	16/22 (72.7)
Kuwait	14/18 (77.8)	10/14 (71.4)	23/32 (71.9)	45/70 (64.3)	39/42 (92.9)	44/51 (86.3)	8/11 (72.7)	12/12 (100)
Mexico	0/4 (0)	—	35/45 (77.8)	36/44 (81.8)	61/67 (91.0)	59/65 (90.8)	12/15 (80.0)	7/10 (70.0)
Portugal	4/6 (66.7)	—	27/34 (79.4)	43/58 (74.1)	38/48 (79.2)	37/59 (62.7)	6/11 (54.5)	27/34 (79.4)
South Africa	18/18 (100)	33/35 (94.3)	34/36 (94.4)	40/42 (95.2)	37/37 (100)	36/38 (94.7)	12/14 (85.7)	29/30 (96.7)
Spain	6/9 (66.7)	3/4 (75.0)	37/49 (75.5)	59/68 (86.8)	27/44 (61.4)	23/46 (50.0)	9/12 (75.0)	6/18 (33.3)
Syria	43/44 (97.7)	67/73 (91.8)	61/64 (95.3)	58/60 (96.7)	4/4 (100)	4/4 (100)	1/1 (100)	—
The Netherlands	0/1 (0)	2/2 (100)	13/23 (56.5)	18/34 (52.9)	31/54 (57.4)	43/73 (58.9)	13/23 (56.5)	27/40 (67.5)
USA	—	1/1 (100)	11/14 (78.6)	21/31 (67.7)	27/36 (75.0)	48/66 (72.7)	40/53 (75.5)	39/49 (79.6)
Venezuela	—	1/5 (20.0)	24/37 (64.9)	28/47 (59.6)	30/49 (61.2)	21/65 (32.3)	7/19 (36.8)	9/28 (32.1)
Total*	154/211 (73.0)	178/224 (79.5)[c,d]	700/894 (78.3)[b]	832/1109 (75.0)[e,f]	661/859 (76.9)[a]	762/1112 (68.5)[a,c,e]	250/349 (71.6)[b]	337/492 (68.5)[d,f]

[a]Significant difference between sexes ($P < .05$).

[b–f]Significant difference between age groups ($P < .05$).

*Significant tests were performed only among the totals.

regions may indeed exist; however, because of the factors previously mentioned, the authors decided not to perform a statistical difference calculation between the analyzed regions.

Other valuable comparisons could be performed among subgroups. The results in each region were based on a sample size of 250 teeth; however, the global sample interpretation was based on a much large sample size of 5250 teeth. Even with this larger sample size, one must still consider the sum of all samples; however, this increase of the sample size reduces the impact of any variable influence in the global sample. Moreover, when analyzing each variable independently in the global sample, such as sex or age, the observer impact on the evaluation is strongly reduced, considering the same observer always performed the evaluation on each region for both sexes and age groups, and the influence of that specific demographic variable becomes eliminated as the variable is isolated. The present study showed a higher prevalence of maxillary first molar MB2 root canals in males, a result that is in agreement with previous studies reporting differences between sexes (3, 6, 39). There is no study available in the literature showing a significantly higher prevalence of MB2 canals in females. Regarding the age influence, the present study showed higher MB2 prevalence in younger patients, which corroborates with previous findings (17, 31). Lower MB2 proportions in older patients may be caused by the possible enclosure of a previously existing MB2 root canal or canals that become so narrow that they are no longer visible upon CBCT examination (40). Taking advantage of the present study's large sample size, it was possible to perform an analysis of each sex at different age intervals. This double variable isolation had never been performed previously, and the results reinforced the conclusions that higher MB2 proportions exist in males and younger patients. Three-rooted configurations presented a higher MB2 proportion when compared with 2-rooted configurations, a finding that cannot be compared with the previous literature because of a lack of information on the subject. Again, taking into consideration the previously mentioned comparison between Australia and Syria, the data indicate that the Australia sample was comprised of 10.4% of 2-rooted molars, whereas the Syria sample contained only 3-rooted molars, a finding that may have also contributed to the large difference observed among these specific regions. Knowing these variables (sex, age and root configuration) before maxillary molar root canal therapy has an important clinical relevance because it is possible to anticipate a higher or lower chance of identifying an MB2 root canal during the treatment.

Another limitation of the present study was the difficulty to compare different geographic regions because of differences in patient demographics. Apparently, this aspect may play an important role even when comparing MB2 proportions in different CBCT prevalence studies. A comparison among studies should be made carefully if the patient demographics are highly variable. This limitation could be bypassed by having the same observer assessing CBCT databases in different countries keeping age constant and implementing a 1:1 sex ratio. However, this methodology may be difficult because of the very strict sample characteristics. Additionally, root canal anatomy is dynamic and can change over the years. It would be difficult to establish an ideal patient age to be evaluated, one that would best represent each region. Moreover, this study had no intention to characterize any patient's ethnic background because countries nowadays are a mix of ethnicities. The convenience sample used in this study in each country represented a sample of the population who attended those clinical practices.

Scarce literature is available regarding the study of MB2 prevalence among sexes and in different age groups. More studies are required to establish a solid knowledge base of these variables and their influence on maxillary first molar MB2 prevalence.

Conclusions

Patient demographics may play an important role in the maxillary first molar MB2 canal prevalence. Males and younger patients presented with higher MB2 proportions when compared with females and older patients. Differences in these sample characteristics make it difficult to compare the results among regions. Three-rooted molars presented with a higher MB2 prevalence than 2-rooted molars. The MB2 proportions ranged from 48.0%–97.6% among the regions, with a worldwide global prevalence of 73.8%.

Acknowledgments

The authors deny any conflicts of interest related to this study.

Supplementary Material

Supplementary material associated with this article can be found in the online version at www.jendodon.com (10.1016/j.joen.2018.07.027).

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Appendix

SUPPLEMENTAL TABLE S1. Deidentified Cohen Kappa Intrarater Reliability Test Results

Rater	1st Evaluation*	2nd Evaluation*	Final sample	% submitted to kappa test	Kappa value (presence of MB2 root canal)	Asymptotic standard error
A	30	30	250	12	1.00	0
B	30	30	250	12	1.00	0
C	30	30	250	12	0.87	0.127
D	30	30	250	12	1.00	0
E	30	30	250	12	0.923	0.075
F	30	30	250	12	0.902	0.096
G	30	30	250	12	†	†
H	30	30	250	12	0.815	0.124
I	30	30	250	12	1.00	0
J	30	30	250	12	0.760	0.162
K	30	30	250	12	1.00	0
L	30	30	250	12	1.00	0
M	30	30	250	12	1.00	0
N	30	30	250	12	0.615	0.194
O	30	30	250	12	0.830	0.116
P	30	30	250	12	0.839	0.157
Q	30	30	250	12	1.00	0
R	30	30	250	12	0.902	0.096
S	30	30	250	12	0.80	0.107
T	30	30	250	12	1.00	0
U	30	30	250	12	1.00	0

MB2, second mesiobuccal.

*The same teeth, from each rater, were analyzed in both evaluations.

†No kappa value was calculated because both evaluations had constant scorings.

SUPPLEMENTAL TABLE S2. Second Mesiobuccal (MB2) Root Canal Prevalence in Different Root Configurations

Region	Single-rooted molars, *n*/*N* (%)	2-rooted molars, *n*/*N* (%)	3-rooted molars, *n*/*N* (%)	4-rooted molars, *n*/*N* (%)
Australia	—	8/26 (30.8)	119/224 (53.1)	—
Belgium	0/1 (0)	27/29 (93.1)	217/220 (98.6)	—
Brazil	—	—	206/250 (82.4)	—
China	—	2/2 (100)	189/248 (76.2)	—
Costa Rica	—	0/1 (0)	144/249 (57.8)	—
Egypt	0/1 (0)	10/16 (62.5)	145/232 (62.5)	0/1 (0)
England	—	7/9 (77.8)	221/241 (91.7)	—
France	0/3 (0)	11/14 (78.6)	189/233 (81.1)	—
Greece	0/1 (0)	15/31 (48.4)	127/214 (59.3)	4/4 (100)
Iceland	1/1 (100)	6/13 (46.2%)	189/235 (80.4)	1/1 (100)
India	—	1/3 (33.3%)	161/247 (65.2)	—
Italy	—	6/24 (25.0)	180/226 (79.6)	—
Kuwait	0/2 (0)	2/6 (33.3)	192/240 (80.0)	1/2 (50.0)
Mexico	—	—	210/250 (84.0)	—
Portugal	0/1 (0)	12/17 (70.6)	170/232 (73.3)	—
South Africa	1/4 (25.0)	2/2 (100)	236/244 (96.7)	—
Spain	—	6/16 (37.5)	163/233 (70.0)	1/1 (100)
Syria	—	—	238/250 (95.2)	—
The Netherlands	0/3 (0)	5/13 (38.5)	142/234 (60.7)	—
USA	1/1 (100)	25/34 (73.5)	161/215 (74.9)	—
Venezuela	0/1 (0)	13/29 (44.8)	107/220 (48.6)	—
Total*	3/19 (15.8)[a,b,c]	158/285 (55.4)[a,d]	3706/4937 (75.1)[b,d]	7/9 (77.8)[c]

[a–d]Significant difference between the number of root groups ($P < .05$).

*Significant tests were performed only among the totals.